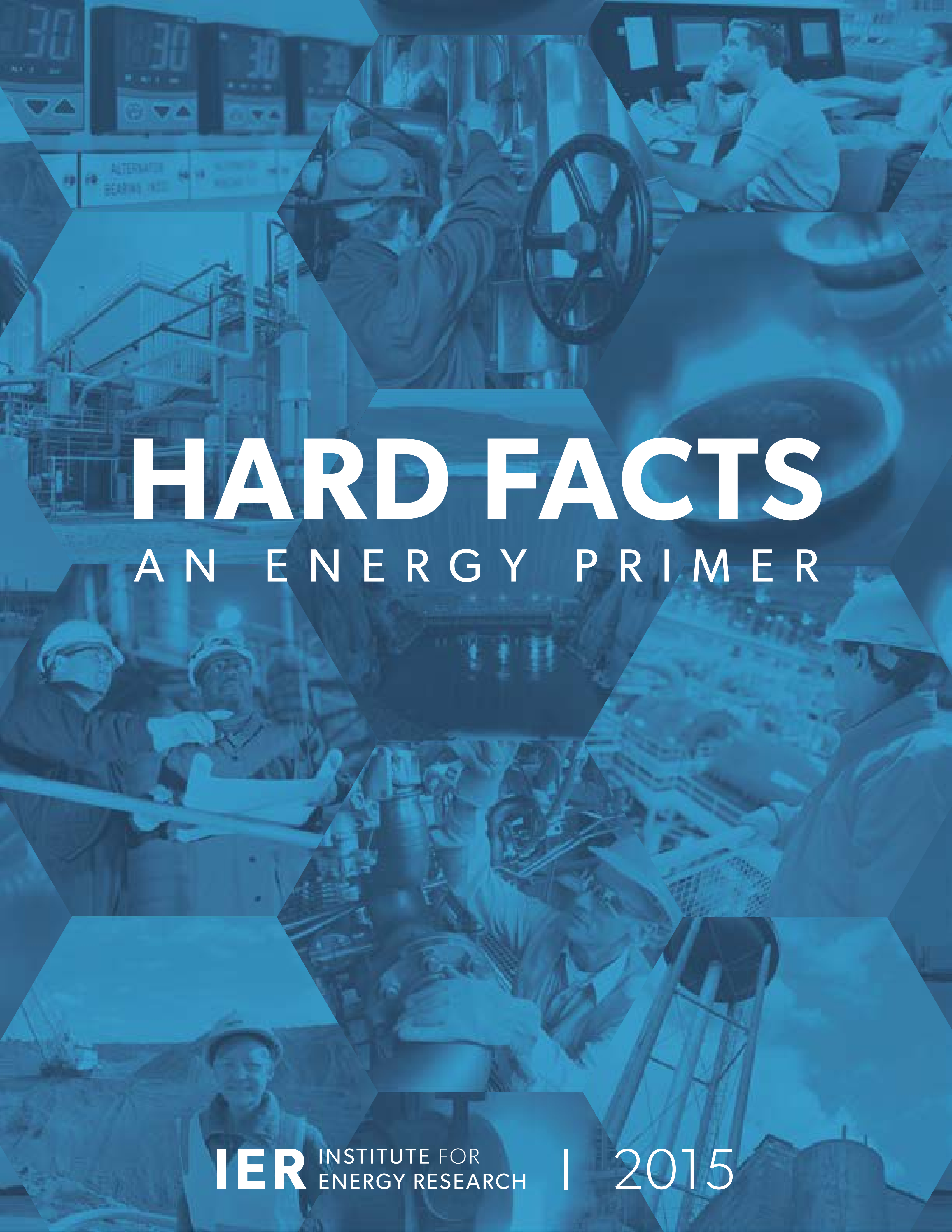


# HARD FACTS

## AN ENERGY PRIMER

IER INSTITUTE FOR ENERGY RESEARCH | 2015

# TABLE OF CONTENTS

# AFFORDABLE, RELIABLE ENERGY IS ESSENTIAL TO THE ECONOMY

Affordable, reliable energy is essential to the economy because energy powers everything that makes modern life possible. It is literally, the capacity to do work. It heats our homes, lights the night, fuels our transportation, and powers our machines. Put simply, energy makes our lives better.

Affordable energy allows the economy to become more efficient, lowers the cost of goods, and saves us money. More importantly, affordable energy allows us to spend more time with our families and friends and spend less time merely working to survive. Moreover, by making transportation less costly, affordable energy gives us greater freedom to live, work, and play how and where we want.  In this way, energy enables more freedom.

Affordable and abundant energy is a crucial component of a strong economy. Low domestic energy prices help keep jobs at home by lowering the cost of producing goods and services in the United States.  This increases our competitive advantage.

There are, however, a number of challenges to maintaining a sufficient supply of affordable energy. Seemingly every year, there is a new energy bill in Congress that alleges to fix our energy problems. These cries for new energy policies or plans often have a common component  the premises of these bills are often fatally flawed, and they are based on inaccurate information about our actual energy situation.

Energy discussions would be greatly improved if policymakers took into account the actual energy landscape. Far too often, energy bills are based on incorrect assumptions, such as the notion that new, revolutionary technologies, such as affordable cellulosic ethanol, are just around the corner if only the federal government provides the energy industry sufficient mandates and subsidies. Time after time, experience has shown that the government cannot force new technologies to market.

Meanwhile, market forces absent government intervention often provide real progress in finding solutions to energy problems more quickly than Washington-driven, red-tape riddled legislation.  One need only look at the massive and rapid change in the energy landscape, at home and abroad, made possible by private investment in combining horizontal drilling and hydraulic fracturing to enable shale oil and gas to be made available to consumers. This “smart drilling” has revolutionized energy production and lowered prices for consumers that repeated legislative efforts have failed to do.

Policymakers should take time to understand the facts about energy and the obstacles to making it affordable and reliable given its critical role in our lives, our economy and our future. America is home to vast natural resources, but many of our energy policies are built on the notion that energy is scarce and becoming more scarce. The reality is that we have more combined oil, coal, and natural gas resources than any other country on the planet. We have enough energy resources to provide reliable and affordable energy for decades, even centuries to come. The only real question is whether we will have ready access to our abundant energy resources and whether government policies will allow us to put it to good use, not whether sufficient resources exist.

# BASIC ENERGY FACTS

## Fossil Fuel Facts

In 2013, the United States produced 25.7 trillion cubic feet of natural gas,[1] making it the world's largest natural gas producer.[2]

In 2013, the United States produced 7.5 million barrels of oil per day , 1 million barrels more a day[3] than in 2012, making it the world's third largest oil producer. With 10 months of data reported for 2014, U.S. oil production in 2014 is averaging 8.5 million barrels per day, another gain of 1 million barrels per day. The United States is projected to soon overtake Saudi Arabia and Russia as the world's leading oil producer. The United States already leads the world in terms of total petroleum supply, which includes oil production, natural gas plant liquids, biofuels, and refinery processing gain.

- Proved conventional oil reserves worldwide more than doubled from 642 billion barrels in 1980 to more than 1.646 trillion barrels in 2013. Proved oil reserves in the United States increased to 36.5 billion barrels at the end of 2013, the fifth consecutive increase.[4]
- The United States is home to the richest oil shale deposits in the world—estimates are about 1 trillion barrels of technically recoverable oil in U.S. oil shale deposits-- nearly four times that of Saudi Arabia's proved oil reserves.[5]
- The United States has 2591 billion tons of coal in its proved coal reserves. They are the world's largest coal reserves, totaling over 26 percent of the world's proved coal reserves.[6]
- In 2013, the United States produced 984 million short tons of coal, making it the world's second largest coal producer.[7] In 2012, China produced over 4,026 million short tons and is the world's largest coal producer.
- The United States has 481 billion tons of coal in its demonstrated reserve base, enough domestic coal to use for over 500 years at current rates of consumption. These estimates do not include Alaska's coal resources, which, according to government estimates are larger than those in the lower 48 states.[8]
- Due to hydraulic fracturing and horizontal drilling technology, our production of domestic oil and

natural gas has increased, decreasing our need for imports. In fact, net energy imports (energy imports of all fuels minus energy exports of all fuels) into the United States have declined by 58 percent between its high in 2005 and 2013.[9]

- Out of the roughly 700 million acres of federal lands onshore[10], only 34,592,450acres are leased by the federal government for oil and natural gas production[11] —less than 5 percent. Out of the roughly 1.7 billion acres offshore, only 32,740,599 acres are leased for oil and natural gas production—about 1.9 percent.[12]
- The world could hold more than 700 quadrillion (700,000 trillion) cubic feet of methane hydrates (a frozen form of clean natural gas) —more energy than all other fossil fuels combined.[13]

## Renewables and Nuclear

- In 2013, wind power produced 1.6 percent of the energy used in the United States and 4.1 percent of the electricity produced in the United States.[14]
- In 2013, solar power produced 0.3 percent of the energy used in the United States.[15]
- Total federal subsidies in fiscal year 2007 were $24.34 per megawatt hour for solar-generated electricity and $23.37 per megawatt hour for wind, compared with $1.59 for nuclear, $0.67 for hydroelectric power, $0.44 for conventional coal, and $0.25 for natural gas and petroleum liquids.[16] In fiscal year 2010, the subsidies were even higher. For solar power, they were $775.64 per megawatt hour, for wind $56.29, for nuclear $3.14, for hydroelectric power $0.82, for coal $0.64 and for natural gas and petroleum liquids $0.64.[17]
- In 2013, hydroelectric power contributed 2.6 percent of the energy used in the United States and 6.6 percent of the electricity produced in the United States (more than wind and solar combined).[18]
- Today, there are 100 nuclear reactors in the United States.[19] In 2013, nuclear power produced 19 percent of electricity in the United States.[20]

## Energy Efficiency and Environmental Indicators

- Between 1970 and 2013, the six so-called “criteria pollutants” have declined by 68 percent, even though the generation of electricity from coal-fired plants has increased by over 125 percent, gross domestic product has increased by 234 percent, energy consumption has increased by 44 percent, and vehicle miles traveled have increased by 168 percent.[21]
- While population grew by 54%, energy use per person in the United States fell 14 percent between 1979 and 2013 from 359 million BTUs to 309 million BTUs per person.[22]
- Energy intensity—energy consumption per dollar of GDP—fell by 57 percent between 1970 and 2013.[23]
- In 2012, China was responsible for 26 percent of global carbon dioxide (CO2) emissions. In comparison, the United States, the second largest emitter of carbon dioxide, emitted 16 percent of the global total.
- China’s CO2 emissions increased by 191 percent between 1999 and 2012, while CO2 emissions from the United States decreased by 7.2 percent over the same period. [24]

[1]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec4_3.pdf .

[2]BP, Statistical Review of Energy 2014, p. 22, https://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf .

[3]Energy Information Administration, Monthly Energy Review, Table 3.1, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf and International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1.

[4]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1980&eyid=2014&unit=BB and U.S. Crude Oil and Natural Gas Proved Reserves, December 4, 2014, http://www.eia.gov/naturalgas/crudeoilreserves/

[5]Task Force on Strategic Unconventional Fuels, Development of America's Strategic Unconventional Fuels Resources—Initial Report to the President and the Congress of the United States (Sept. 2006), p. 5, http://instituteforenergyresearch.org/wp-content/uploads/2014/12/sec369h_report_epact1.pdf ; US Geological Survey, Oil Shale and

[6]Nahcolite Resources of the Piceance Basin, Colorado p. 1, Oct. 2010, http://pubs.usgs.gov/dds/dds-069/dds-069-y/ . The Task Force on Strategic Unconventional Fuels estimated that U.S. oil shale resources were 2.1 trillion barrels. In 2010, the USGS estimated that in-place resources in the Piceance Basin were 50 percent larger than previously estimated (1.5 trillion barrels versus 1.0 trillion barrels). The addition of these 0.5 trillion barrels makes U.S. in-place oil shale resources a total of 2.6 trillion barrels. Previous estimates put the total economically recoverable oil shale resources at 800 billion barrels. Assuming the same rate of recovery for these additional 0.5 trillion barrels brings the total recoverable resources to 982 billion barrels of oil resources.

