THE HAMILTON PROJECT

Energy Policy Opportunities and Continuing Challenges in the Presence of Increased Supplies of Natural Gas and Petroleum

Michael Greenstone, Dmitri Koustas, Karen Li, Adam Looney, and Harrison Marks

MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth.

We believe that today's increasingly competitive global economy demands public policy ideas commensurate with the challenges of the 21st Century. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments.

Our strategy calls for combining public investment, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine — to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first Treasury Secretary, who laid the foundation for the modern American economy. Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces. The guiding principles of the Project remain consistent with these views.

THE HAMILTON PROJECT

THE HAMILTON PROJECT

Energy Policy Opportunities and Continuing Challenges in the Presence of Increased Supplies of Natural Gas and Petroleum

Michael Greenstone, Dmitri Koustas, Karen Li,
Adam Looney, and Harrison Marks

JUNE 2012

BROOKINGS

Energy Policy Opportunities and Continuing Challenges in the Presence of Increased Supplies of Natural Gas and Petroleum

We are in the midst of one of the most significant transformations in the energy sector in many decades. This transformation is the result of the development of new recovery techniques, such as hydraulic fracturing (fracking), that have unlocked massive supplies of previously unrecoverable fossil fuels, primarily natural gas and, to a lesser degree, petroleum. Since 2007, natural gas supplies and production in the United States have increased dramatically, and the price of natural gas-powered energy has plummeted. Only a few years ago, many in the United States were concerned about the prospects of dwindling supplies of natural gas in North America; today, we must determine how to manage vast new reserves. The implications of this natural gas revolution will be profound and are only now coming into focus.

On the positive side, there are several benefits to this technological revolution. Most immediately, it has created economic opportunity in several regions of the country, which is especially important in this extended period of weak economic growth. Additionally, it has reduced the cost of energy for American businesses, manufacturers, and consumers, and freed up resources for other important uses. Over the longer run, it will improve our energy security, making it easier to realize our foreign policy objectives, and making us less susceptible to oil price shocks in global markets by diversifying our fuel sources away from petroleum, especially in the transportation sector. Finally, natural gas has already begun to replace coal as an electricity source; this transition will improve our health and slow down the rate of climate change because the combustion of natural gas only leads to one-twentieth of the release of local pollutants and half the greenhouse gas emissions as coal.

Nevertheless, many are concerned that these advances represent a "white elephant"—a rich gift, but one that is costly to manage. Fracking itself may have significant environmental effects on local communities and on air and water quality, a fact which has caused many to question the wisdom of embracing this new technology, as evidenced in Vermont's recent decision to prohibit fracking entirely, and New York State's continued uncertainty about whether to allow it. Furthermore, low prices for natural gas reduce the economic incentive to invest in nuclear energy and newer technologies that can reduce the build-up of greenhouse gases in the atmosphere that cause climate change.

Policymakers have spent the last several decades searching for ways to facilitate the development of energy sources to power our economic growth, while protecting us from the harmful by-products of our energy choices. There have been some successes along the way, including the regulation-induced reduction of particulate air pollution concentrations, but there have been too many failures, ranging from costly subsidies that have produced few benefits, to unnecessarily expensive regulations. While the dramatic increase in the supplies of natural gas and the expanding petroleum production offer many potential benefits, it is as important as ever to implement sound policies to manage the development of these energy sources. Poor policy could expose us to even greater risks or cause us to squander an opportunity to make progress on the energy and environmental challenges that our country and the world continue to face.

This framing paper provides a summary of some of the recent changes in the energy sector, tallies the benefits and costs, and speculates about the changes yet to come. It also introduces three new discussion papers written for The Hamilton Project that aim to harness the opportunities that the technological advances in the recovery of natural gas offer, while managing the risks. It then assesses the energy challenges that continue to confront the United States, and reiterates four principles for sound energy and environmental policy developed in The Hamilton Project's paper, "A Strategy for America's Energy Future: Illuminating Energy's Full Costs" (Greenstone and Looney 2011). Finally, it introduces a fifth principle motivated by the vast increase in the supplies of natural gas and petroleum in the United States. These five principles follow:

1. **Appropriately price the social cost of energy production and use.** Many sources of energy, especially fossil fuels, have costs beyond what users pay at the pump or to the utility company. Because consumers and companies do not face the full costs of their energy use, they overconsume fuels that harm the environment and human health. Pricing these costs through cap-and-trade or tax policies would give consumers and firms the incentive to make decisions that are more informed and socially efficient, and that induce innovation in the energy sector.

2. **Fund basic research, development, and demonstration of new energy technologies.** Basic research and technology demonstration projects today are necessary to lay the groundwork for future technologies that can provide cleaner, low-cost energy. However, the private sector does not have

sufficient incentives to undertake all beneficial projects because they benefit multiple firms so individual firms cannot recoup the full benefits of these activities; this creates a critical role for government in funding and supporting the early stages of research and demonstration in the energy sector.

3. **Make regulations more efficient.** Regulation helps create a balance between the benefits of energy consumption and the negative environmental and health consequences of energy production. In order to create the right balance, regulation should be subject to rigorous cost-benefit analysis and retrospective review.

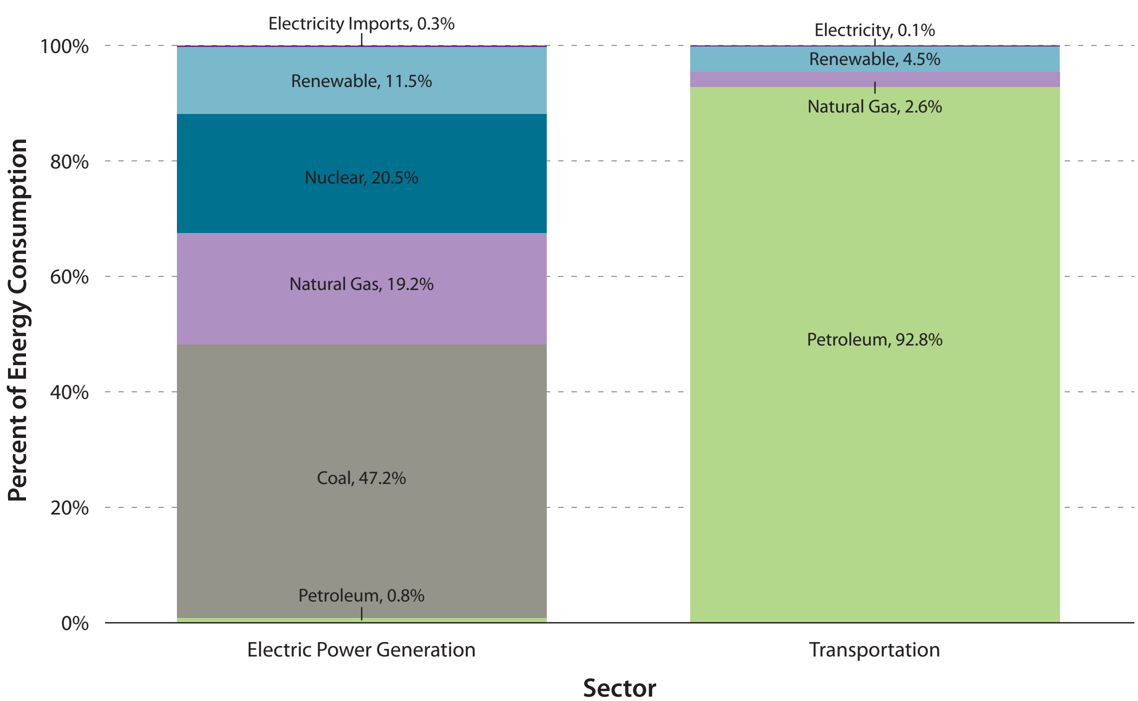
4. **Address climate change on a global scale.** Any solution to climate change will require an international effort by both the developed countries that currently lead the world in emissions, and the developing countries that will drive emissions growth in the future. Negotiations must play a large part in this effort, but some smaller steps can be taken in the interim to begin setting the stage for a global solution.

5. **Capitalize on the economic opportunities arising from new domestic natural gas and oil discoveries, while protecting the environment.** The increased production of domestic supplies of natural gas and oil can help reduce energy prices for American consumers and businesses; enhance the country's energy security and reduce its susceptibility to macroeconomic shocks arising from oil supply disruptions; reduce pollution emissions; and boost employment, incomes, and economic output. In order to achieve all these gains, energy policies should facilitate domestic gas and oil production in settings where the benefits exceed a full accounting of the social costs.

In accordance with these principles, three new Hamilton Project discussion papers propose new ideas on how to position public policy to take better advantage of the economic opportunities presented by the increased supplies of natural gas and petroleum, while also taking into account risks to the environment and to the health and safety of American families.

FIGURE 1.

Electric Power Consumption by Fuel Type, 2011: Coal dominates the electric power sector, while petroleum dominates transportation.



Source: EIA (2012a).

Note: In electricity power generation (left-hand column), the renewable category can be further broken down into hydropower (66 percent), wind power (25 percent), biomass (5 percent), geothermal (3 percent), and solar (less than 1 percent). In transportation (right-hand column), renewable energy is largely ethanol (91 percent) and biodiesel (9 percent). Numbers may not sum to 100 due to rounding.