[7]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=6

[8]Energy Information Administration, International Energy Statistics-Coal-Production, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=1&pid=7&aid=1&cid=regions&syid=2000&eyid=2012&unit=TST and Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_3.pdf .

[9]Energy Information Administration, U.S. Coal Reserves, December 16, 2013, http://www.eia.gov/coal/reserves/ and U.S. Geological Survey, Alaska Coal Geology, Resources, and Coalbed Methane Potential, Nov. 2005, http://pubs.usgs.gov/dds/dds-077/.

[10]Energy Information Administration, Monthly Energy Review, November 2014, Table 1.1, Primary Energy Overview, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_3.pdf

[11]Congressional Research Service, Federal Land Ownership: Overview and Data, February 8, 2012, http://www.fas.org/sgp/crs/misc/R42346.pdf

[12]Bureau of Land Management, Oil & Gas Statistics, http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/statistics.html h

[13]Bureau of Ocean Management, Combined Leasing Report, November 3, 2014, http://www.boem.gov/Combined-Leasing-Report-November-2014/ and Institute for Energy Research, Outer Continental Shelf Statistics, http://instituteforenergyresearch.org/analysis/outer-continental-shelf-ocs-statistics/ .

[14]U.S. Geological Survey, Natural Gas Hydrates-Vast Resource, Uncertain Future, http://pubs.usgs.gov/fs/fs021-01/fs021-01.pdf and Department of Interior, Gas Hydrates on Alaska's North Slope Hold One of Nation's Largest Deposits of Technically Recoverable Natural Gas , Nov.12, 2008, http://www.doi.gov/news/archive/08_News_Releases/111208.html .

[16]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf and http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf

[17]Id.

[18]Energy Information Administration, Federal Financial Interventions and Subsidies in Energy Markets 2007- Chapter 5: Electricity Subsidies Per Unit of Production (April 2008), p. 106, http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/chap5.pdf . See also Institute for Energy Research, Subsidizing American Energy: A Breakdown By Source, July 30, 2008, http://www.instituteforenergyresearch.org/2008/07/30/energy-subsidies-study/ .

[19]Energy Information Administration, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010, July 2011,

http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf and http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/

[20]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf and http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf

[21]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec8_3.pdf and Matthew L. Wald, Nuclear 'Renaissance' Is Short on Largess, NEW YORK TIMES, Dec. 7, 2010, http://green.blogs.nytimes.com/2010/12/07/nuclear-renaissance-is-short-on-largess/ .

[22]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

[23]Environmental Protection Agency, Air Quality Trends, http://www.epa.gov/airtrends/images/y70_13.png and Energy Information Administration, Monthly Energy Review, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .

[24]Energy Information Administration, Annual Energy Review p. 13, Table 1.5, http://www.eia.gov/totalenergy/data/annual/pdf/sec1_13.pdf and Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_16.pdf and U.S. Census Bureau, http://quickfacts.census.gov/qfd/states/00000.html

# A BRIEF HISTORY OF ENERGY USE IN THE UNITED STATES

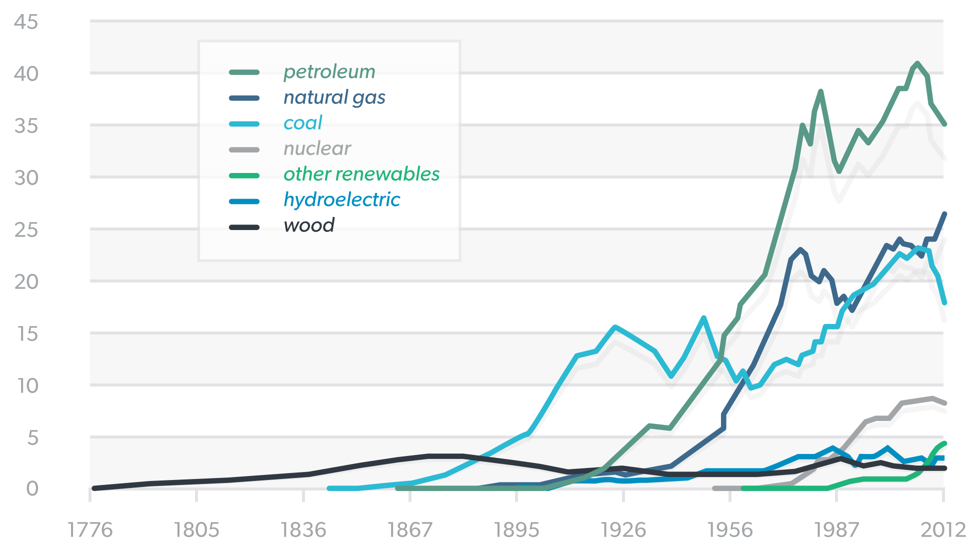
We use energy because it makes our lives better. Our prehistoric ancestors used fire for cooking, light, and warmth. During colonial times, people used renewable energy almost exclusively, harnessing energy from animal labor, watermills, windmills, and wood. In fact, wood energy was the dominant source of energy in the United States until the late 1800s when energy from coal entered the picture.[25]

Energy from wood, wind, and water power started the Industrial Revolution, but by 1885, coal took over as the dominant fuel. The energy demands of the late Industrial Revolution were prodigious—America's energy use quadrupled between 1880 and 1918, fueled largely by coal.[26]

Among its many uses, coal fueled blast furnaces, generated steam in steam engines, heated homes, and (after being turned into gas) illuminated streets and homes. By the end of World War I, coal produced 75 percent of the energy used in the United States.[27]

History of energy consumption in the United States (1776-2012)

*Quadrillion Btu*




Source: http://www.eia.gov/todayinenergy/detail.cfm?id=11951

With the advent of the automobile, coal use began to decline as America's dominant source of energy. Petroleum was first used for lighting and as an ingredient in medicines, but as automobile use greatly increased, petroleum use grew along with it. By 1950, petroleum surpassed coal and became the largest source of energy in the United States.

As petroleum use grew, so too grew the use of natural gas. As with petroleum, the first major use of natural gas was for lighting. But when electricity became a safer source of illumination than coal-gas, petroleum, or natural gas, the natural gas industry was forced to look for other markets. As a result, natural gas started to be used for household heating, industrial heating, cooking, and making electricity. In the late 1950s, natural gas use surpassed coal use.[28] Coal use continues to remain strong, however, because it is currently the dominant fuel source for electricity production. However, coal is experiencing a declining share of the electric generation market due to policies and regulations instituted by the Obama administration that are more favorable to natural gas and renewable energy.

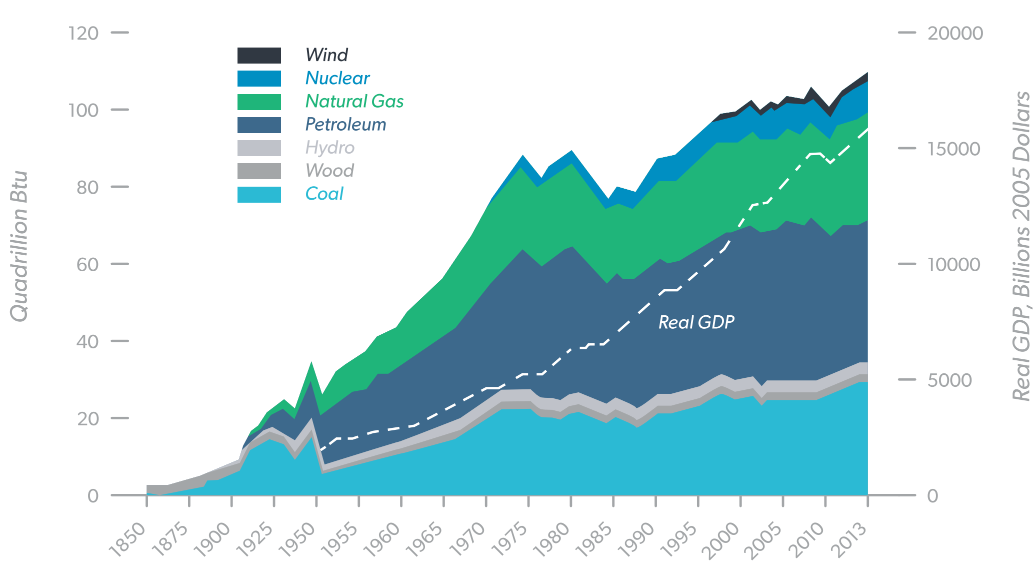
America has a long history of harnessing power from water. In Colonial America, water was used to power mills that ground grain, wove fabric, and made paper. In the late 1800s, water was used as one of the first important sources of electricity production, and hydroelectric power was born.[29]

Nuclear electric power is the newest source of electricity generation and was first produced in 1957. The amount of nuclear electric power has grown steadily over time, but the rate of growth has leveled off in recent years. Today there are 100 nuclear reactors in the United States, and ground was broken for all of them before 1974.[30] The recent growth in nuclear electric power capacity is the result of capacity upgrades at existing nuclear plants, although advanced nuclear reactors are currently under construction in South Carolina and Georgia.

Since 1950, Americans have consumed energy from a wide variety of sources. The following chart shows how the pattern of U.S. energy consumption has changed over the past 60 years: [31]

In the past few decades, there has been a strong political push to return to renewable energy. Solar and wind power have proved to be expensive sources of energy and so far have not lived up to the economic promises of their proponents. Since at least the 1980s, wind and solar advocates have claimed that these technologies would be affordable in just a few years if they continued to receive subsidies.[32] Despite decades of subsidies and special treatment, wind and solar continue to be far more expensive than other sources of energy.[33] Even with these subsidies and mandates, wind and solar still provide very little of our energy needs. In 2013, for example, wind and solar combined to produce just

U.S. Energy Consumption by Source vs. Real GDP




Source: http://www.eia.gov/todayinenergy/detail.cfm?id=11951

1.9 percent of the energy used in the United States.

The American taxpayer does not get much of a bang for his/her buck with renewable energy subsidies. According to a study by the Congressional Research Service, in 2009, renewable energy subsidies were 49 times greater than fossil fuel subsidies when comparing the amount of energy produced per dollar of subsidy.[34] In that same year, renewables received a 77 percent share of total federal energy incentives, while fossil fuels received a 13 percent share but produced more than 7 times the energy. This is not to say that oil, coal, or natural gas should receive subsidies, but they do produce much more energy per dollar of subsidy received.