1. The Current U.S. Energy Landscape

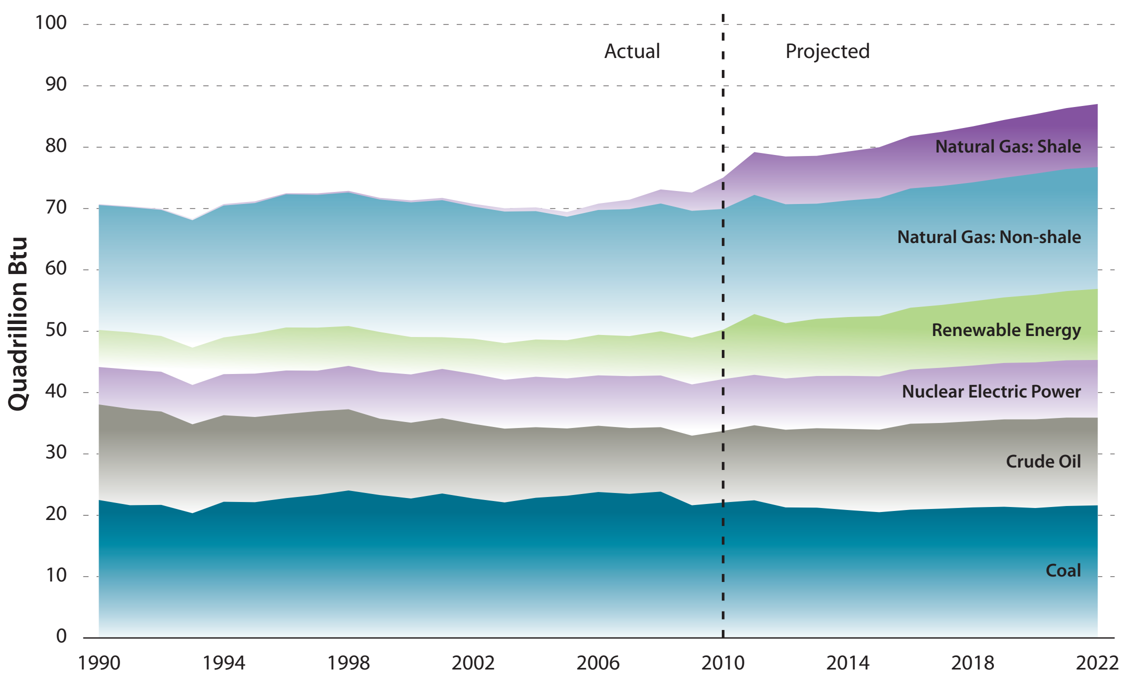
The U.S. energy sector is shaped by an interaction between energy markets and a frequently incoherent energy policy. Consumers and companies make decisions about how much and what types of energy to consume based on the prices they pay for energy from petroleum, coal, natural gas, renewables, and other sources. This has led to a dependence on the fuel sources that produce the cheapest forms of energy for consumers. In electric power generation, coal dominates, while in transportation, petroleum dominates (Figure 1). Together, these two sectors account for 68 percent of energy consumption in the United States; industrial and residential use accounts for the rest.

Our chosen energy sources largely reflect the private or direct costs of energy consumption—the amounts paid at the pump or on our electricity bills. But the combustion of fossil fuels, primarily coal, natural gas, and petroleum, creates greenhouse gases, which contribute to global warming, and creates other pollutants, which cause health problems and shortened life spans. Dependence on oil also exposes the United States to macroeconomic risk from increases in oil prices, and undermines our energy security in ways that constrain our foreign policy. These external costs are not fully reflected in the price tag of different forms of energy, so consumers do not consider them as they make decisions about energy. This leads to overconsumption of fuels that appear cheap but that come with high external costs.

Natural gas has historically played a smaller role in electric power generation and transportation than coal and petroleum because its private or direct costs are higher. However, the recent technological advances in natural gas extraction have already begun to expand this role. Because natural gas has lower external costs than coal and petroleum, falling natural gas prices create the potential for better alignment between external costs and private energy choices, resulting in decisions that are better for society as a whole. We explore the increase in the supply of natural gas and petroleum due to fracking in the next section, and the potential for greater natural gas usage in both the electricity and transportation sectors in Section 3.

FIGURE 2.

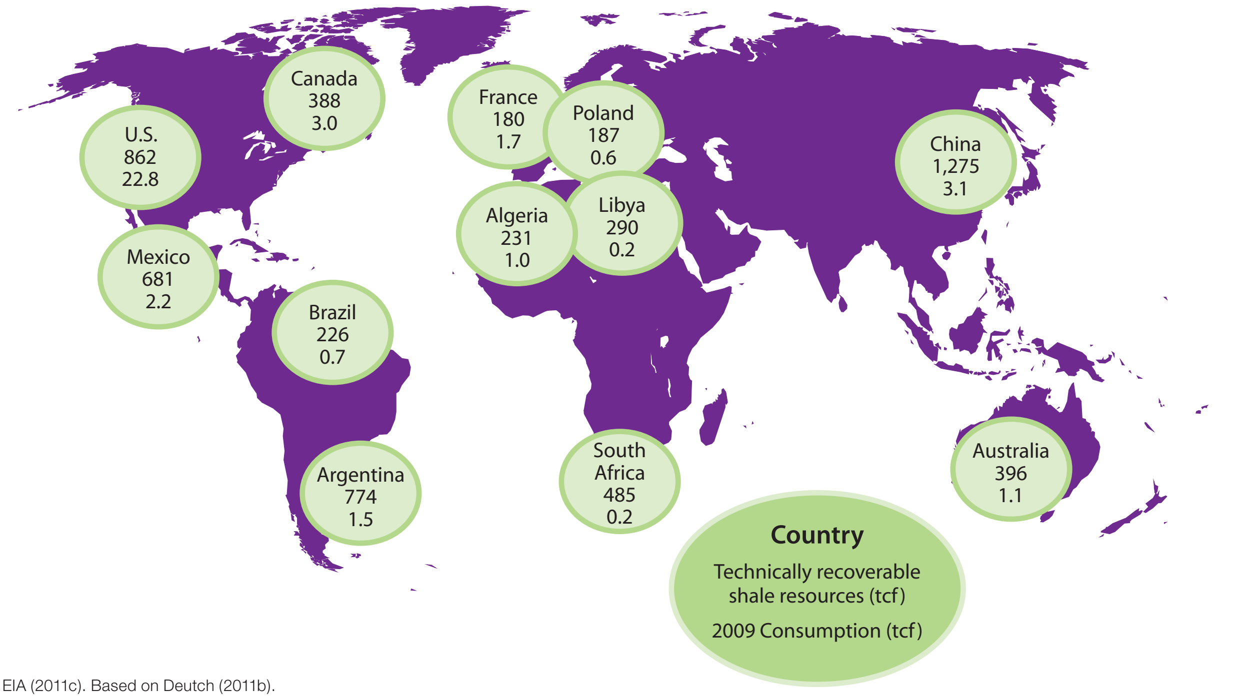
U.S. Primary Energy Production by Source: New technologies have led to dramatic increases in the supply of domestic natural gas.



Source: EIA (2011b, 2012a).

FIGURE 3.

Worldwide Recoverable Shale Resources and 2009 Consumption: The expansion in newly recoverable gas reserves is a global phenomenon.

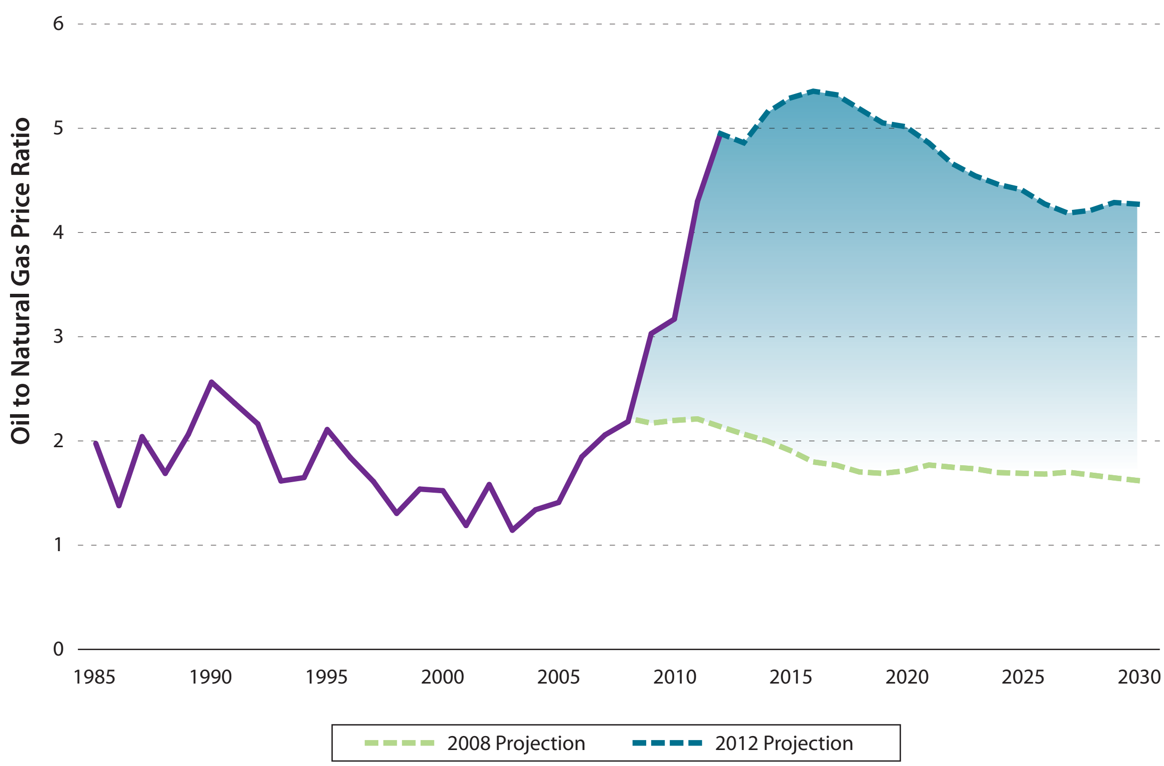


Source: EIA (2011c). Based on Deutch (2011b).

Note: Figures denote technically recoverable shale reserves and consumption of natural gas in trillions of cubic feet.

FIGURE 4.

U.S. Oil to Natural Gas Price Ratio: Natural gas prices have fallen and are projected to remain low.



Source: EIA (2008, 2012a).

Note: Figure plots the ratio of oil prices to natural gas prices on an energy-equivalent basis.

2. Increases in the Supply of Natural Gas and Petroleum

The most obvious result of evolving extraction technologies is increased natural gas production in the United States. Since 2007, horizontal drilling techniques and fracking have enabled access to shale gas reserves that were previously thought to be undevelopable. As a result, total U.S. natural gas production jumped from 18.5 trillion cubic feet in 2006 to 23 trillion cubic feet in 2011 (Energy Information Administration [EIA] 2012c). Virtually all of this increase comes from shale gas—indeed, shale gas production increased by nearly 50 percent between 2008 and 2009 alone. Figure 2 demonstrates how much the production of shale gas has grown in recent years and is projected to rise over the next decade.