## **FOOTNOTES:** A BRIEF HISTORY OF ENERGY USE IN THE UNITED STATES

[25]*Energy Information Administration, United States Energy History, Aug. 19, 2010, http://www.eia.gov/todayinenergy/detail.cfm?id=10 .*

[26]*Id.*

[27]*Id.*

[28]*Id.*

[29]*Id.*

[30]*Matthew L. Wald, Nuclear 'Renaissance' Is Short on Largess, NEW YORK TIMES, Dec. 7, 2010, http://green.blogs.nytimes.com/2010/12/07/nuclear-renaissance-is-short-on-largess/ and Energy Information Administration , Monthly Energy Review, Nuclear Energy Overview, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec8_3.pdf .*

[31]*Energy Information Administration, Annual Energy Review 2011, p. 8, http://www.eia.gov/totalenergy/data/annual/index.cfm*

[32]*Robert L. Bradley, Jr., Will renewable become cost-competitive anytime soon?, Apr. 1, 2009, http://www.instituteforenergyresearch.org/2009/04/01/will-renewables-become-cost-competitive-anytime-soon-the-siren-song-of-wind-and-solar-energy/ .*

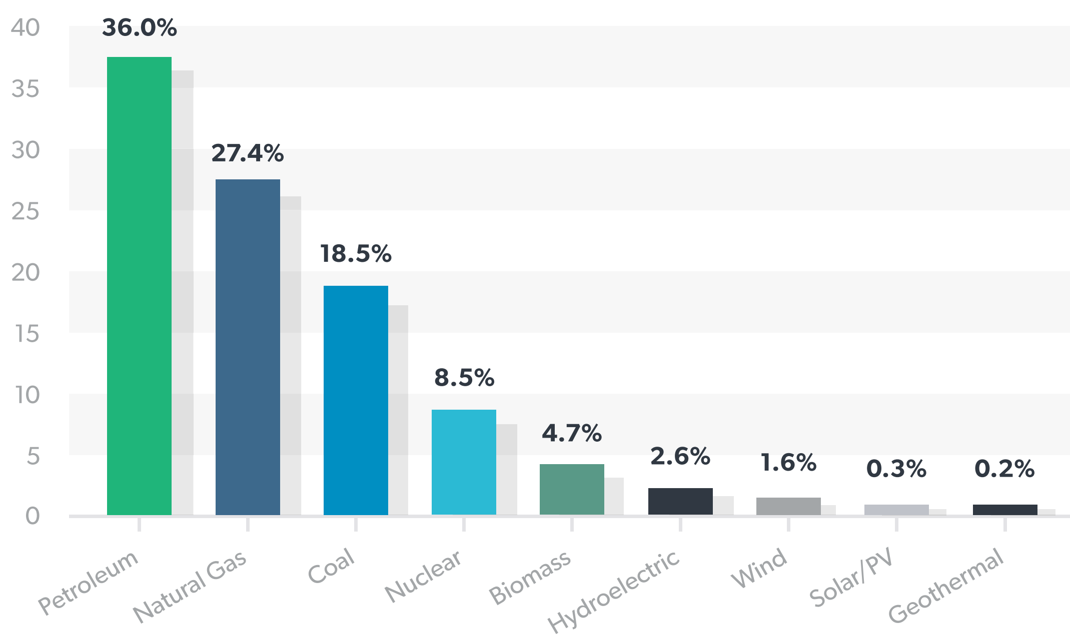
[33]*See Institute for Energy Research, Electricity Generation Costs, May 20, 2014, http://instituteforenergyresearch.org/topics/policy/electricity-generation-cost/ and The Hidden Costs of Wind Power, January 4, 2013, http://instituteforenergyresearch.org/analysis/the-hidden-costs-of-wind-power/ .*

[34]*Institute for Energy Research, On a Btu Basis, Renewable Subsidies are 49 Times Greater than Fossil Fuel Subsidies, Jun. 10, 2011, http://www.instituteforenergyresearch.org/2011/06/10/on-a-btu-basis-renewable-subsidies-are-49-times-greater-than-fossil-fuel-subsidies/ .*

# WHAT POWERS THE UNITED STATES?

The United States uses energy from an array of sources. Petroleum, the vast majority of which is used as a transportation fuel, is our largest source of energy, followed by natural gas, coal, nuclear, biomass, hydroelectric, and the other renewable sources (wind, solar, geothermal).[35]

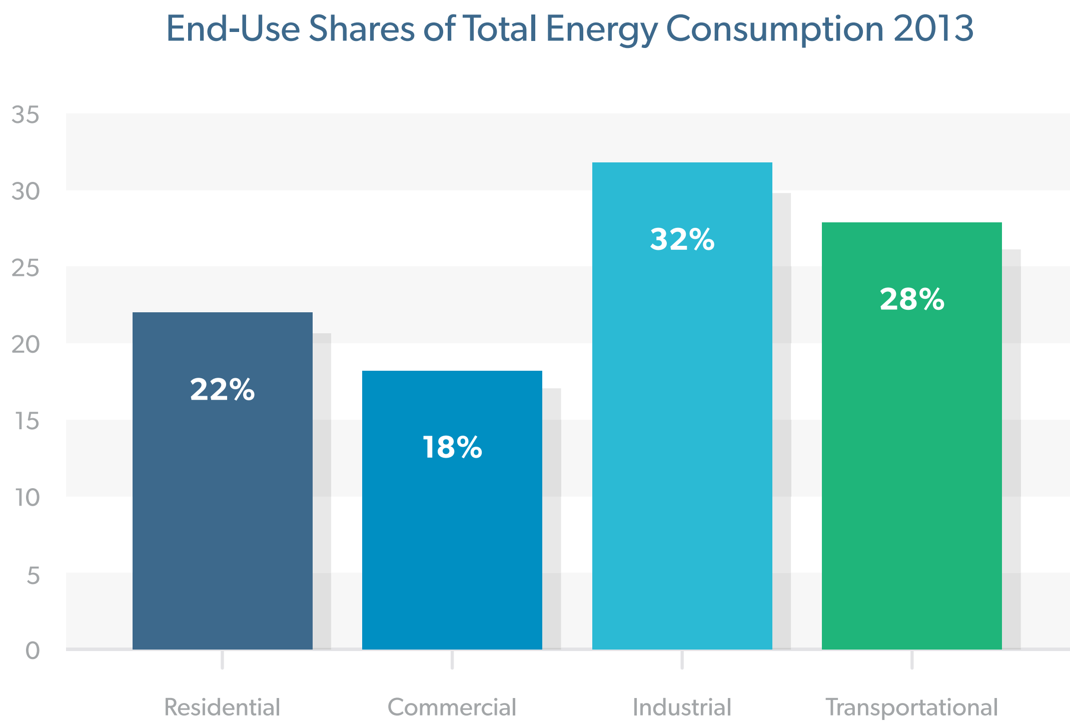
U.S. Energy Consumption by Source 2013




Source: Energy Information Administration

## Energy Consumption

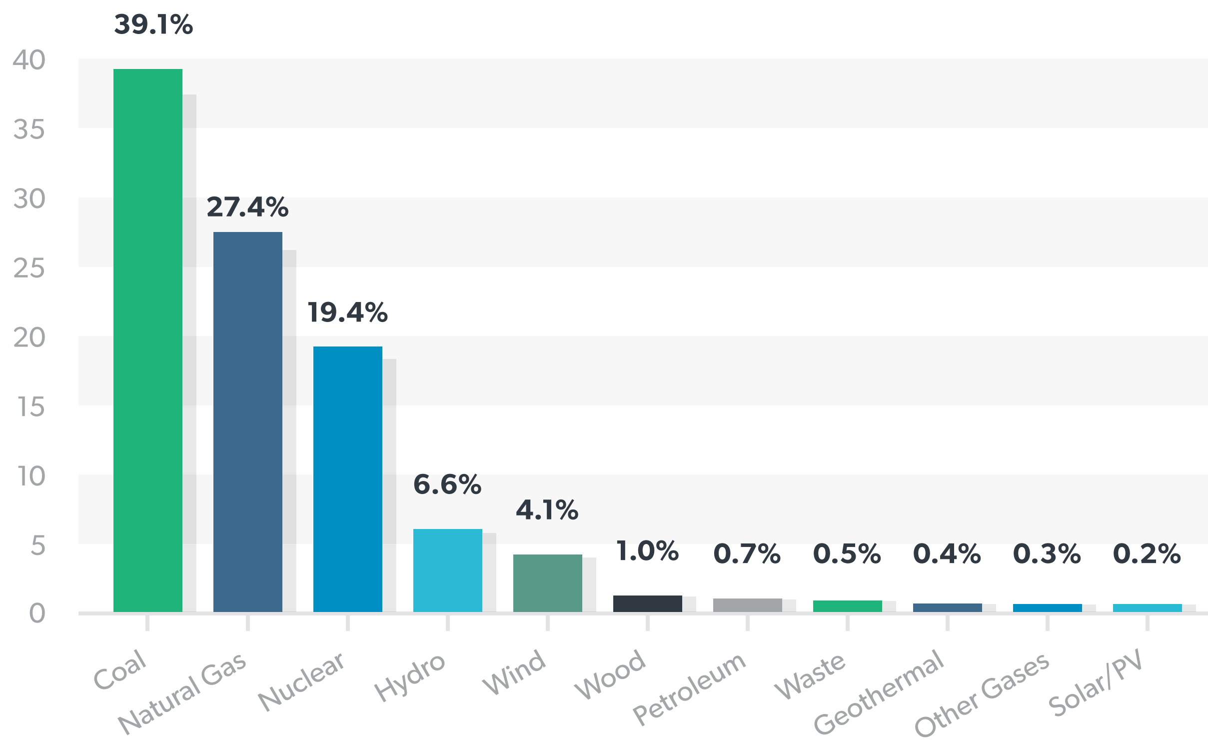
Energy is generally used in four sectors—residential, transportation, industrial, and commercial. Policies that affect the price and use of energy affect all four sectors. [37]



## Sources of Electricity Generation

Electricity in the United States is generated from a wide variety of sources, shown in the graph below. In 2013, coal produced 39 percent of our electricity, natural gas produced 27 percent, nuclear 19 percent, hydroelectric 7 percent, and wind four percent. The remaining percentage comes from a variety of smaller sources such as petroleum, biomass, geothermal, and solar power.[38]

### Electricity Generation by Source in 2013




FOOTNOTES: WHAT POWERS THE UNITED STATES?

*[35]Energy Information Administration, Monthly Energy Review, Table 1.3 Primary Energy Consumption By Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

*[36]Energy Information Administration, Table 2.1 Energy Consumption by Sector, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf .*

*[37]Energy Information Administration, Monthly Energy Review, Table 7.2a Total (All Sectors), November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[38]Energy Information Administration, Monthly Energy Review, Table 1.3 Primary Energy Consumption By Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

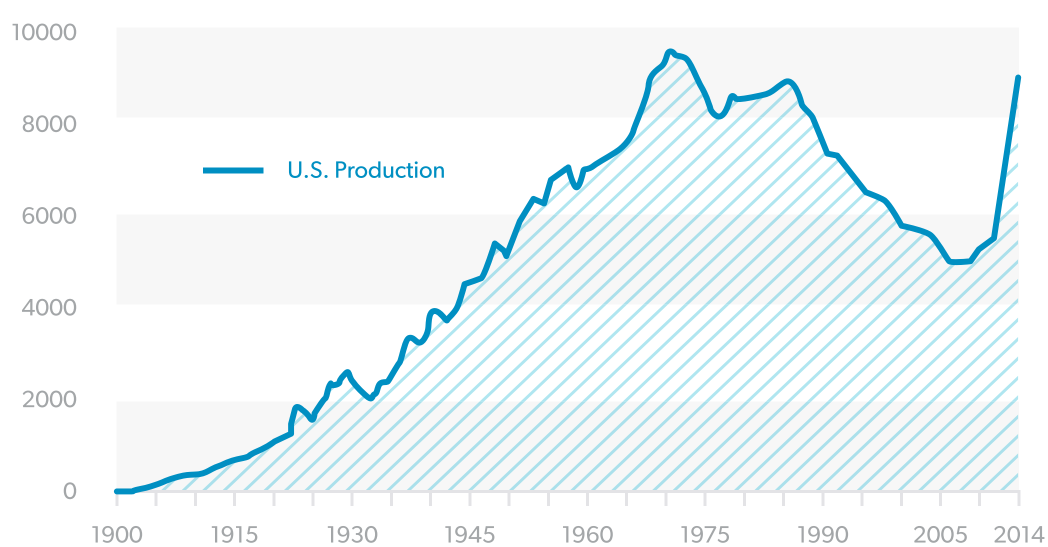
# HYDRAULIC FRACTURING: How Smart Drilling Achieved the Most Important Development in Energy in Decades

## Why is Hydraulic Fracturing Important?

U.S. oil production peaked in 1970 and steadily decreased afterward for four decades. Every President from Richard Nixon to Barack Obama has talked about energy independence, yet oil production did not increase until the rise of hydraulic fracturing.[41] In fact, to many, it seemed like oil was running out—there was even talk of "Peak Oil." Today, people rarely talk about "Peak Oil," and this graph shows why.