This is a major change. Less than a decade ago, experts expected demand for natural gas in the United States to outstrip American production, and many companies contemplated building import terminals to increase our access to supplies from overseas. Now, the United States produces enough natural gas to sate its domestic needs, and several companies have filed applications to develop export facilities, with one such application recently approved. The magnitude of this sudden shift has altered the energy landscape.

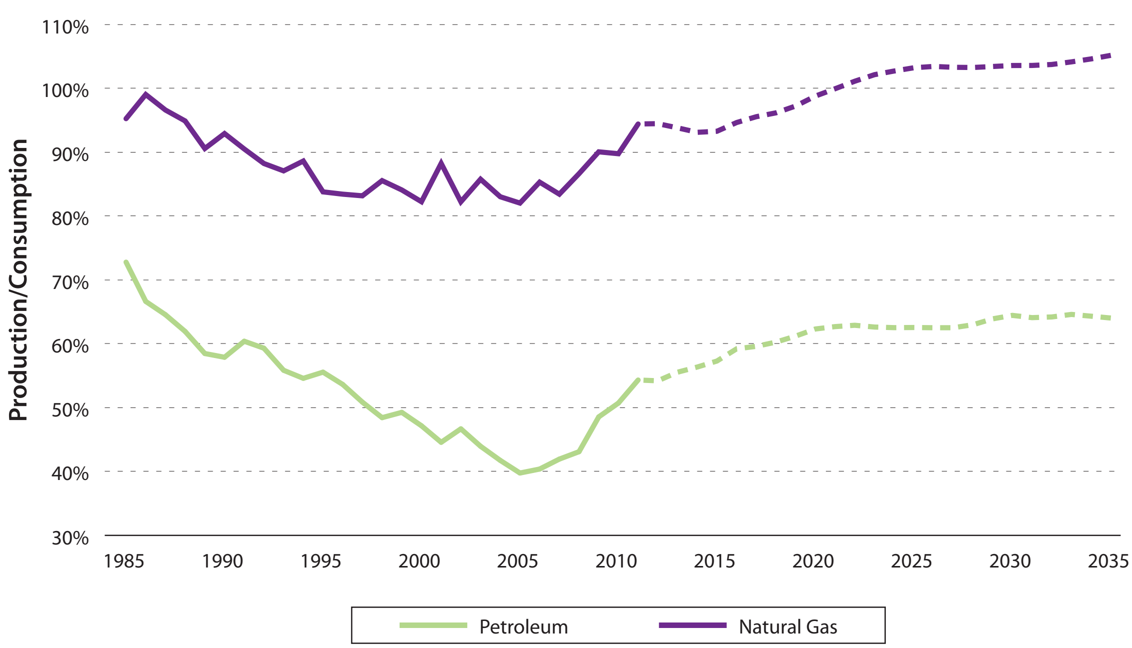
The increased ability to recover shale gas is not just an American phenomenon. Argentina, Australia, Brazil, Canada, China, Mexico, Poland, and South Africa, among other countries from an economically and geographically diverse list, also possess large newly recoverable reserves (Figure 3). We are only at the very beginning of realizing the worldwide potential of increased natural gas availability.

Increased production and expanded reserves have had a major impact on the relative price of natural gas compared to other energy options. Historically, oil has traded at roughly twice the price of natural gas, when comparing apples to apples, using an energy-equivalent basis. Until recently, analysts expected that this two-to-one price ratio would continue for decades into the future. But increased natural gas production has dramatically reduced its price, and today petroleum trades at roughly five times the price of natural gas. Figure 4 illustrates the historical price ratio (in purple), as well as the future prices that were expected in 2008 (in green) and in 2012 (in blue). The figure illustrates the dramatic jump in the relative price of oil over the past several years due to the fall in the price of natural gas. It is possible that future oil prices could decrease more than has been projected—driving the ratio down—but, generally, this price differential makes natural gas an even more appealing option for energy consumers than it once was.

Historical experience suggests that sustained shifts in relative prices like these provide strong incentives to redirect investments

FIGURE 5.

Ratio of Domestic Production to Consumption Projected through 2035: The United States is projected to produce more natural gas than it consumes by 2022.



Source: EIA (2012a, 2012c).

and to refocus innovation, and often lead to dramatic changes. For instance, these price changes suggest that natural gas will be used more intensively to generate electricity, and indeed this process has already begun. As we discuss below, there are opportunities for greater natural gas usage in transportation, and there is room for sound policy to facilitate this transition. But future changes precipitated by these recent changes in resources are difficult to foresee, and depend on innovations that will knock down many current conventions in the energy sector and lead to new opportunities and greater natural gas usage.

Finally, although the new technologies thus far have had the largest effects in natural gas markets, these new technologies have also expanded recoverable supplies of petroleum. Indeed, in the past few years domestic crude oil production has increased, reversing a decline that began more than twenty-five years ago. Increased petroleum production is anticipated by the EIA to continue alongside increases in natural gas. As a result of these trends, as seen in Figure 5, the United States is projected to produce more natural gas than it consumes within a decade. Further, the ratio of domestic production to consumption for petroleum will rise, which will improve our energy security.

3. What Do the Increased Supplies of Natural Gas Mean for the U.S. Energy Sector?

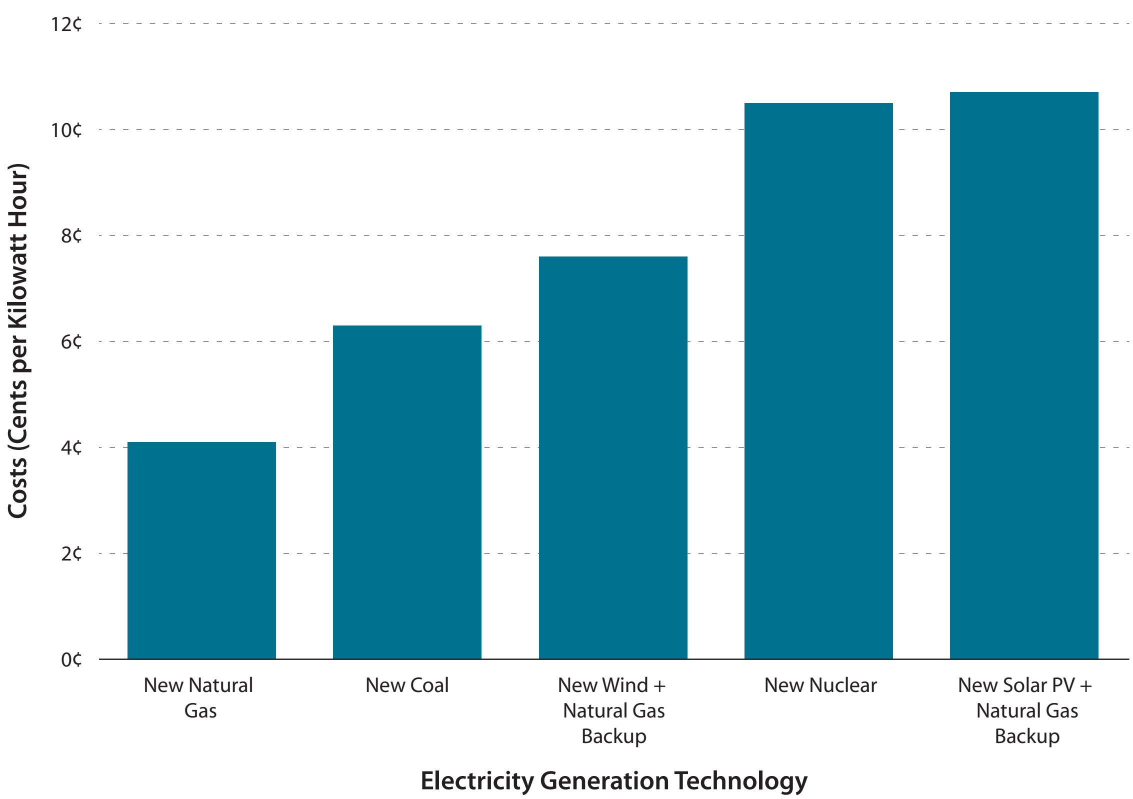
Domestically, the rapid drop in natural gas prices has opened opportunities for increased natural gas use in many sectors. Natural gas already plays a prominent role in heating homes and businesses, but recent trends have made it competitive in areas where other energy sources used to dominate, including electricity generation and transportation. In these areas, the availability of cheap and abundant natural gas creates both the incentives and the opportunities for greater natural gas use.

Electricity Generation

As discussed in Section 1, electric power generation in the United States is dominated by coal; natural gas plays a relatively small role in that sector. But this energy mix is a holdover from the investment and building decisions made many years ago based on past prices.

FIGURE 6.

Private Costs of Electricity Generation at Current Prices: New electric power generation from natural gas is cheaper than new generation from coal.

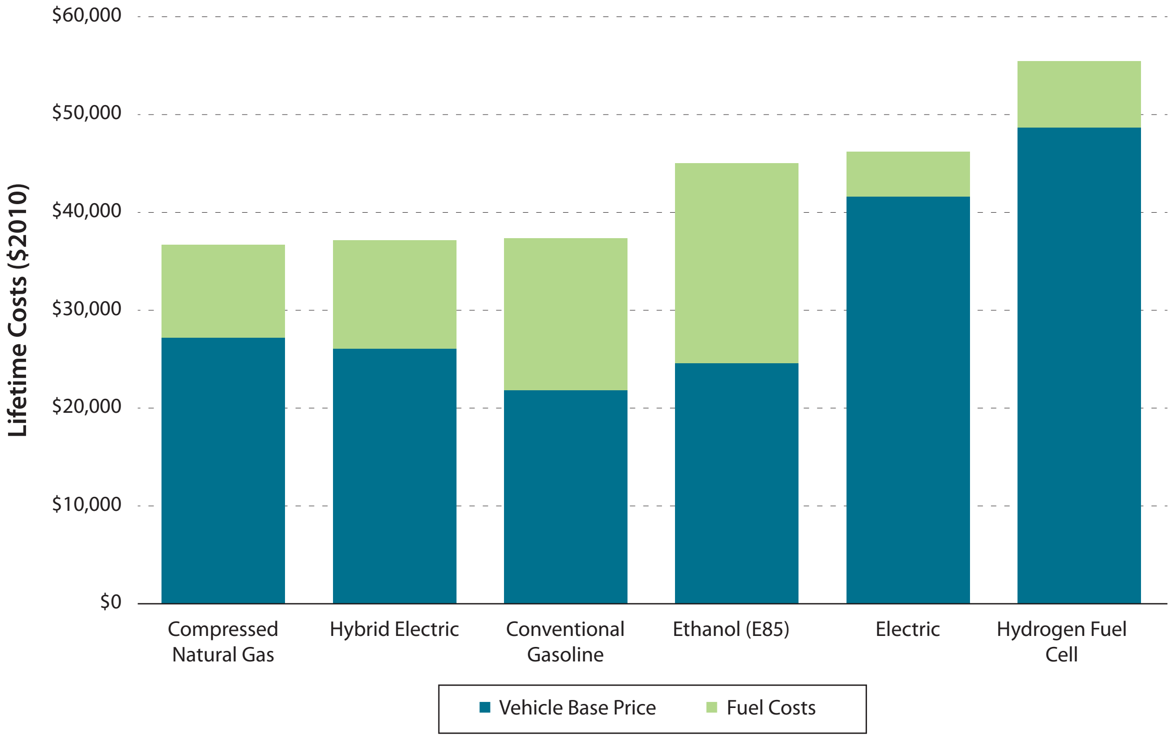


Source: See Greenstone and Looney (2011) for notes and source.

Note: Data are updated to reflect current prices. Private costs include "levelized" costs of building and operating a new power plant, as well as the cost of fuel, but exclude external costs such as those arising from damages to health, the local environment, or from climate change.

FIGURE 7.

Private Costs of Transportation Choices: Natural gas vehicles are cost competitive with conventional gasoline and other types of vehicles.



Source: Authors' calculations; DOE (2011, 2012a, 2012b); EIA (2012b); Jerram and Gartner (2012); Knittel (2012).

Note: Technical appendix available upon request. Fuel and vehicle costs are current prices. Private costs exclude taxes, licensing or financing costs, maintenance costs, transportation infrastructure costs, and costs associated with more frequent refueling. The analysis assumes vehicle lifetime of 150,000 miles over twelve years, and a discount rate of 4 percent for fuel purchases. Estimates do not reflect differences in driving ranges between refueling; many alternative-fuel vehicles have shorter driving ranges and therefore impose time costs from more frequent refueling.

Today, natural gas provides the cheapest option for those looking to build new electric power generation capacity, when measured by the private costs of building and operating a new power plant. Figure 6 shows the cost per kilowatt-hour (kWh) of electricity production for a variety of energy technologies, taking into account these private costs but excluding external costs such as those arising from damages to health and the local environment, or from climate change.

Electricity produced from a new natural gas plant costs only 4.1 cents per kWh to produce—about one-third less than a new coal plant's cost of 6.3 cents per kWh, which is the next-cheapest option. The typical household uses 12,216 kWh of electricity per year, so the potential savings for families from increasing the use of natural gas in the electricity sector are substantial. Furthermore, the relative cost advantage of natural gas compared to coal represents a reversal from 2007, when a new coal plant could provide electricity at a cost 9 percent lower than the cost of electricity produced at a new natural gas plant. The combination of low natural gas prices and relatively low natural gas use in electric power generation indicates that there is room for natural gas to play a larger role in power generation in the future.

Transportation

A similar pattern holds in the transportation sector, where natural gas represents less than 3 percent of consumption (EIA 2012a). As is the case with electric power generation, low natural gas prices in combination with high gasoline prices mean that, today, fuels from natural gas are cost competitive with petroleum-based fuels.

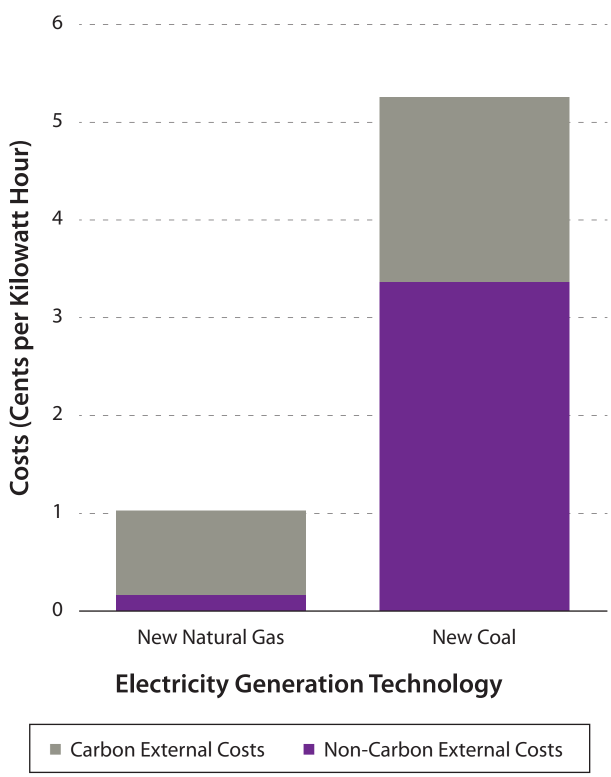
Figure 7 compares the lifetime private costs of purchasing and operating a conventional gasoline vehicle with the lifetime private costs of vehicles powered by alternative energy sources. Natural gas technology has recently become available for retail sales in cars like the Honda Civic GX. Electric vehicles, such as the Nissan Leaf, have also recently become widely available. Gas and electric hybrid technologies, such as the Toyota Prius, have been on the market for years, and are available across a broad range of vehicle types and manufacturers. Although

Honda and Mercedes currently have a hydrogen fuel cell car on the market, these cars can only be leased, and are only available in California.

The blue portions of the bars in Figure 7 represent the purchase costs, and the light green portions represent the costs associated with fueling and operating the vehicles over a 150,000-mile life span. As the figure illustrates, despite slightly higher purchase prices, vehicles operating on compressed natural gas (CNG) are now less expensive than traditional gasoline-powered vehicles and are comparable to hybrids. The vehicle base price for a mid-size hybrid, CNG automobile, and conventional automobile are roughly $27,000, $28,000, and $22,000, respectively (Jerram and Gartner 2012; Knittel 2012). This price differential appears to be entirely compensated for in fuel savings from cheaper natural gas. And all three of these technologies remain far more cost effective than using ethanol-based fuel, which is more expensive on a per-mile basis, and battery-powered cars and hydrogen cars, whose high costs arise from expensive technology.

FIGURE 8.

External Costs of Electricity Generation: Natural gas has fewer environmental costs than coal.



Source: NAS (2010).

Note: Non-carbon social costs include only damages associated with operating the plant, not upstream costs from mining, drilling, or construction.

Of course, one obvious impediment to realizing the benefits of low natural gas prices is the lack of natural gas fueling infrastructure. Currently, consumers are reluctant to purchase natural gas vehicles since fueling stations are not widely available, while companies are reluctant to invest in constructing stations since there is little consumer demand for natural gas-based fuel. Both sides must reach a critical mass before natural gas becomes a viable transportation option, creating a chicken-and-egg problem for increasing natural gas use in the transportation market.

In general, falling natural gas prices offer significant benefits to domestic consumers and companies that choose to shift away from oil and coal.

4. The Broader Benefits of Greater Natural Gas and Petroleum Production

As the previous section outlined, current prices suggest that there will be greater consumption of natural gas in the United States due to the cost savings available for consumers and businesses. (See Deutch 2011a and Deutch 2012 for insightful discussions of the broad changes in the United States and world that may emerge.) However, the private cost savings are only one part of the picture. To calculate the overall benefit of substituting natural gas for currently dominant energy sources, one must also factor in the unpriced environmental, macroeconomic, and foreign policy costs of petroleum and coal. In addition, the availability of these resources is increasing employment as we recover from the Great Recession, and can lead to higher standards of living over the long term.

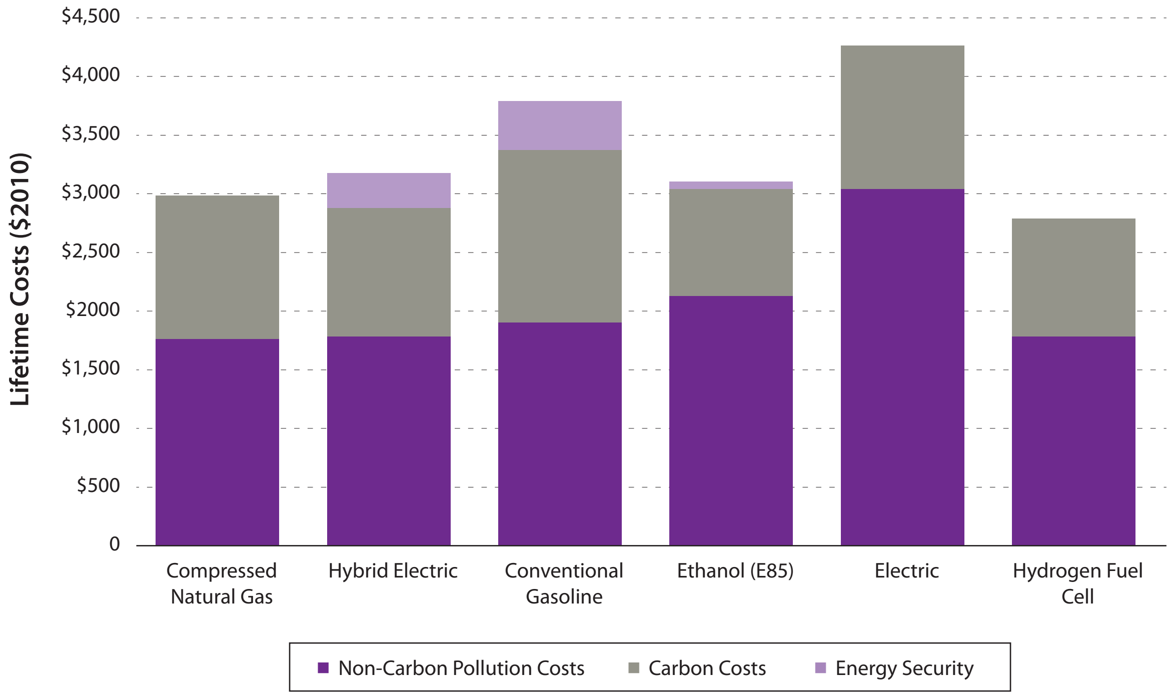
Environmental Benefits

Natural gas emits fewer greenhouse gases and other pollutants than coal and petroleum, making it a less environmentally damaging fuel. Natural gas, however, can only postpone the risks of climate change, rather than eliminate them, since its combustion still involves the substantial release of greenhouse gases. Indeed, many observers consider it a bridge fuel to a period when renewable energy sources are closer to being cost competitive. In terms of electricity generation, natural gas produces about half the carbon emissions of coal (Figure 8). Furthermore, burning coal creates other types of air pollution (e.g., particulate matter) that have significant effects on health and lead to shorter life spans. These non-carbon external costs total about 3.4 cents per kWh—more than half the comparable private cost. Natural gas, on the other hand, nearly eliminates these costs, reducing them by 95 percent relative to coal.