From the early 1970s through 2008, it appears that oil production was in terminal decline, but the hydraulic fracturing revolution completely changed that.[42]

U.S. Crude Oil Production



From the low point in 2008, oil production has increased 77 percent from an average of 5 million barrels a day in 2008 to 8.9 million barrels a day in September 2014.[45]

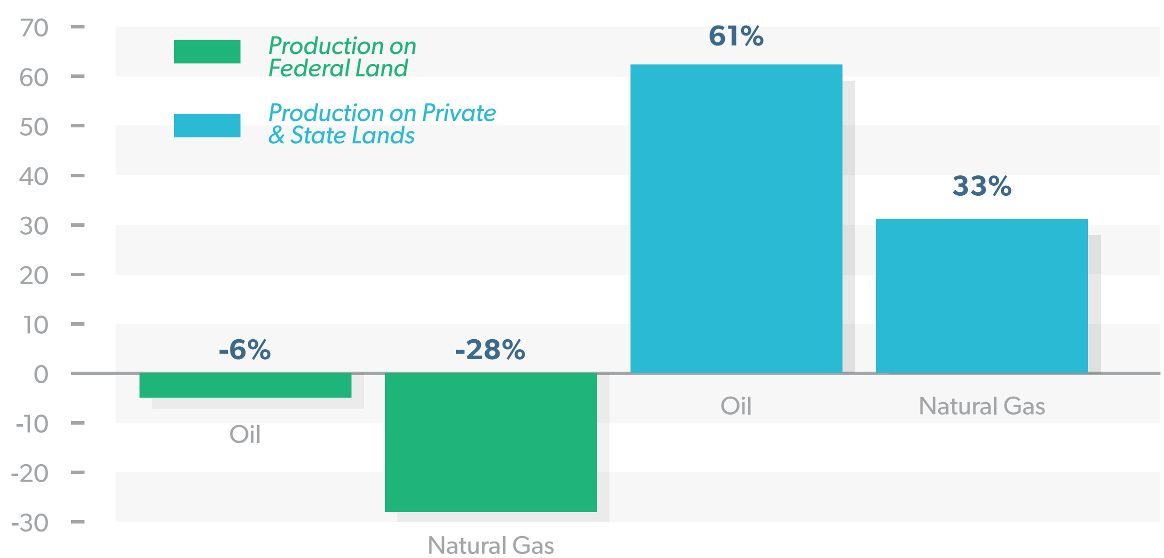
It's not just oil. The natural gas landscape has completely changed as well. In the mid-2000s, everyone thought the United States would be importing natural gas from abroad. Now, there is great pressure for the U.S. Department of Energy and the Federal Energy Regulatory Commission to approve natural gas export terminals.

From 1970 through about 2006, natural gas production was essentially level. Since 2006, U.S. natural gas production increased by 28 percent.[46]

## Oil and Natural Gas Production Increases are Occurring on Private Lands, Not on Federal Lands

The phenomenal increase in oil and natural gas production is due to hydraulic fracturing and horizontal drilling technology that is taking place on private and state lands, not on federal lands. According to a report by the Congressional Research Service,[47] between fiscal years 2009 and 2013, oil production on federal lands fell 6 percent, while oil production on private and state lands increased by 61 percent. Likewise, between 2009 and 2013, natural gas production on federal lands decreased by 28 percent, while natural gas production on private and state lands increased by 33 percent.[48]

Percent Change in U.S. Oil and Natural Gas Production on Federal vs. Non-Federal Lands, FY 2009-2013



This difference is over-regulation by the federal government regarding oil and natural gas production. The federal government has limited the federal acreage for lease by the oil and gas industry and has taken inordinate amounts of time to process permits for drilling, while the states understand that it is possible to both increase energy production and protect the environment without resorting to onerous regulation. An example is in North Dakota where unemployment is the lowest in the nation and economic growth is the highest—all due to oil production. Because the hydraulic fracturing process is more complicated than traditional oil and natural gas production, the regulatory environment is important for oil and gas drilling and production.

## Increased U.S. Production Means a More Stable Oil Market and Lower Oil Prices

Another benefit of oil production from hydraulic fracturing is that it has made the world oil market more stable, even with unrest in the Middle East.[49]

The Energy Information Administration (EIA) reported that U.S. liquid fuels production growth, led by oil production growth, has more than offset unplanned disruptions to the world's oil supply. U.S. liquid fuels production, including crude oil, hydrocarbon gas liquids, biofuels, and refinery processing gain, increased by more than four million barrels per day between January 2011 and July 2014.[50] To put that in perspective, Canada produces about four million barrels of oil a day in total.

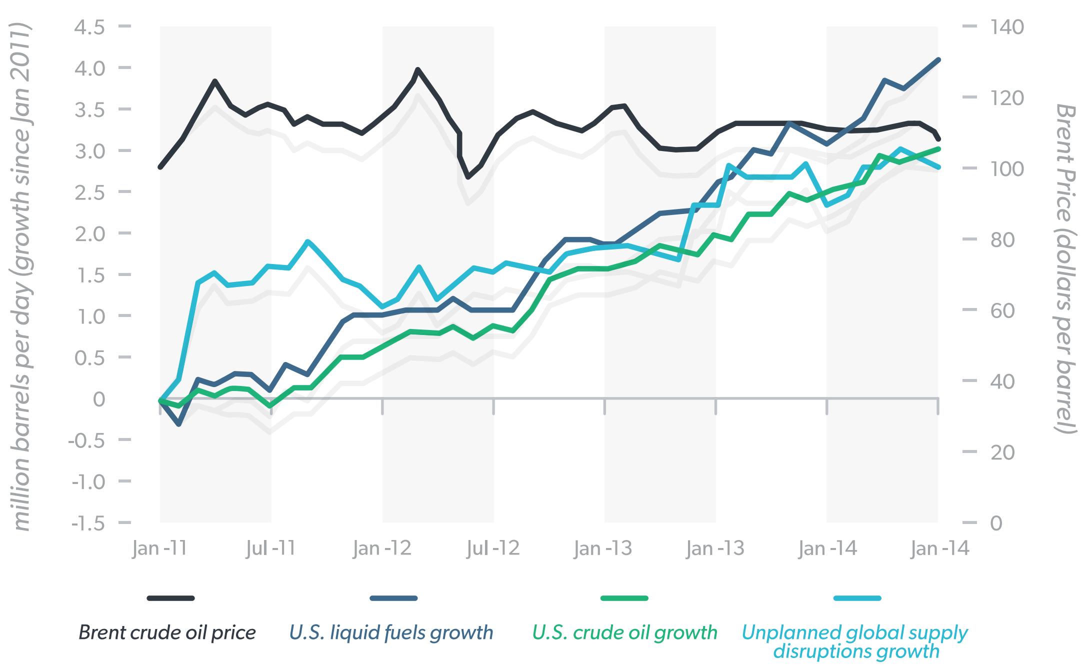
The increase in crude oil production from January 2011 to July 2014 was three million barrels per day or about 75 percent of the increase in U.S. liquid fuels production, surpassing the global unplanned supply disruptions that grew by 2.8 million barrels per day. That increased production has kept world oil prices in check as depicted in the graph below[51] even with the trouble with ISIS, the Gaza situation, and Russia's slow-motion invasion of Ukraine.

## What is hydraulic fracturing?

Hydraulic fracturing was first used in 1947. Since then, it has been employed in more than a million wells to extract more than 7 billion barrels of oil and 600 trillion feet of natural gas from deep underground shale formations.[52]

Geologists have long known that shale rock formations contain large amounts of natural gas and oil, but these energy resources were trapped in layers of rock and could not easily be extracted. Hydraulic fracturing breaks the shale rock and then

Growth in U.S. Oil Production and Unplanned Global Supply Disruptions



further deepens the cracks with high-pressure water, along with sand and some chemicals. This fracturing liberates some of the natural gas and oil trapped in the rock, allowing the natural gas or oil to travel up the well.

Hydraulic fracturing is not the entire process of exploration, drilling, and completing a well. It is just one phase of the process.

Because natural gas and oil resources are found thousands of feet below the surface of the ground while groundwater is located within a few hundred feet of the ground's surface, there has not been a single confirmed case of groundwater contamination from hydraulic fracturing. To protect the groundwater, extractors drill a well vertically underground to a point past the deepest aquifer containing fresh groundwater. At this stage, the operator inserts steel surface casing down the length of the drilled hole, then pumps in cement to create a barrier of cement and steel between the groundwater and the well bore. The well is then drilled further down into the underground shale formation.

In or near the shale formation, the operator directs the drill to change from drilling vertically to drilling horizontally through the shale formation to create as much contact with the shale as possible. After the well casing is cemented in place and the well is "completed," then the hydraulic fracturing operation occurs.

Six to eight horizontal wells drilled from just one well pad produce the same volume as sixteen vertical wells. This use of multi-well pads significantly reduces the overall infrastructure needed for a drilling and production operation, such as access roads, pipeline routes, and production facilities, thereby minimizing disturbances to the habitat and impacts to the public.

## Does Hydraulic Fracturing Endanger Groundwater?

A wave of complaints regarding hydraulic fracturing dealt with allegations that hydraulic fracturing and the chemicals used in the process contaminated groundwater. A good example of this is from a review of the 2010 movie Gasland. [53]

The chemicals used in the fracking process seep into the soil and water supply, leaving many families with bizarre aberrations like flammable tap water. Uh oh. And as Fox makes his way across the country, into dozens of areas crippled by decade-past drilling efforts, he collects bottles of yellow-brown water like postcards in some macabre travel diary.

These claims were all false. There is not a single confirmed case of groundwater contamination from hydraulic fracturing. Former EPA administrator Lisa Jackson testified under oath to a House committee that she was "not aware of any proven cases where the fracking process itself has affected water." [54] Jackson also told reporters "in no case have we made a definitive determination that the [fracturing] process has caused chemicals to enter groundwater."[55]

Also, two studies conducted by the Environmental Protection Agency (EPA) and the Ground Water Protection Council (GWPC)—the national association of state ground water and underground injection agencies whose mission is to promote the protection and conservation of ground water—found that there have been no confirmed incidents of groundwater contamination from hydraulic fracturing.[56] This is particularly noteworthy considering the fact that more than 1.2 million wells have been hydraulically fractured in the United States.[57] Furthermore, according to the Interstate Oil and Gas Compact Commission (IOGCC)—the multi-state governmental agency representing states' oil and gas interests—each IOGCC member state has confirmed that there has not been a case of groundwater contamination in which hydraulic fracturing was attributed to be the cause.[58]

Despite this, much ado has been made regarding the use of hydraulic fracturing fluids and their potential to contaminate groundwater. Fracturing fluids consist predominately of water and sand—98 percent or more in a typical fracturing solution—while the rest is made up of high-viscosity chemical additives designed to maximize the effectiveness of the fracture job.[59] Many of the additives consist of common household compounds, and while you certainly wouldn't want to go out of your way to drink them, the EPA concluded in a 2004 study that the additives are not considered harmful to human life or the environment in the capacity they are used.[60] Additionally, the formula for each fracturing fluid used in a drilling operation must, by mandate of the Occupational Safety and Health Administration, be disclosed at each drilling site, and a coalition of state groundwater and oil and gas regulators launched the Frac Focus Chemical Disclosure Registry to allow companies to voluntarily disclose the content of fracturing fluids used at individual well sites.

Furthermore, stringent state and federal regulations on well design and construction ensure that fracturing fluid additives do not migrate upward into active or treatable water reservoirs. As aforementioned, groundwater is protected during the process of hydraulic fracturing by steel and cement casing that is installed when the well is first drilled to isolate groundwater resources. Operators have a further interest in ensuring that fractures are sufficiently well removed from underground water resources, as the penetration of a water table above a formation could render the oil and gas resources unusable.

After a fracturing job has been completed, the majority of fracturing fluids are recovered from the well and recycled in a closed system for future use. Surface disposals of fracturing fluid are subject to the federal Clean Water Act, requiring treatment for any potentially harmful substances prior to discharge, or the federal Safe Drinking Water Act if disposed in an oil and gas injection well. [61]

While hydraulic fracturing has not been tied to groundwater contamination, this is not to say that there are no problems with oil and gas drilling. There are some issues from time to time, but those problems have not occurred from hydraulic fracturing. In 2011, the Groundwater Protection Council representing states analyzed over 200,000 wells drilled between 1983 and 2007 in Ohio and Texas. In Ohio, they found 12 incidents of groundwater contamination from well construction issues of more than 33,000 wells drilled (see page 47 of the report), which is a failure rate of 0.036 percent. In Texas, between 1992 and 2007, nearly 188,000 wells were drilled. The study found 10 ground water contaminations from drilling and completion activities (page 78) and 2 incidents of "deficient well construction practices" (page 84), which is a failure rate of 0.006 percent. Even if you include all 211 incidents of groundwater contamination in Texas, the failure rate is a mere 0.1 percent. And while not perfect, this remarkably successful track record pertains to the drilling process, not the process of hydraulic fracturing.[62] None of these is because of hydraulic fracturing.

## Shale Oil Boom Major Reason for Oil Price Drop

Hydraulic fracturing is the most important development in oil and gas production in many decades. Because of hydraulic fracturing, coupled with directional drilling and advanced imaging technologies, the U.S. turned its decades-long slow-down in oil production to an oil production boom and became the largest natural gas producer in the world. The benefits are enormous. Instead of oil approaching $150 a barrel, as the administrator of the Energy Information Administration thought was possible,[63] oil is around $60 a barrel at the time of this writing. This boom in domestic oil production driven by hydraulic fracturing is a major reason for the huge decline in oil price. These lower oil prices saved consumers up to $248 billion in 2013. [64]

## **FOOTNOTES:** HYDRAULIC FRACTURING

[41]*Institute for Energy Research, State of the Union's Energy History, YouTube, January 25, 2011, https://www.youtube.com/watch?v=50gJcZnExmE*

[42]*Energy Information Administration, U.S. Field Production of Crude Oil, October 2014, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpus2&f=m*

[45]*Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf and http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpus2&f=m*

[46]*Energy Information Administration, Monthly Energy review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec4_3.pdf and http://www.eia.gov/dnav/ng/hist/n9010us2A.htm*

[47]*Congressional Research Service, U.S. Crude Oil and Natural Gas Production in Federal and Non-Federal Areas, April 10, 2014, http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/20140410CRS-US-crude-oil-natural-gas-production-federal-non-federal-areas.pdf and Institute for Energy Research, Oil and Gas Production on Federal Lands Still a Disappointment, April 24, 2014, http://instituteforenergyresearch.org/analysis/oil-and-gas-production-on-federal-lands-still-a-disappointment/*

[48]*Id.*

[49]*New York Times, A New American Oil Bonanza, August 28, 2014, http://www.nytimes.com/2014/08/29/business/energy-environment/shale-oil-in-texas-keeps-gas-prices-affordable.html)*

[50]*Energy Information Administration, U.S. liquid fuels production growth more than offsets unplanned supply disruptions, Today in Energy, August 27, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=17731*

[51]*Energy Information Administration, U.S. liquid fuels production growth more than offsets unplanned supply disruptions, August 27, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=17731*

[52]*American Petroleum Institute, Hydraulic Fracturing Primer, July 2014, http://www.api.org/~/media/files/oil-and-natural-gas/hydraulic-fracturing-primer/hydraulic-fracturing-primer-2014-lowres.pdf,*

[53]*GasLand, http://www.imdb.com/title/tt1558250/*

[54]*Energy in Depth, EPA Administrator Lisa Jackson Tells Congress "No Proven Cases Where Fracking Has Affected Water", YouTube, May 24, 2011, https://www.youtube.com/watch?v=L4RLzlcox5c&feature=youtu.be&t=38s*

[55]*Energy in Depth, EPA's Lisa Jackson on safe hydraulic fracturing, April 30, 2012, https://www.youtube.com/watch?v=_tBUTHB_7Cs&feature=youtu.be*

[56]*Ground Water Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources: 2014 Edition, http://www.gwpc.org/state-oil-gas-regulations-designed-protect-water-resources-2014-edition ; Environmental Protection Agency, Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing, June 2004, http://www.epa.gov/safewater/uic/pdfs/cbmstudy_attach_uic_exec_summ.pdf .*

[57]*Energy In Depth, Just the Facts, http://energyindepth.org/just-the-facts/ .*

[58]*Interstate Oil and Gas Compact Commission, Remarks on Hydraulic Fracturing from State Regulatory Officials, June 2009, http://www.iogcc.state.ok.us/Websites/iogcc/Images/2009StateRegulatoryStatementsonHydraulic%20Fracturing.pdf .*

[59]*Ground Water Protection Council, Modern Shale Gas Development in the United States: A Primer, April 2009, http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf , p. 61.*

[60]*Environmental Protection Agency, Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing, June 2004, http://www.epa.gov/safewater/uic/pdfs/cbmstudy_attach_uic_exec_summ.pdf .*

[61]*Ground Water Protection Council, Modern Shale Gas Development in the United States: A Primer, April 2009, http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf , p. 25.*

[62]*Ground Water Protection Council, State Oil and Gas Agency Groundwater Investigations and Their Role in Advancing Regulatory Reforms, FracFocus, August 2011, http://fracfocus.org/sites/default/files/publications/state_oil__gas_agency_groundwater_investigations_optimized.pdf*

[63]*Reuters, Oil prices would hit $150/barrel without U.S. shale, EIA says, September 24, 2014, http://www.reuters.com/article/2014/09/24/eia-forecast-idUSL2N0RP1PP20140924*

[64]*Institute for Energy research, Hydraulic Fracturing Saved Consumers Up to $248 Billion Last Year, November 6, 2014, http://instituteforenergyresearch.org/analysis/hydraulic-fracturing-saved-consumers-248-billion-last-year/*

# OVERVIEW OF ENERGY SOURCES

Rational energy policy should be based on energy facts, not on wishes or hopes. Too often, debates about energy are steeped in misinformation and misdirection instead of hard facts. Americans have been told for decades that we are running out of energy and that we are energy poor, but the reality is that we are an energy rich country.

For example, how many people know that the United States has the largest combined reserves of coal, oil, and natural gas of any country on earth?[65]

How many people know that the United States is the world's third largest oil producer?

How many people know that increasing nuclear power would not reduce our oil imports? Less than one percent of our electricity is generated from petroleum.

How many people know that the United States leads the world in natural gas production?

How many people know that the United States leads the world in consumption of non-hydro renewables (wind, solar, biomass)?[66]

Sound energy policy should reflect reality. The only way policies can reflect reality is if we understand where our energy comes from, how much it costs, and how reliable its sources are. The following describes the most important facts about our energy sources in order of their market share.

**FOOTNOTES:** OVERVIEW OF ENERGY SOURCES

*[65]Gene Whitney et. al, U.S. Fossil Fuel Resources: Terminology, Reporting, and Summary, Congressional Research Service, Nov. 30, 2010, http://www.instituteforenergyresearch.org/wp-content/uploads/2011/07/CRS-US-Fossil-Fuel-Resou rces.pdf .*

*[66]Institute for Energy Research, BP Statistical Report Shows U.S. Largest Non-Hydro Renewable User in the World, Jun. 13, 2011, http://www.instituteforenergyresearch.org/2011/06/13/bp-statistical-report-shows-u-s-largest-non-hydro-renewable-user-in-the-world/ .*

# PETROLEUM

- Petroleum provides 36 percent of our total energy.[67]
- However, petroleum generates less than 1 percent of our electricity.
- In 2013, the United States produced 7.46 million barrels per day of oil[68], (10.068 million barrels per day including natural gas plant liquids) making it the world's third largest oil producer.[69] It is the world's largest liquids producer, ahead of Saudi Arabia and Russia, as well as the largest petroleum product exporter.[70]
- The U.S. has 1.44 trillion barrels of technically recoverable oil resources, enough to power America for the next 210 years at current rates of consumption.[71]
- The United States has almost 1 trillion barrels of recoverable oil in oil shale deposits. This is almost four times greater than Saudi Arabia's proved oil reserves.
- The federal government leases 1.9 percent of federal offshore areas and less than 6 percent of federal onshore lands for oil and natural gas production.

Oil is the most-used energy source in the United States because it is our primary transportation fuel. Petroleum is used to make both gasoline and diesel, which combine with jet fuel and other transportation fuels to supply 92 percent of our transportation fuel needs.[72] The use of petroleum is ubiquitous because it is energy-dense, easily transportable, and thus available nearly everywhere.

One hundred years ago, it was not obvious that petroleum would be our most-used energy source. At the time, there were a number of competing sources of energy for horseless carriages, including electricity, steam, ethanol, kerosene, coal oil, and gasoline. In 1910, for example, the New York Times declared that the electric car "has long been recognized as the ideal solution" because it "is cleaner and quieter" and "much more economical."[73] In 1925, Henry Ford told a New York Times reporter that ethanol was "the fuel of the future."[74] But over time, both the New York Times and Henry Ford were proven wrong, and petroleum emerged because it was more efficient and more easily transported than ethanol.

Although petroleum is the most-used source of energy for transportation, it is seldom used for electricity generation. Less than one percent of American electricity is generated from petroleum power plants because other sources of electricity are usually more cost-effective.

## World and U.S. Oil Production

America's largest source of oil is America itself—64 percent of the petroleum we consumed in 2013 came from U.S. domestic sources.[75] The United States is the third largest oil-producing nation in the world, behind Saudi Arabia and Russia, but it is the largest liquids producer when natural gas plant liquids, refinery processing gain and biofuels are included in the mix.[76]

The top oil-producing states, in order of their volume, are Texas, North Dakota, California, Alaska, and Oklahoma.[77] In 2013, the United States domestically produced 64 percent of the crude oil and refined petroleum products that it used.[78] The United States imported (on a net basis: imports minus exports) 6.24 million barrels of oil per day, about 33 percent of consumption.[79]

## America's Oil Imports

Oil import statistics can be cited on a net basis (because the United States both imports and exports oil) or on a gross basis. For example, in 2013 the United States imported 9.86 million barrels a day of crude oil and other petroleum products and exported 3.62 million barrels a day, for net oil imports of 6.24 million barrels a day.[80] In 2013, on a net basis, we imported 33 percent of the petroleum we used and, on a gross basis, we imported 52 percent of the petroleum we used.

The United States imports oil from a variety of countries. By far the largest foreign oil source is Canada, followed by Saudi Arabia, Mexico, Venezuela, Russia, Iraq, and Nigeria.[81]

Approximately 20 percent of our petroleum product supply in 2013 (38 percent of gross imports) was imported from the Organization of Petroleum Exporting Countries (OPEC).[83] OPEC is comprised of 12 oil-exporting countries: Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

### Top 10 Sources of U.S. Petroleum Imports

| COUNTRY | BARRELS PER DAY |
|---|---|
| CANADA | 3,142,000 |
| SAUDI ARABIA | 1,329,000 |
| MEXICO | 919,000 |
| VENEZUELA | 806,000 |
| RUSSIA | 460,000 |
| COLOMBIA | 389,000 |
| IRAQ | 341,000 |
| KUWAIT | 328,000 |
| NIGERIA | 308,000 |
| ECUADOR | 242,000 |

Non-OPEC countries supplied 32 percent of U.S. petroleum product supply (62 percent of gross imports). The non-OPEC countries include Brazil, Canada, Colombia, Mexico, Netherlands, Norway, Russia, the United Kingdom, and others. [84]