The discovery and accessibility of new supplies of natural gas make realization of these benefits both easier and more likely.

FIGURE 9.

External Costs of Transportation Use: CNG is more environmentally friendly than conventional gasoline.



Source: Authors' calculations; Argonne National Laboratory (2010, 2011); DOE (2012b); Interagency Working Group on Social Cost of Carbon, United States Government (2010); Michalek, Chester, Jaramillo, Samaras, Shiau, and Lave (2011); National Academy of Sciences (NAS 2010). Oil supply disruption estimate quoted in Michalek et al. (2011), based on Brown and Huntington (2010).
Note: Lifecycle cost analysis includes external costs associated with fuel extraction, fuel production, vehicle assembly, and vehicle operation. Vehicle emissions in 2015 for 2010 model years. The analysis assumes vehicle lifetime of 150,000 miles over twelve years, and a discount rate of 4 percent.

Indeed, newly available gas resources and declining prices for natural gas have already contributed to a shift away from coal in electrical generation. Between 2006 and 2011, the share of electricity generated from natural gas increased from 20 percent to 25 percent, while the share produced from coal fell from 49 percent to 42 percent (EIA 2011a).

The story in the transportation sector is similar. Natural gas produces fewer local pollutants and is less carbon intensive than gasoline, as illustrated in Figure 9. As a result, a CNG vehicle offers a 17 percent reduction in costs related to carbon dioxide (gray bars) and a 7 percent reduction in other pollution-related external costs (dark purple bars) over the vehicle lifetime relative to a conventional gasoline vehicle. The pollution costs in this "lifecycle assessment" include the known emissions associated with fuel extraction, fuel production, vehicle assembly, and vehicle operation. As shown in the figure, over a lifetime of driving a CNG vehicle instead of a conventional gasoline vehicle, local pollution and climate-related costs are reduced by the equivalent of $390 per vehicle. While the external costs from pollution are comparable to a hybrid vehicle, another benefit arises from the fact that the CNG vehicle does not rely on oil as its main fuel source. Substitution away from petroleum is likely to lead to better energy security implications for our economy as a whole. The energy security costs resulting from our reliance on petroleum are difficult to quantify. A literature review for a National Academies of Science article found estimates of the costs of oil supply disruptions to range between $0.00 and $0.28 per gallon, with a midpoint estimate of $0.09 from a 2010 study by Brown and Huntington (Michalek et al. 2011). These state-of-the art estimates for oil supply disruptions are represented by the light purple bars in the figure. In addition, there are costs associated with increased military spending that are not included in the chart because of difficulties obtaining precise estimates. Putting together the private costs described above, the environmental benefits of natural gas over other fuels, and the macroeconomic energy security benefits associated with diversified energy sources, CNG vehicles represent a lower-cost option for American consumers and the environment.

Despite the potential benefits of more widespread natural gas use in transportation, the lack of infrastructure and the fact that economic incentives do not reflect the true social costs of reliance on gasoline in the transportation sector impose barriers to greater use.

In a discussion paper for The Hamilton Project, "Leveling the Playing Field for Natural Gas in Transportation," Christopher R. Knittel (2012) of MIT addresses these challenges, offering a set of proposals for increasing use of natural gas in transportation. Knittel finds that the current government incentives that encourage the use of alternative fuels place natural gas at a disadvantage relative to other transportation technologies. The paper offers a set of policy recommendations aimed at placing natural gas on a level playing field with ethanol, petroleum, and electric vehicles, and also offers a set of recommendations aimed at addressing the lack of natural gas refueling infrastructure.

Macroeconomic Benefits

Our economy's historical dependence on oil for its energy needs has left it susceptible to damage from oil price shocks—sudden major shifts in the world price of oil. In fact, ten out of the last eleven economic recessions were preceded by oil price shocks (Hamilton 2009, 2011). And although there is a healthy academic debate, estimates suggest that the oil price shock in 2007–2008 reduced total U.S. annual GDP by nearly 4 percent (Hamilton 2011, Table 3). Our susceptibility to oil price shocks is largely independent of exactly how the United States participates in the oil market, such as whether the United States is a net importer or net exporter of oil. Rather, the potential negative consequences of our exposure to oil are largely based on the existence of a single world price for oil and our relatively small share of global reserves.

An important way to mitigate this risk is to diversify energy sources away from oil. Increasing the United States' reliance on natural gas in lieu of oil would reduce the susceptibility of the U.S. economy to oil price shocks in the future. Although U.S. oil intensity—the amount of oil the U.S. consumes per dollar of economic activity—has been declining by about 2 percent per year since 1980, our economy remains heavily dependent on oil (Sieminski 2010). In fact, the vast majority of our transportation sector is powered by oil. The current price discrepancy between oil and natural gas in the United States has created an opportunity that never existed before: an opportunity to diversify our energy reliance in a real way. Reducing dependence on petroleum-based energy sources in favor of domestically produced natural gas could have many benefits, including the development of a more diverse set of options for satisfying our energy demand, meaning reduced concern about potential oil price shocks in the future.

Energy Security Benefits

Because of the macroeconomic risks associated with the United States' current level of reliance on foreign petroleum sources, energy security has rightly been a critical focus for U.S. policymakers since at least the oil shocks of the 1970s. This raises geopolitical and national security issues that have contributed to the fact that, for more than fifty years, the United States has maintained a military presence in the Persian Gulf. Although it is difficult to disentangle energy security from other national security goals, the need to guard against the possibility of oil disruptions has added urgency to U.S. military action. For instance, according to Brent Scowcroft, the national security adviser under President Gerald Ford and President George H. W. Bush, "What gave enormous urgency to [the Persian Gulf War] was the issue of oil" (Scowcroft 1996).

As Cohen, Joutz, and Loungani (2011) point out, U.S. energy security is determined, in part, by the variety of our fuel types and our energy sources. Increased diversification away from oil and toward natural gas provides two energy security–related benefits: first, it reduces America's need for oil, which is produced in a concentrated group of countries. Second, it provides a more widespread array of sources because natural gas reserves are located in a broader and more stable group of countries (Cohen et al. 2011). What that means is that as gas and petroleum production expands in the Western world, the potential for disruptive events, like the oil embargoes of the 1970s or those triggered by conflicts in the Middle East, will be greatly reduced.

The geographic concentration of newly recoverable natural gas could also potentially shift the role that the United States plays in the international energy trade. As discussed in Section 2, Brazil, Poland, the United States, and certain other countries all possess large and newly exploitable shale gas resources (EIA 2011a). One implication is that the influence that currently oil- and gas-rich states like Russia command in world markets will wane. The expansion of energy supplies in the Americas—a phenomenon that includes Argentina, Brazil, Canada, and Mexico, as well as the United States—implies that the Americas will command greater importance as a center of free trade and economic influence. Finally, it is important to note that, while China has vast amounts of newly-discovered natural gas resources, its energy resources are unlikely to match its need for energy production, and thus China and other East Asian countries will find themselves in the unenviable situation of rising dependence on foreign sources of energy. These states should welcome supplies of gas from new suppliers.

Indeed, these changes in resources have already had an impact. For instance, in Japan, which has few domestic energy resources, natural gas is now more than three times as expensive as it is in the United States (Figure 10). Moving forward, this price discrepancy means that exporting U.S. natural gas to countries around the world is an attractive option for natural gas producers. The natural gas boom in the United States has created the opportunity for producers to export liquefied natural gas to Asian and European energy markets; some worry, however, that allowing exports of natural gas will expose U.S. consumers to higher and more volatile natural gas prices.

In a new discussion paper for The Hamilton Project, "A Strategy for U.S. Natural Gas Exports," Michael Levi (2012) of the Council on Foreign Relations analyzes the effects of different natural gas export policies, asking six essential questions about their macroeconomic, distributional, energy security, climate change, foreign policy, and other environmental consequences. He argues that restricting exports of natural gas would deprive the United States of gains from trade and undermine its position in trade talks. On the other hand, Levi finds that allowing exports of natural gas could unlock gains from trade that outweigh other negative economic consequences, provide the United States with leverage in trade talks, and have few of the negative effects that opponents of exports claim. Finally, he recommends that policymakers approve applications for exports and work to create a more transparent global market for natural gas.

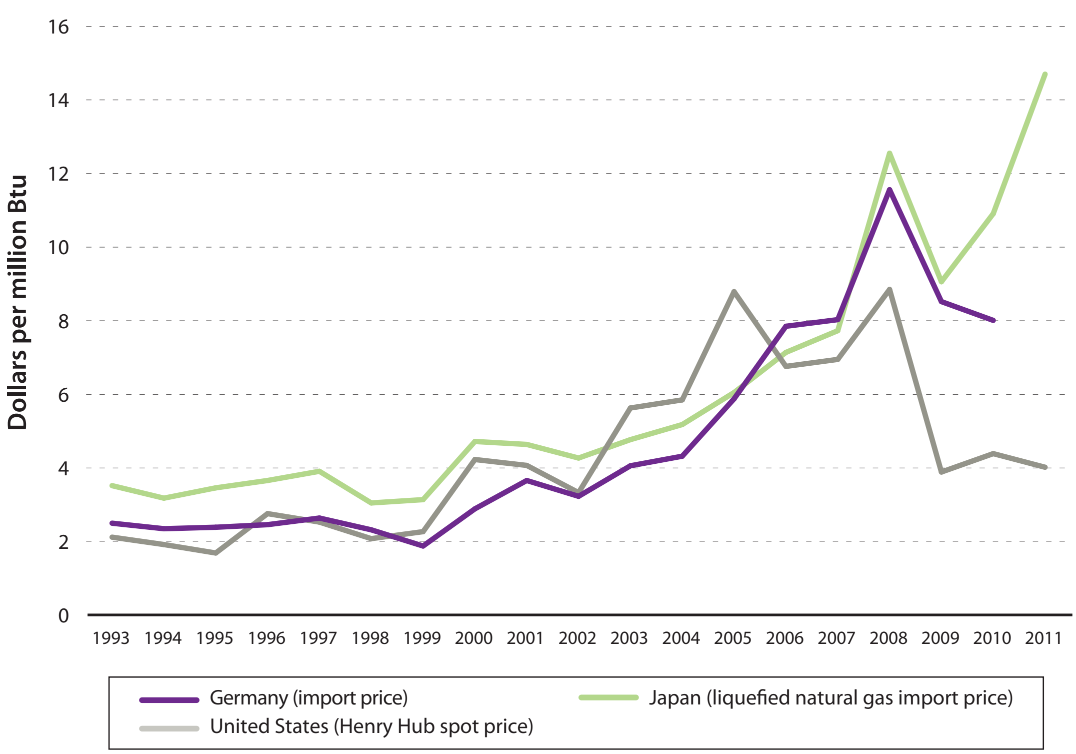
Near-Term Employment Benefits

At a time when our economy has been recovering from an economic recession, new developments in natural gas and oil extraction have led to a boom in employment in the oil and gas industries. Between 2007 and 2011, employment in oil and gas extraction increased by 28,000; employment increased by an additional 45,000 jobs in mining support activities. During this period of economic weakness, these jobs have boosted employment in a wide variety of other industries that likely add up to tens of thousands of additional jobs.

This employment growth has occurred predominately in states with shale gas reserves. In the twelve states that encompass nearly all proven shale reserves, employment in mining and logging has increased 15 percent since 2007, while declining in the rest of the country. States such as North Dakota, Pennsylvania, and West Virginia, which saw some of the largest increases in proven reserves, have also had some of the most remarkable employment growth. For instance, employment in mining more than tripled in North Dakota and increased 59 percent in Pennsylvania and 17 percent in

FIGURE 10.

Select Prices of Natural Gas, 1993–2011: U.S. natural gas prices have diverged from natural gas prices in Asia and Europe.



Source: BP (2011); EIA (2012d); World Bank (2012). Based on Levi (2012).

Note: German and Japanese prices are the sum of cost, insurance and freight (average).

West Virginia. Over time, as the rest of the economy recovers and we return to full employment, the economic benefits will manifest as higher wages and greater economic well-being for our nation as a whole (rather than higher employment levels).

5. The Potential Costs of Greater Natural Gas Production

Natural gas production, however, brings with it important environmental concerns, specifically related to fracking, and could potentially act to disincentivize the shift to renewable and nuclear energy. Recent changes in the relative prices of natural gas and other fossil fuels have put natural gas at an advantage in comparison to renewable and nuclear energies. Natural gas has always been cheaper than wind, solar, and nuclear power, but this gap has widened recently. For electric power generation, natural gas is now about half the price of wind power and about one-third the price of solar or nuclear (see Figure 6). It is important to note that while some view natural gas as a bridge to renewable energies, others worry that the availability of natural gas and its advantages over coal and petroleum will reduce investments in renewables; this would further push back the date when renewable technologies are cost competitive and extend dependence on greenhouse gas-emitting energy sources.

Although new technologies have made it possible to reach reserves of natural gas that were previously too expensive or difficult to access, these technologies have also raised concerns about environmental damage, particularly the contamination of water supplies. Because the type of fracking that has greatly increased these reserves is still a new technology, the extent of its environmental impacts is uncertain, and some risks may still be coming to light. The following is a summary of certain risks associated with fracking.

Groundwater contamination. During fracking, natural gas producers inject large quantities of water, sand, and chemicals at high pressure into their wells. Concerns about groundwater contamination arise because of the use of these fracturing fluids. The primary risk of contamination arises from faulty well construction, as well as surface spills and disposal issues. These risks can be mitigated by using proper safety and fluid management techniques, provided that the appropriate incentives or regulations are in place to encourage those efforts. The actual fracturing process takes place thousands of feet below where groundwater is present, and experts agree that these fluids are unlikely to penetrate the layers of rock between the shale and the groundwater (MIT 2011). Nevertheless, one Environmental Protection Agency (EPA) investigation near a drilling site in Wyoming found that groundwater might have been contaminated by fracking fluids. The generality of this finding is unclear, however, since the Wyoming wells are unusually shallow (EPA 2011). It is evident that more needs to be learned here about both the degree to which local water becomes contaminated and any resulting health consequences.

Local air pollution. Natural gas wells are associated with increased local road traffic, which increases local air pollution. Drilling can emit volatile organic compounds that contribute to ground-level ozone formation and air pollution. These pollutants were the target of recent EPA rules, which required producers to capture them before they escaped into the air (EPA 2012).

Water usage. Fracking uses large volumes of water, raising concerns about impacts on local water resources. The amounts used—on the order of 100,000 barrels for high-volume fracturing—have small overall impacts, but may place a strain on local resources, particularly in some parts of the country, without careful management (MIT 2011).

Methane leakages. Although natural gas generally emits less greenhouse gas than other fossil fuels when combusted, fugitive methane leakages raise other concerns about the global warming effects of natural gas production. Methane is a potent greenhouse gas, and any releases during recovery should be included in calculations of the climate change-associated effects of natural gas. Current estimates of the magnitude of the problem are highly uncertain, though, and producers, who are able to sell methane and who the EPA has encouraged to capture methane, have already taken steps to mitigate this problem (MIT 2011). This is another area where further research is necessary.

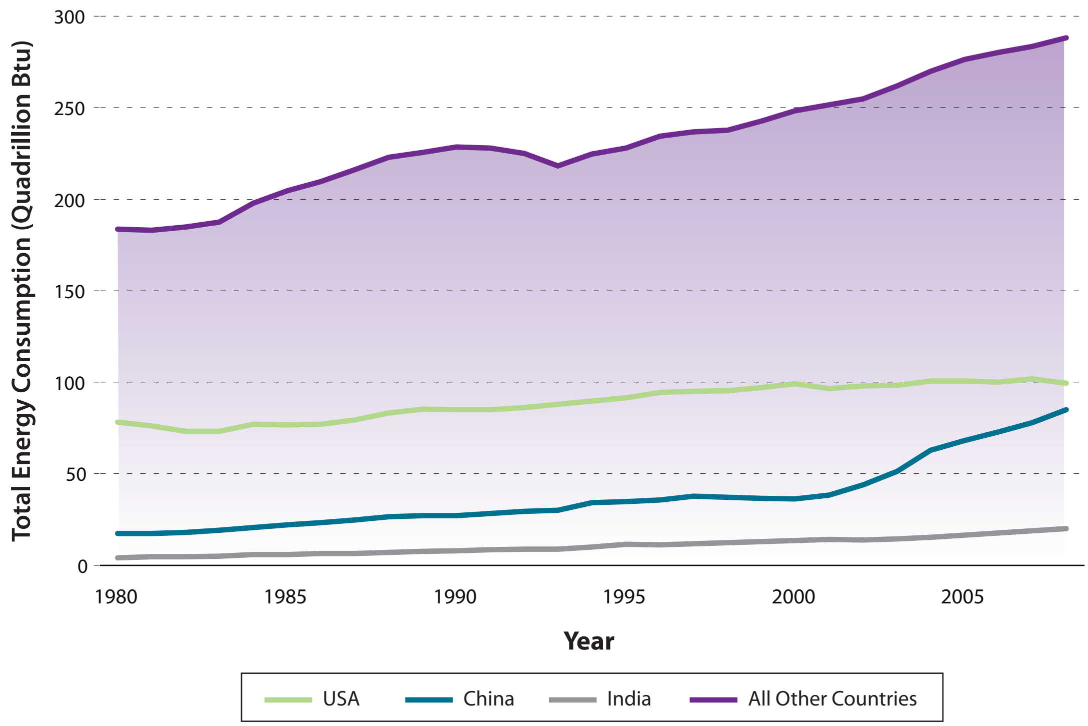
Seismic incidents. Other concerns have arisen about the potential of these drilling techniques to cause earthquakes, but the evidence remains inconclusive about both the relationship between fracking and seismic activity, and, if a such a causal relationship exists, the intensity of such seismic activity.

These environmental effects impose real costs, primarily on those living near drilling sites. As the fracking technology matures and new information comes to light, policymakers must adapt regulations and policies to protect the environment and local residents, and to ensure a proper balance between the costs and benefits of fracking. The environmental risks to local communities should be carefully considered by regulators and industry. The concern in Vermont, which recently became the first state to ban fracking, underlines the imperative for proper regulation both to protect people and to ensure that people feel safe near drilling sites.

Regulators have taken other steps to address these concerns. An August 2011 report by the Department of Energy (DOE) Subcommittee on Shale Gas Production examines many of these concerns and puts forward twenty recommendations to mitigate the effects of fracking on the environment. The report

FIGURE 11.

World Energy Consumption by Country: The United States consumes a disproportionately large amount of the world's energy, but growth in energy consumption will be driven by other countries, such as China and India.



Source: EIA (2009).

emphasizes the importance of giving industry a significant role in environmental management, with regulators requiring firms to demonstrate progress in reducing the impact of drilling (Deutch 2012; DOE, Secretary of Energy Advisory Board 2011).

Lucas Davis of the University of California, Berkeley, has put forward an economic approach to dealing with the environmental risks and uncertainty surrounding fracking in a new discussion paper for The Hamilton Project, "Modernizing Bonding Requirements for Natural Gas Producers" (2012). To reduce the potential environmental consequences of fracking, Davis would enhance and expand requirements for natural gas drilling companies to post bonds prior to drilling. In addition to providing funds for environmental cleanups, the bonds incentivize companies to take proper safety precautions when drilling to ensure that the bonds will be returned. At the end of the required time, the remainder of the bond would be returned to the company with interest.

Federal bonding requirements in use today were most recently updated in 1960, and many states have similarly out-of-date bonding requirements. Davis argues that bond amounts should be increased first to account for inflation. Second, in light of the considerable uncertainty around the potential damages from fracking, there appears to be a good case for raising bond amounts beyond simple inflation adjustment for fracked wells. As new information emerges about the potential damages of fracking, sound policy should adjust the minimum bond amounts for fracked wells in response.