## The Very Limited Leasing of Federal Lands for Oil and Natural Gas Production

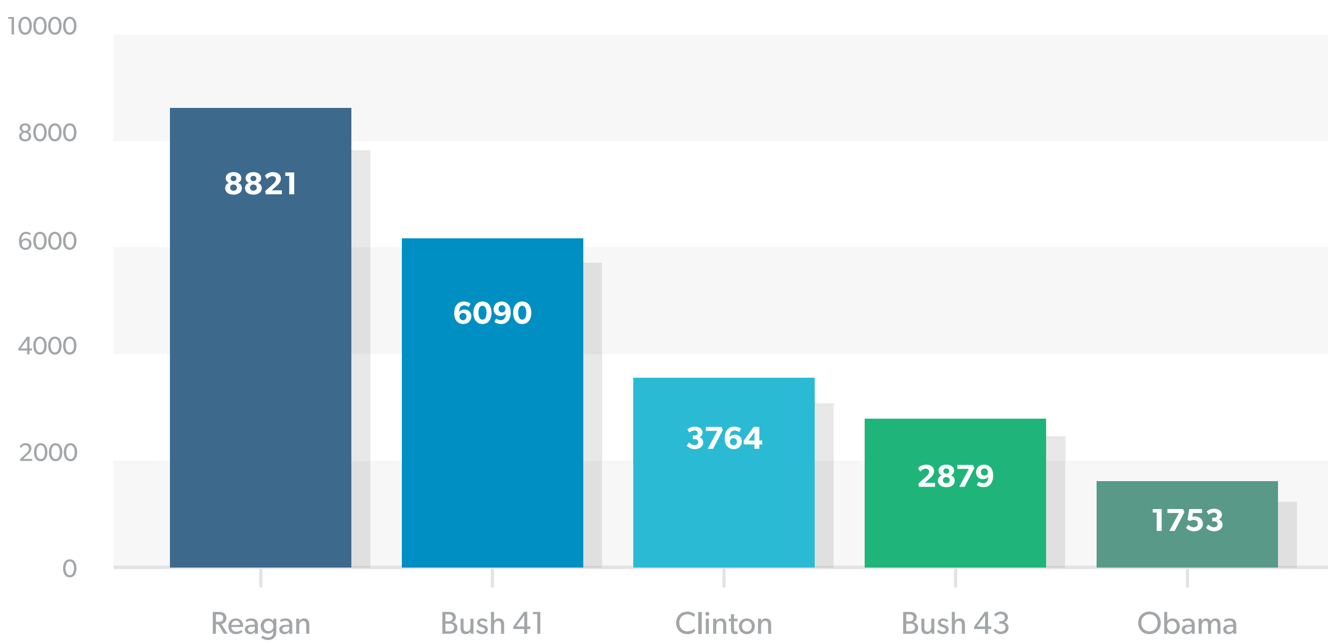
One reason we import more than half of our oil (on a gross basis) is because of federal policies. The United States is an energy-rich country, with large quantities of U.S. energy resources located on federal lands. The federal government owns 28.8 percent of the land in the United States, and a majority of the land in the energy-rich western states.[85] The federal government also controls oil and natural gas leasing on the Outer Continental Shelf (OCS)—the submerged area between land and the deep ocean.

Developing oil and natural gas production on federal lands is becoming more difficult and time consuming. As a result, oil production is decreasing in the federally controlled offshore areas and Alaska, but increasing on state and privately controlled onshore areas.[86]

Furthermore, the federal government offers very little of that land for energy production. In fact, the federal government leases just 1.9 percent of federal offshore areas[87] and less than 6 percent of federal onshore lands for oil and gas production.[88] If additional lands were leased, more domestic energy production could be pursued.

In fiscal year 2013, the Obama administration leased fewer onshore acres for energy development than in any other year on record.[89] But the declining trend did not begin with the Obama administration. For example, President Bush leased less land than President Clinton.[90] The next graph shows the decline in federal lands leased by the Bureau of Land Management since the 1980s. [91]

Average Number of Onshore Leases Issued During Each Admministration



Part of the reduction in area offered for lease occurred because in 1982, Congress banned the development of oil and natural gas resources on most of the Outer Continental Shelf. America's OCS encompasses 1.76 billion acres of submerged, taxpayer-owned lands, with over 98 percent of these offshore lands not leased for energy exploration and development.[93]

The Bureau of Ocean Energy Management (BOEM),[94] an agency of the U.S. Department of Interior, estimates that the OCS contains 86 billion barrels of technically recoverable oil (over 12 years of supply at current consumption rates) and 420 trillion cubic feet of technically recoverable natural gas (over 16 years of supply at current consumption rates).[95] The Congressional prohibition was reinforced by a presidential moratorium instituted in 1990 by President George H.W. Bush. These moratoria made the United States the only developed country in the world that banned access to its own offshore energy sources.

The moratoria remained in place until the price of oil rose to more than $145 a barrel in 2008. Only then did President George W. Bush finally lift the presidential offshore ban. Because of a strong public outcry, Congress allowed its moratorium to expire on September 30, 2008. With the expiration of the congressional moratorium, it was finally permissible for the United States to move forward with developing its offshore energy resources.

Near the end of President George W. Bush's term in 2009, the Department of the Interior issued a plan to lease new offshore areas, but this plan was quickly rescinded by the Obama administration. President Obama proposed opening a few additional offshore areas in March of 2010,[96] but he canceled those plans less than a month later, citing safety reasons following the Deepwater Horizon accident in the Gulf of Mexico. Instead of offering more areas for energy production, the Obama administration halted all drilling in the Gulf, initially as a six-month moratorium.

Later, the administration claimed to have relaxed the moratorium, but a de facto moratorium, or aptly named permitorium, had remained in place because the administration had granted only a handful of the necessary government permits needed for drilling on federal land (including offshore areas). Through the rest of 2010 and into 2011, the Obama administration failed to issue a single permit to drill a new deepwater well, and a federal judge held the administration in contempt for its "determined disregard" to take action on drilling permits.[97]

After a disaster like Deepwater Horizon, some introspection is understandable, but the Obama administration's response was considered overblown by many experts. For example, the drilling moratorium and the subsequent permitorium not only affected deepwater drilling, but also shallow-water drilling in the Gulf of Mexico. Yet shallow-water operators have a very impressive safety record. Over the 15 years prior to the Deepwater Horizon accident, 11,070 wells were drilled in shallow water and less than 15 barrels of oil were spilled.[98]

Beginning the end of February 2011, the Obama administration slowly began issuing deep-water offshore permits for the Gulf of Mexico.[99] The administration had also approved a few supplemental plans to applications for deepwater drilling that were originally submitted in the 1980s. But at that time, the moves were made too late, for 10 deepwater drilling rigs had already been moved to Brazil, French Guiana, Egypt, and other parts of Africa.[100]

Data from the Energy Information Administration (EIA) show that production in the Gulf of Mexico slowed significantly following the moratorium. In early 2010, EIA estimated that 1.75 million barrels of oil a day would be produced in the Gulf of Mexico in 2010 and 1.65 million barrels a day in 2011. But after the moratorium and permitting difficulties, oil companies produced 11 percent less oil a day in 2010 than EIA's estimate and 14 percent less oil a day in 2011.[101]

Oil production projects frequently have long lead times. Multi-billion dollar projects, such as many of the large offshore projects, take years for developers to plan and build the necessary infrastructure to bring oil to market. For example, the Thunder Horse field was discovered in the Gulf of Mexico in 1999, but the first barrel of oil was produced in 2008.

This long lead-time means that decisions made today affect oil production for years in the future. One frequent criticism of the development of the Arctic National Wildlife Refuge (ANWR), for instance, is that it may take years to start producing oil. This may be true, but it is also true that if energy development in ANWR had been approved in the past, ANWR would be producing oil today. In 1995, President Clinton vetoed a bill to permit oil exploration and development in ANWR. If he had signed that bill, oil most certainly would be being produced in ANWR today.

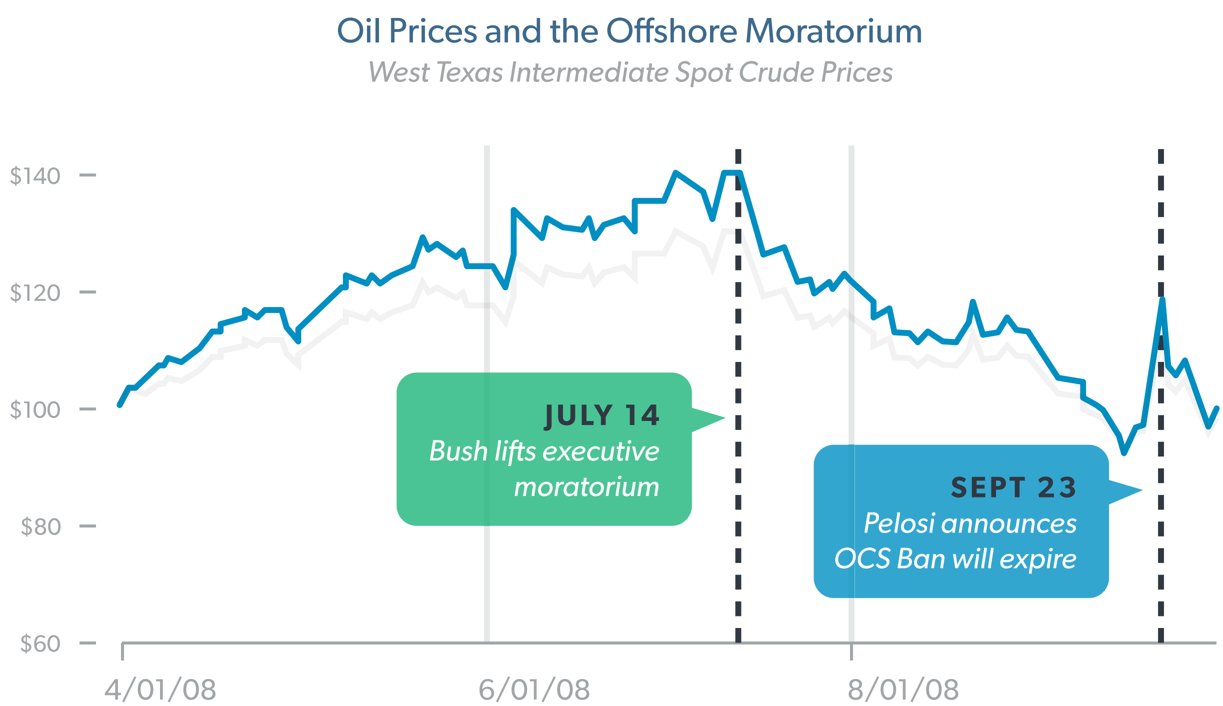
Decisions made today about access to energy resources affect energy production for years and decades into the future. The more areas that are accessible to energy production today, the higher the likelihood of more domestic energy production in the future.

## Offshore Drilling and the Price of Oil

Some advocates have argued that allowing more domestic offshore drilling would have little impact on oil prices. While it is true that oil is a global commodity, it is also true that presidential and Congressional actions can have an impact on oil prices. In 2008, when President George W. Bush ended the executive branch moratorium on oil and gas drilling on the Outer Continental Shelf, oil futures dropped by $9.26, or 6.3 percent, just after the announcement was made.[102]

The oil price drop continued after then House Speaker Nancy Pelosi announced on September 23, 2008 that Congress would allow the Congressional moratorium to expire.[103] The chart below illustrates these price changes: [104]

Economic theory predicts that the potential for



greater future oil production should lead to price relief—this is precisely what we are seeing in 2014, now that our oil prices have essentially been halved. It is true that lifting the moratorium did not immediately increase oil production from the affected areas, but other oil producers with excess capacity (such as Saudi Arabia) would have an incentive to produce more in the present once they realize that future U.S. output would be higher.

## U.S. and World Oil Reserves in Perspective

People frequently confuse the crucial differences between proven reserves and the total amount of resources in the ground. For example, in March 2011 President Obama said:

> *America holds about 2 percent of the world's proven oil reserves. What that means is that even if we drilled every drop of oil out of every single one of the reserves that we possess—offshore and onshore—it still wouldn't be enough to meet our long-term needs.*[106]

The President is confusing proven oil reserves with recoverable oil or the total amount of oil actually in the ground. His comment is similar to looking at all of the food in a grocery store and saying that when the food currently in the store is gone, there is no more food.