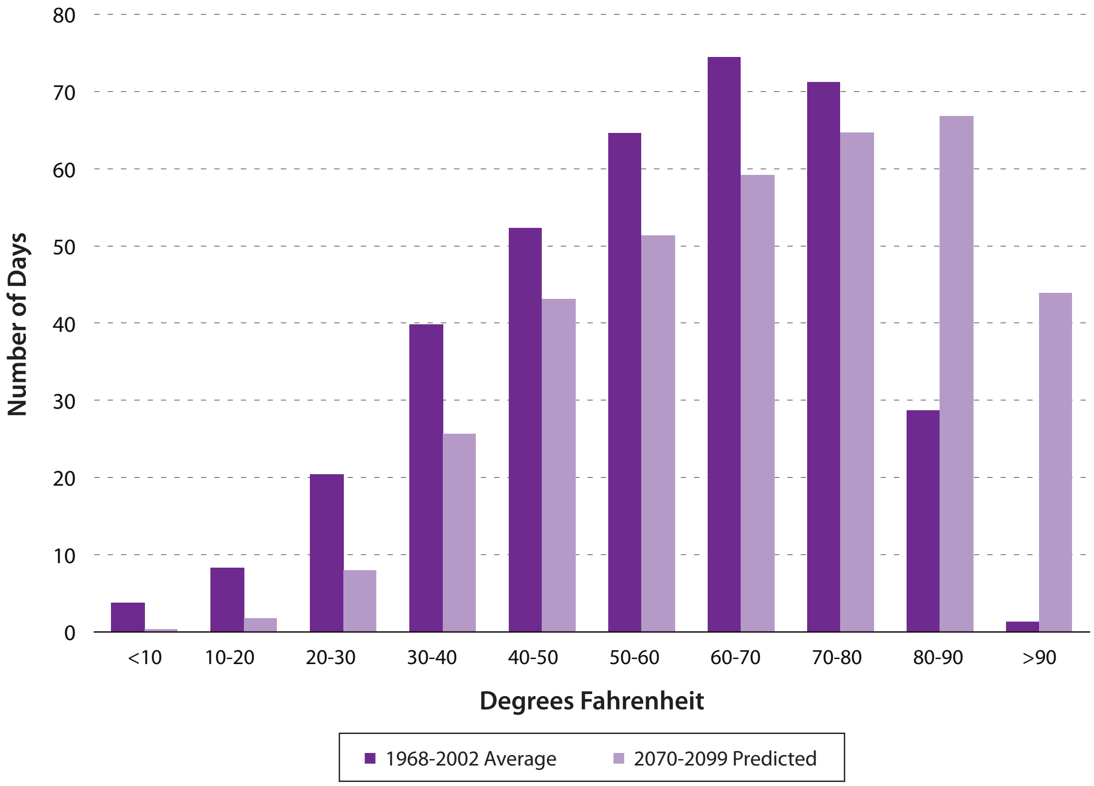
6. The Continuing Challenge for Energy Policy

The increase in the supply of natural gas and petroleum holds many opportunities for the United States. It is already reducing the costs of energy and is beginning to reduce the emissions of pollutants that cause climate change and harm our health, while improving U.S. energy security and resistance to macroeconomic shocks. U.S. energy policy should recognize and seek to realize these gains. If the local environmental problems can be managed through sound regulation, then the new drilling techniques will have reduced the magnitude of the challenges that we face in the energy sector.

Despite the opportunities, the scale of the energy and environmental challenges that we face remains enormous. Natural gas is a fossil fuel, and combustion of those fuels harms

FIGURE 12.

Current and Predicted End-of-Century Daily Temperatures: Global climate change is predicted to have dramatic effects on the weather in the United States.



Source: Deschenes and Greenstone (2007).

Note: Hadley 3-A1FI Predictions, Error-Corrected. Temperature represents the average of the daily high and low temperature.

local air quality and leads to climate change. Furthermore, the global market for petroleum and petroleum's continued vital role in our energy system mean that we still face macroeconomic shocks and compromised foreign policy.

There are many ways to illustrate our continued energy challenge, but Figures 11 and 12 present an especially clear picture. While the United States is the world's leading emitter of greenhouse gases, developing countries will provide most of future growth in emissions as standards of living rise and demand for energy increases (Figure 11). Until there are inexpensive ways to reduce greenhouse gas emissions, the world will continue to make energy choices that cause climate change.

Figure 12 illustrates the resulting effects on the American climate and weather. In the period 1968–2002, very hot days—days where the average of the daily high and low temperature was above 90 degrees Fahrenheit—were rare in the United States, occurring once a year on average. By the end of the twenty-first century, the United States is projected to experience more than forty of these days each year.

Although switching from coal and oil to natural gas has many benefits, it does not solve all of our energy and environmental problems. Energy policymakers therefore need to remain vigilant about the energy and environmental challenges that confront the United States and the world. For these reasons, we expand on the five policy principles mentioned above. The application of these principles would produce an energy system that improves our well-being.

1. ***Appropriately price the social cost of energy production and use.*** With the boom in shale gas, the market has momentarily put energy prices and social costs into closer alignment, creating the opportunity for low-cost reductions in environmental costs and increased energy security. But the playing field is still far from level—natural gas prices still do not reflect their total private and external costs, and renewable energy sources still operate at a disadvantage to dirtier fossil fuels. The Hamilton Project strategy paper,

"An Economic Strategy to Address Climate Change and Promote Energy Security" (Furman, Bordoff, Deshpande, and Noel 2007) argues that the best approach is to directly price these costs through cap-and-trade or tax policies. These policies would force consumers and companies to make decisions about energy use based on the full costs that society must pay for energy, thus incentivizing energy choices that are best for society as a whole.

2. ***Fund basic research, development, and demonstration of new energy technologies.*** The availability of natural gas may serve to decrease the public sense of urgency for research into renewable energies and to make renewable energy sources even less competitive, but it is essential for policymakers to continue to support research and development of future energy technologies. Natural gas can provide many medium-term benefits, but its combustion still contributes to climate change. Many believe that technological innovations will ultimately be the solution to finding cleaner low-cost energy sources—in other words, that we will innovate our way out of the energy and climate change debate. The problem with this argument is that there is little incentive for the private sector to undertake either basic research or technology demonstration projects that are critical for innovation because no single company can capture their benefits. This creates a vital role for government research to provide funding and support for the types of basic research that could help facilitate the creation of low-cost, clean energy sources to compete with oil, gas, and coal in the marketplace.

3. ***Make regulations more efficient.*** Fracking has refocused public attention on the potential environmental effects of our energy consumption and on how regulation can address these concerns. Proper regulation of new practices is essential to protect those who live near drilling sites, and to ensure that the costs and benefits of drilling are properly balanced. In general, the guiding principles for creating regulation remain the same. Rigorous cost-benefit analysis of regulatory rules can greatly enhance the effectiveness and reputation of our environmental regulatory system. This analysis should be done as the rules are created, but also should be institutionalized as part of ongoing retrospective review to ensure that regulations remain relevant and useful.

4. ***Address climate change on a global scale.*** To the extent that natural gas pushes out other fossil fuels that are more carbon intensive, such as coal and petroleum, the increase in natural gas can help slow the rate of climate change. As with research and development, international efforts to address climate change should remain a priority for policymakers. One element of this effort is simply making clean technologies affordable for developing countries. Negotiations are also part of the process, but are complicated. Smaller steps can be taken immediately to start us on a path toward a global solution. These can include measures such as building the capability to monitor total net emissions at the country level through satellite technology, which could be a building block for a trading system. This would provide evidence of carbon emissions by countries and eliminate issues surrounding the accuracy of reporting, which has been a stumbling block in international negotiations.

5. ***Capitalize on the economic opportunities arising from new domestic natural gas and oil discoveries, while protecting the environment.*** The expansion in recoverable gas and oil reserves presents many economic, environmental, and geopolitical opportunities for the United States. The potential benefits for oil and gas producers, consumers, manufacturers, and other businesses are significant—as are the larger benefits that could be reaped from environmental improvements and enhanced energy security. Full realization of these gains will require policies designed to promote widespread growth in employment, income, and resources, while ensuring environmental protection. In short, energy policy should facilitate domestic gas and oil production in settings where the benefits exceed a full accounting of the social costs.

Conclusion

Energy policy in the United States has long had a mix of goals, including keeping consumer costs low, minimizing environmental impacts, and promoting energy security. Few other recent developments have ushered in changes across such a variety of areas as has the increase in the supplies of natural gas and petroleum in the United States. Our increased ability to produce natural gas inexpensively has already altered the landscape of energy prices in the United States. But these increased supplies also have the ability to change the types of cars we drive, the effects our energy use has on the environment, and our trade and political relationships with the rest of the world. The opportunities for the United States to reap economic, environmental, and energy security benefits are there for the taking, provided we implement sound policies for developing those resources and using them appropriately. However, while positive, these developments have not eliminated the energy challenges facing the United States, and indeed the world, and the urgency of identifying sound energy and environmental policy remains.

References

Argonne National Laboratory. 2010. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Vehicle Cycle Model Version 2.7a. Transportation Technology R&D Center, U.S. Department of Energy, Argonne, IL.

Argonne National Laboratory. 2011. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Fuel Cycle Model Version 1 2011. Transportation Technology R&D Center, U.S. Department of Energy, Argonne, IL.

British Petroleum (BP). 2011. "Statistical Review of World Energy, June 2011." Retrieved from http://www.bp.com/statisticalreview.

Brown, Stephen, and Hillard Huntington. 2010. "Estimating U.S. Oil Security Premiums." Resources for the Future, Washington, DC.

Cohen, G., F. Joutz, and P. Loungani. 2011 "Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies." *Energy Policy* 39: 4860–4869.

Davis, Lucas. 2012 (June). "Modernizing Bonding Requirements for Natural Gas Producers." Discussion Paper 2012-02, The Hamilton Project, Washington, DC.

Department of Energy (DOE). 2011 (June). "2010 Fuel Cell Technologies Market Report." Accessed at http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/2010_market_report.pdf

Department of Energy (DOE), Secretary of Energy Advisory Board. 2011. "Shale Gas Production Subcommittee Second Ninety Day Report." Accessed at http://www.shalegas.energy.gov/resources/111811_final_report.pdf

Department of Energy (DOE). 2012a (January). "Clean Cities: Alternative Fuel Price Report. http://www.afdc.energy.gov/afdc/pdfs/afpr_jan_12.pdf

Department of Energy (DOE). 2012b. "Download Fuel Economy Data." http://www.fueleconomy.gov/feg/download.shtml

Deschenes, Olivier, and Michael Greenstone. 2007 (August). "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the U.S." MIT Joint Program on the Science and Policy of Global Change. Report No. 153, Massachusetts Institute of Technology, Cambridge, MA.

Deutch, John. 2011a. "The Good News About Gas." *Foreign Affairs*, 90 (January/February 2011).

Deutch, John. 2011b. "The Secretary of Energy Advisory Board Subcommittee on Shale Gas Production." Presentation, Massachusetts Institute of Technology Energy Initiative, Cambridge, MA, December 13.

Deutch, John. 2012 (January 18). "Grasping Opportunity: Why It Is Important and What Should Be Done." Presented at North American Energy Resource Summit, James A. Baker Institute for Public Policy, Rice University, Houston, TX.

Energy Information Administration (EIA). 2008 (June). "Annual Energy Outlook 2008 with Projections to 2030." DOE/EIA-0383(2008). Accessed at http://www.eia.gov/oiaf/aeo/pdf/0383(2008).pdf

Energy Information Administration (EIA). 2009 (November). "International Energy Statistics database (as of November 2009)." http://www.eia.gov/emeu/international

Energy Information Administration (EIA). 2011a (April). "Annual Energy Outlook 2011 with Projections 2035". Accessed at http://205.254.135.7/forecasts/aeo/pdf/0383(2011).pdf

Energy Information Administration (EIA). 2011b (October). "Total Energy." Annual Energy Review. Accessed at http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0102

Energy Information Administration. 2011c. "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States." Accessed at http://www.eia.gov/analysis/studies/worldshalegas/.

Energy Information Administration (EIA). 2012a (January). "AEO2012 Early Release Overview." DOE/EIA-0383ER (2012). Accessed at http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2012).pdf

Energy Information Administration (EIA). 2012b. "Electric Power Monthly." Accessed at http://205.254.135.7/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3

Energy Information Administration (EIA). 2012c (April). "Natural Gas Summary." http://205.254.135.7/dnav/ng/ng_sum_lsum_dcu_nus_m.htm.

Energy Information Administration (EIA). 2012d (April). "Natural Gas Prices." Accessed at http://205.254.135.7/dnav/ng/ng_pri_sum_dcu_nus_m.htm

Environmental Protection Agency (EPA). 2011. "Investigation of Ground Water Contamination near Pavillion, Wyoming." EPA 600/R-00/000. Accessed at http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf.

Environmental Protection Agency (EPA). 2012. "Overview of Final Amendments to Air Regulations for the Oil and Natural Gas Industry." Accessed at http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf.

Furman, Jason, Jason Bordoff, Manasi Deshpande, and Pascal Noel. 2007. "An Economic Strategy to Address Climate Change and Promote Energy Security." The Hamilton Project, Washington, DC. http://www.hamiltonproject.org/files/downloads_and_links/An_Economic_Strategy_to_Address_Climate_Change_and_Promote_Energy_Security.pdf

Greenstone, Michael, and Adam Looney. 2011. "A Strategy for America's Energy Future: Illuminating Energy's Full Costs." The Hamilton Project, Washington, DC. http://www.hamiltonproject.org/files/downloads_and_links/05_energy_greenstone_looney.pdf

Hamilton, James. 2009 (Spring). "Causes and Consequences of the Oil Shock of 2007–2008." Brookings Papers on Economic Activity, Washington, DC. http://www.brookings.edu/~/media/Files/Programs/ES/BPEA/2009_spring_bpea_papers/2009a_bpea_hamilton.pdf

Hamilton, James. 2011. "Historical Oil Shocks." Working Paper, University of California at San Diego, CA. http://dss.ucsd.edu/~jhamilto/oil_history.pdf.

Interagency Working Group on Social Cost of Carbon, United States Government. 2010 (February). "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." http://www.epa.gov/oms/climate/regulations/scc-tsd.pdf

Jerram, Lisa, and John Gartner. 2012. "Executive Summary: Total Cost of Ownership of Alternative Fuel Vehicles for Fleet Operators." Pike Research, Boulder, CO.

Knittel, Christopher. 2012 (June). "Leveling the Playing Field for Natural Gas in Transportation." Discussion Paper 2012-03, The Hamilton Project, Washington, DC.

Levi, Michael. 2012 (June). "A Strategy for U.S. Natural Gas Exports. Discussion Paper 2012-04, The Hamilton Project, Washington, DC.

Massachusetts Institute of Technology (MIT). 2011. "The Future of Natural Gas: An Interdisciplinary MIT Study." Accessed at http://web.mit.edu/mitei/research/studies/documents/natural-gas-2011/NaturalGas_Report.pdf

Michalek, Jeremy, Mikhail Chester, Paulina Jaramillo, Constantine Samaras, Ching-Shin Norman Shiau, and Lester Lave. 2011 (October). "Valuation of Plug-In Vehicle Life-Cycle air Emissions and Oil Displacement Benefits." Proceedings of the National Academy of Sciences of the United States of America, 108 (4): 16554–16558.

National Academy of Sciences (NAS). 2010. "Hidden Costs of Energy: Unpriced Consequences of Energy and Use." National Academies Press, Washington, DC.

Scowcroft, B. 1996 (January). "Oral History: Brent Scowcroft." Interview. PBS *Frontline*. http://www.pbs.org/wgbh/pages/frontline/gulf/oral/scowcroft/1.html.

Sieminski, A. 2010 (April). "Energy and the Economy." Deutsche Bank. US EIA & JHU SAIS 2010 Energy Conference. http://www.eia.doe.gov/conference/2010/session5/sieminski.pdf.

World Bank. 2012. "Commodity Price Forecast Update." Accessed at http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1304428586133/Price_Forecast.pdf

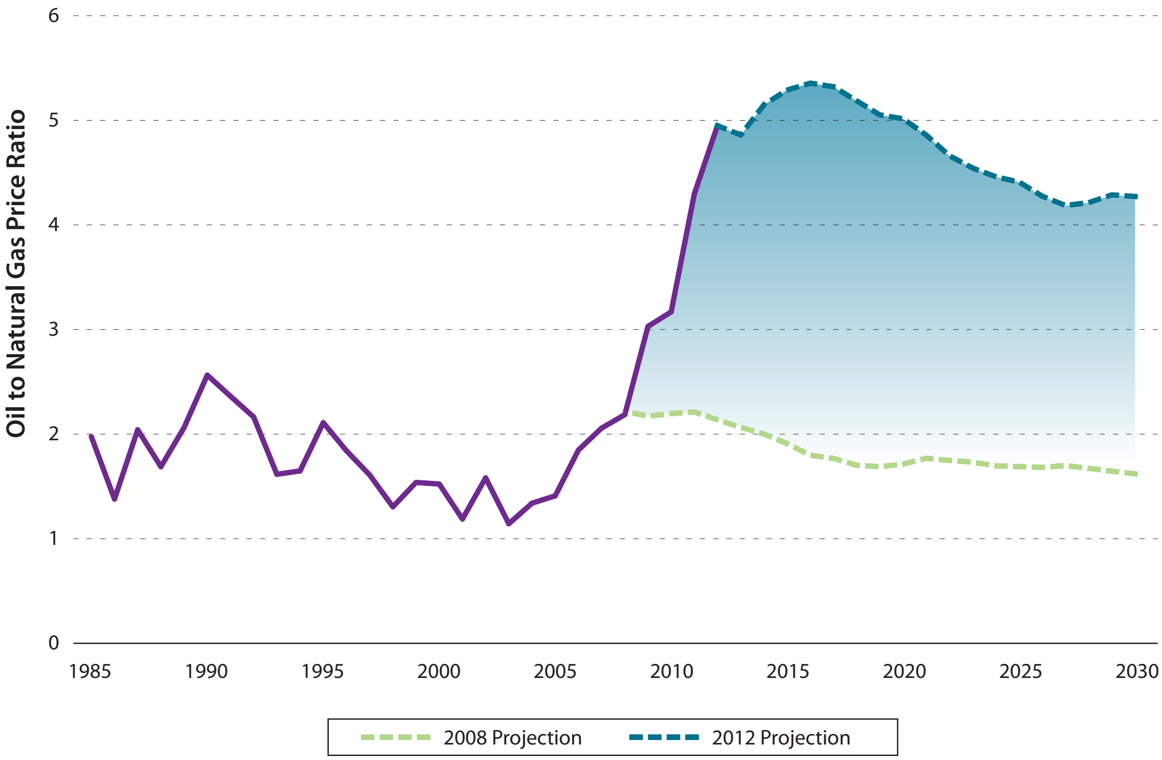
Acknowledgements

The authors thank Roger C. Altman, Karen Anderson, John Deutch, David Dreyer, Meeghan Prunty, and Robert E. Rubin for innumerable insightful comments and discussions. They are also grateful to Kristina Gerken and Kaitlyn Golden for help at many stages of producing this paper.

THE HAMILTON PROJECT

ADVISORY COUNCIL

U.S. Oil to Natural Gas Price Ratio: Natural Gas Prices Have Fallen and Are Projected to Remain Low.



The figure illustrates the historical price ratio of oil to natural gas on an energy-equivalent basis (in purple), as well as the future prices that were expected in 2008 (in green) and in 2012 (in blue). Historically, oil has traded at roughly twice the price of natural gas, when comparing apples to apples, using an energy-equivalent basis. Until recently, analysts expected that this two-to-one price ratio would continue for decades into the future. But increased natural gas production has dramatically reduced its price, and today petroleum trades at roughly five times the price of natural gas. It is possible that future oil prices could decrease more than has been projected—driving the ratio down—but, generally, this price differential makes natural gas an even more appealing option for energy consumers than it once was.

THE HAMILTON PROJECT

1775 Massachusetts Ave., NW
Washington, DC 20036

(202) 797-6279

BROOKINGS