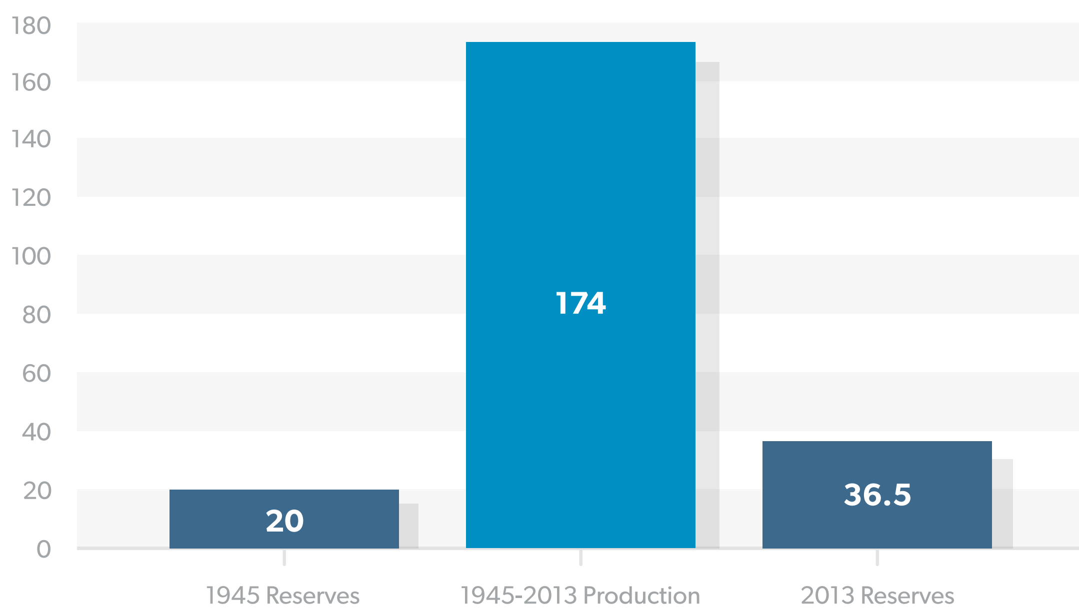
Proven reserves are similar to the food currently in the grocery store. They are the estimated reserves that are easily accessible and recoverable with today's technology and today's oil prices.[107] But proven reserves are a small fraction of the amount of oil that is in the ground. History has shown that as today's proven reserves are used, people find more reserves.

Consider the history of proven oil reserves in the United States. In 1980, the U.S. had 31.3 billion barrels of proven oil (and lease condensate) reserves.[108] From 1980 through 2013, however, we produced 84.6 billion barrels of oil.[109] In other words, over the last 33 years, we produced more than double our total proved oil reserves in 1980.

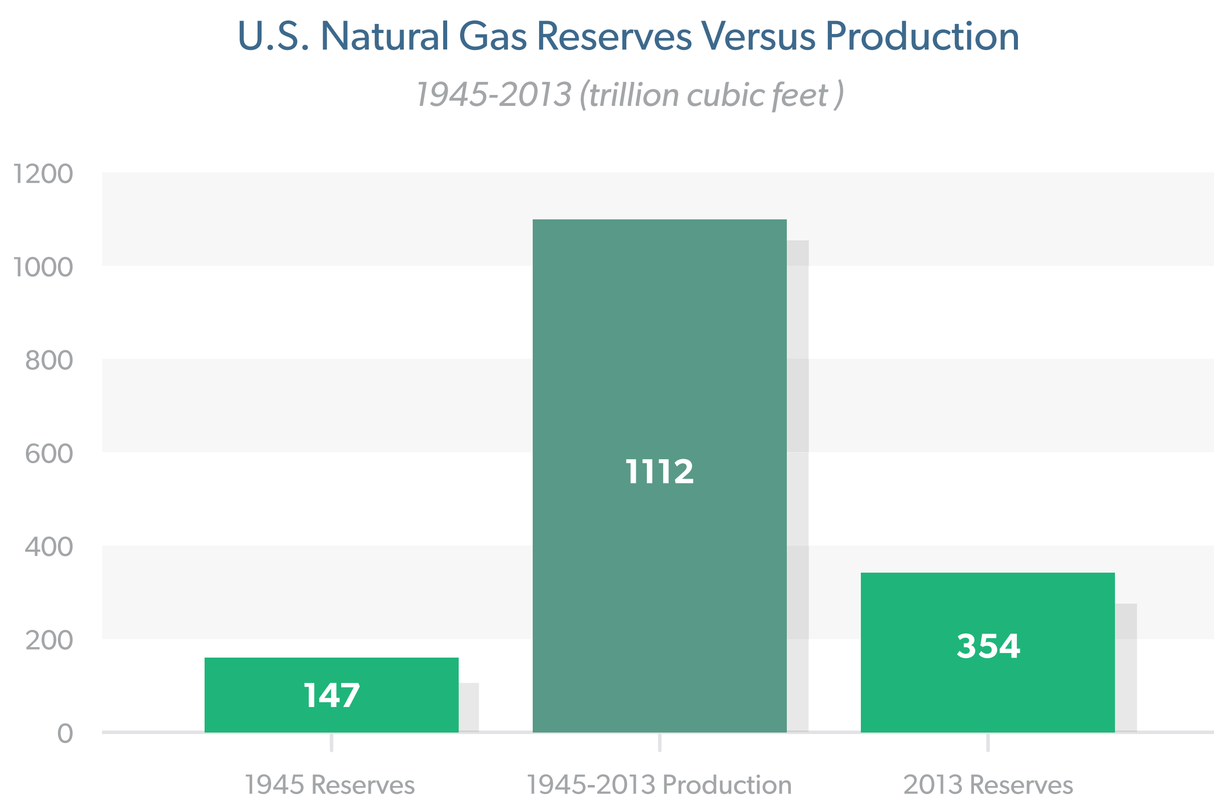
This is true over a longer timeframe as well. The chart below shows U.S. proved oil reserves in 1944, total U.S. oil production from 1944 through 2013, and proved reserves in 2013.[110]

U.S. Oil Reserves Versus Production

*1945-2013 (billion barrels)*



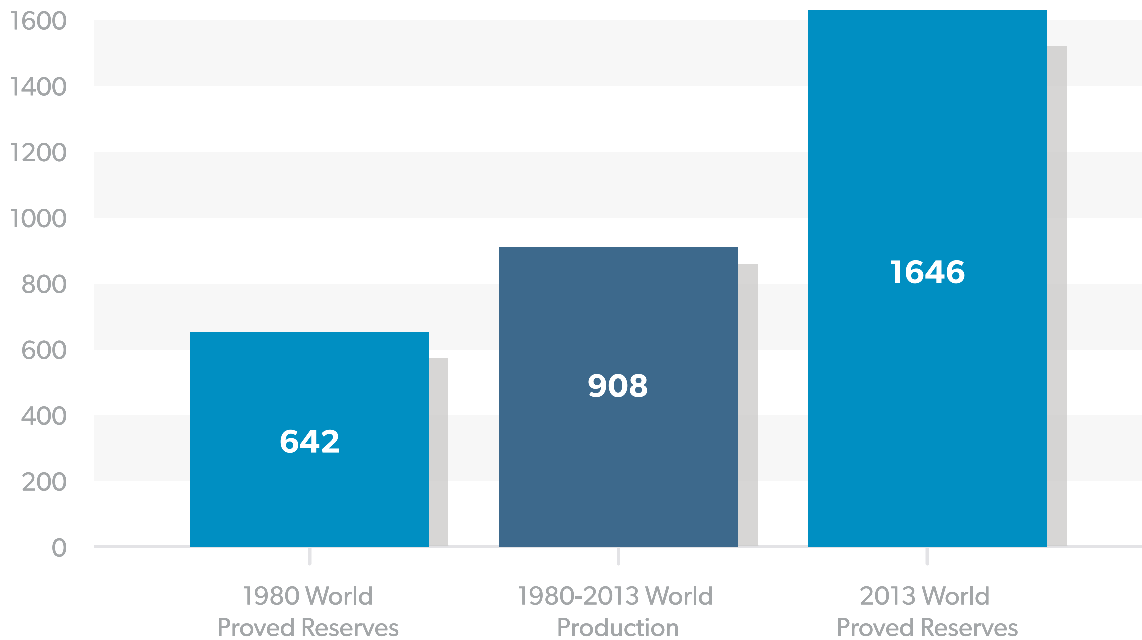
Over time, not only have we produced many times the amount of proved oil reserves we had just a few decades ago, but the same is true of natural gas reserves and production, as the following chart shows. [111]




This same story of producing far more resources than our proven reserves is also true on a global scale. In 1980, global proven oil reserves stood at 642 billion barrels.[112] But from 1980 through 2013, the world produced 908 billion barrels of oil.[113] In other words, globally from 1980 through 2013 we produced 141 percent of the proven oil reserves we had in 1980. While we were producing these reserves, oil companies discovered more reserves, and new technologies unlocked even more oil resources. Today the world has more proven oil reserves than ever before.[114] In fact, from 1980–2013 proven reserves more than doubled.[115]

## World Proved Oil Reserves Versus Production

*1980-2013 (billion barrels)*




One reason proven reserves more than doubled over the last 33 years is that oil exploration and production technologies improved. One of the most important recent technological advancements is precision horizontal and directional drilling. Coupling horizontal and directional drilling with hydraulic fracturing has enabled oil production in new areas where oil was known to exist, but was not considered part of our proven reserves.

In the United States, oil production increased almost 50 percent from 2008 through 2013[116] as a result of drilling investment made during the time of high oil prices in 2008[117] as well as improved technology. Oil production increased from 5 million barrels per day in 2008 to 7.4 million barrels per day in 2013. [118]

## Oil Potential in the 1002 Area of the Arctic National Wildlife Refuge

As previously noted, the federal government only allows energy production on a small fraction of taxpayer-owned lands. The 1002 Area of the Arctic National Wildlife Refuge (ANWR) is one area that contains large amounts of oil and remains off limits to production. In 1980, Congress and President Jimmy Carter set aside 1.5 million acres of ANWR's 19 million acres for future study of its energy resource potential.[119] These 1.5 million acres, known as the 1002 Area, have no trees, deepwater lakes, or mountain peaks, but contain immense energy resources. [120]

The U.S. Geological Survey has estimated that the 1002 Area has an average expected value of 10.3 billion barrels of recoverable oil that could be produced at a rate of about one million barrels of oil per day.[121] This potential resource could make ANWR the largest oil-producing field in the United States. The area's oil and natural gas resources could be developed using merely 2,000 acres of the surface area, or less than 0.01 percent of ANWR's total area.[122]

Despite ANWR's great energy potential, Congress has prohibited the development of these resources for over 30 years. One reason given by the opponents of energy production in ANWR is that it might adversely impact caribou populations. The good news about the caribou is that since energy development began in nearby Prudhoe Bay in 1977, the size of the Central Arctic Herd has grown more than 1,015 percent, from about 5,000 animals in the 1970s to record levels of an estimated 67,000 caribou in 2009 for the Central Arctic herd and 64,107 for the Teshekpuk Lake herd in 2008. [123]

## **FOOTNOTES:** PETROLEUM

*[67]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

*[68]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf .*

*[69]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf .*

*[70]International Energy Agency, Medium-Term Oil Market Report 2014, http://www.iea.org/Textbase/npsum/MTOMR2014sum.pdf .*

*[71]Institute for Energy Research, North American Energy Inventory, December 2011, http://instituteforenergyresearch.org/wp-content/uploads/2013/01/Energy-Inventory.pdf.*

*[72]Energy Information Administration, Table 2.5 Transportation Sector Energy Consumption, November 2014, http://www.eia.gov/emeu/mer/pdf/pages/sec2_11.pdf.*

*[73]NEW YORK TIMES, Nov. 12, 1911, cited in Robert Bryce, The Electric Car Boondoggle, The Daily Beast, July 29, 2010, http://www.thedailybeast.com/blogs-and-stories/2010-07-29/electric-cars-subsidized-by-harry-reid-and-the-senate/ .*

*[74]Ford Predicts Fuel from Vegetation, NEW YORK TIMES, Sept. 20, 1925, p. 24, cited in Bill Kovarik, Henry Ford, Charles Kettering and the "Fuel of the Future", Automotive History Review, Spring 1998, p. 7, available at http://www.radford.edu/wkovarik/papers/fuel.html.*

*[75]See Energy Information Administration, Monthly Energy Review, Table 3.1, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf.*

*[76]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1 .*

*[77]Energy Information Administration, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm .*

*[78]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf*

*[79]Id.*

*[80]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf*

*[81]Energy Information Administration, http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbblpd_a.htm.*

*[83]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_10.pdf.*

*[84]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_11.pdf .*

*[85]See Bureau of Land Management, BLM Public Land Statistics 1999, Table 1.3, Mar. 2000, http://www.blm.gov/public_land_statistics/pls99/99pl1-3.pdf .*

*[86]Congressional Research Service, U.S. Crude Oil and Natural Gas Production in Federal and Non-Federal Areas, April 10, 2014, http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/20140410CRS-US-crude-oil-natural-gas-production-federal-non-federal-areas.pdf*

*[87]Bureau of Ocean Management, Combined Leasing Report, November 3, 2014, http://www.boem.gov/Combined-Leasing-Report-November-2014/ and Institute for Energy Research, Outer Continental Shelf Statistics, http://instituteforenergyresearch.org/analysis/outer-continental-shelf-ocs-statistics/ .*

*[88]Bureau of Land Management, http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/oil___gas_statistics/data_sets.Par.67327.File.dat/table-03.pdf .*

*[89]Bureau of Land Management, Source: BLM, Table 4, http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/oil___gas_statistics/data_sets.Par.80157.File.dat/numberofacresleasedeachyear.pdf*

*[90]Congressional Research Service, Federal Land Ownership: Overview and Data, February 8, 2012, http://www.fas.org/sgp/crs/misc/R42346.pdf .*

*[91]Bureau of Land Management, Number of New Leases Issued During the Fiscal Year, December 23, 2013, http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/oil___gas_statistics/data_sets.Par.62098.File.dat/numberofleasesissuedeachyear.pdf In the chart, the average for each*

*administration includes the fiscal years where there is overlap between two administrations. For example, FY2009 is used in the average for both Bush 43 and Obama.*

*[93]Bureau of Ocean Management, Combined Leasing Report, November 3, 2014, http://www.boem.gov/Combined-Leasing-Report-November-2014/ and Institute for Energy Research, Outer Continental Shelf Statistics, http://instituteforenergyresearch.org/analysis/outer-continental-shelf-ocs-statistics/*

*[94]Bureau of Ocean Energy Management, Regulation and Enforcement, http://www.boemre.gov/revaldiv/RedNatAssessment.htm*

*[95]Bureau of Ocean Energy Management, Regulation and Enforcement, Outer Continental Shelf Oil & Gas Assessment 2006, http://www.boem.gov/About-BOEM/BOEM-Regions/Alaska-Region/Resource-Evaluation/RedNatAssessment.aspx .*

*[96]John M. Broder, Obama to Open Offshore Areas to Oil Drilling for First Time, NEW YORK TIMES, Mar. 31, 2010, http://www.nytimes.com/2010/03/31/science/earth/31energy.html .*

*[97]Laurel Brubaker Calkins, U.S. in Contempt Over Gulf Drill Ban, Judge Rules, BLOOMBERG, Feb. 3, 2011, http://www.bloomberg.com/news/2011-02-03/u-s-administration-in-contempt-over-gulf-drill-ban-judge-rules.html .*

*[98]Brett Clanton, Drillers fear sinking in shallow waters: They saw federal delays in permit process threaten companies' existence, HOUSTON CHRONICLE, Aug, 18, 2010, http://www.chron.com/disp/story.mpl/business/energy/7159334.html .*

*[99]Institute for Energy Research, The Obama Administration is Slowing Reissuing Offshore Drilling Permits, Mar. 23, 2011, http://www.instituteforenergyresearch.org/2011/03/23/the-obama-administration-is-slowly-reissuing-offshore-drilling-permits/ .*

*[100]Forbes, Why U.S. Oil rigs left Gulf of Mexico for Brazil, Mar. 23, 2011, http://blogs.forbes.com/kenrapoza/2011/03/23/as-us-oil-rigs-leave-for-brazil-permits-and-prices-only-factor .*

*[101]See Energy Information Administration, Short-Term Energy Outlook Apr. 2010 and Short-Term Energy Outlook Dec. 2011, http://www.eia.gov/forecasts/steo/outlook.cfm .*

*[102]Larry Kudlow, Bush Says Drill, Drill, Drill—and Oil Drops $9, July 15, 2008, http://www.nationalreview.com/kudlows-money-politics/2249/bush-says-drill-drill-drill-151-and-oil-drops-9 .*

*[103]Institute for Energy Research, Lifting the Offshore Ban Gave Immediate Price Relief, Oct. 2, 2008, http://www.instituteforenergyresearch.org/2008/10/02/lifting-the-offshore-ban-gave-immediate-price-relief/ .*

*[104]Institute for Energy Research, Lifting the Offshore Ban Gave Immediate Price Relief, October 2, 2008, http://instituteforenergyresearch.org/analysis/lifting-the-offshore-ban-gave-immediate-price-relief/*

*[106]Remarks by the President on America's Energy Security, Mar. 30, 2011, http://www.whitehouse.gov/the-press-office/2011/03/30/remarks-president-americas-energy-security .*

*[107]Energy Information Administration, Glossary, http://www.eia.gov/emeu/iea/glossary.html#ProvedEnergyReserves.*

*[108]Energy Information Administration, Annual Energy Review, Table 4.2, http://www.eia.gov/totalenergy/data/annual/pdf/sec4_5.pdf*

*[109]Energy Information Administration, U.S. Crude Oil and Natural Gas Reserves, December 4, 2014, http://www.eia.gov/naturalgas/crudeoilreserves/ and Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf*

*[110]Robert L. Bradley Jr. & Richard W. Fulmer, Energy: The Master Resource, p. 88 (2004).*

*[111]See Energy Information Administration, Annual Energy Review 2011, Table 4.2, http://www.eia.gov/totalenergy/data/annual/pdf/sec4_5.pdf ; Energy Information Administration, Dry Natural Gas Production, http://www.eia.gov/dnav/ng/hist/n9070us2A.htm ;Energy Information Administration, U.S. Crude Oil and Natural Gas Reserves, December 4, 2014, http://www.eia.gov/naturalgas/crudeoilreserves/ ; Robert L. Bradley Jr. & Richard W. Fulmer, Energy: The Master Resource, p. 88 (2004).*

*[112]Energy Information Administration, International Energy Statistics: Petroleum—Reserves, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1980&eyid=2014&unit=BB .*

*[113]Energy Information Administration, International Energy Statistics: Petroleum—Production, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1.*

*[114]Energy Information Administration, International Energy Statistics: Crude Oil Proved Reserves, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1980&eyid=2014&unit=BB.*

*[115]Id.*

*[116]Energy Information Administration, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm .*

*[117]Mead Gruver, Govt. says US oil production increased in 2009, ASSOCIATED PRESS, Mar. 25, 2010, http://www.businessweek.com/ap/financialnews/D9EL8MI00.htm .*

*[118]Energy Information Administration, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm .*

*[119]U.S. Department of Interior, Facts: Environmentally Responsible Energy Production in Alaska's ANWR, http://www.doi.gov/initiatives/ANWRmediafactsheet.pdf.*

*[120]Id.*

*[121]U.S. Geological Survey, Arctic National Wildlife Refuge, 1002 Area, Petroleum Assessment, 1998, Including Economic Analysis (April 2001), http://pubs.usgs.gov/fs/fs-0028-01/ .*

[122]*Energy Information Administration, Potential Oil Production from the Coastal Plain of the Arctic National Wildlife Refuge: Updated Assessment, 3. Summary, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/arctic_national_wildlife_refuge/html/summary.html and Free Republic, Top 10 Reasons to Support Development in ANWR, http://freerepublic.com/focus/f-news/2245453/posts .*

[123]*Cameron et al, Central Arctic Caribou and Petroleum Development: Distributional, Nutritional, and Reproductive Implications, 58 ARCTIC 1, Mar. 2005, http://pubs.aina.ucalgary.ca/arctic/Arctic58-1-1.pdf and Arctic Report Card: Update for 2011, http://www.arctic.noaa.gov/report11/reindeer.html*

# UNCONVENTIONAL OIL PRODUCTION

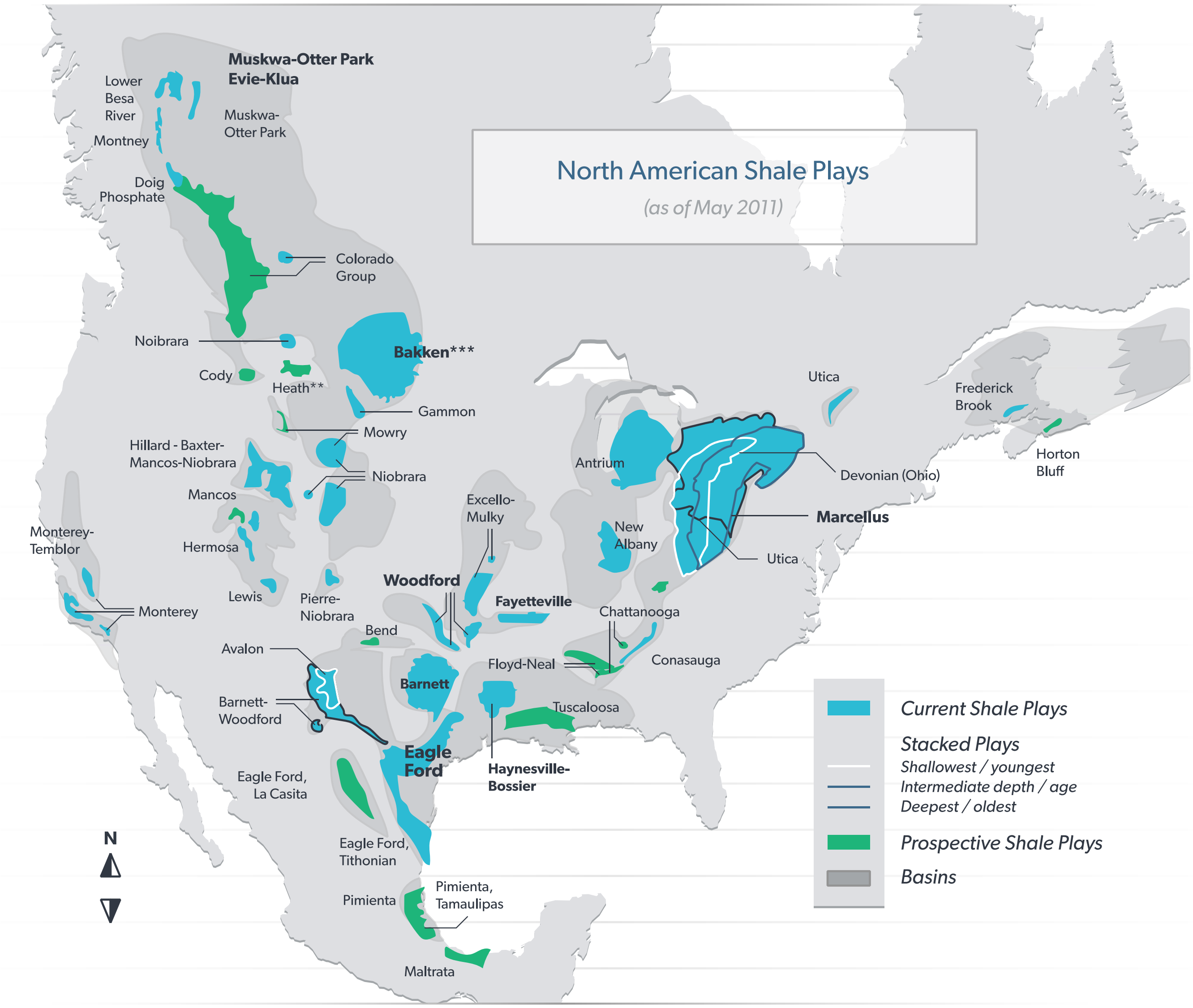
In addition to conventional oil deposits, the United States has large shale oil resources and the richest oil shale deposits in the world.[124] The United States also has oil sands resources. In the past, these energy resources have been too expensive to produce, but new advancements in technology have created a shale oil and shale gas revolution.

## Shale Oil versus Oil Shale

Despite having similar names, shale oil and oil shale are very different oil resources. Shale oil is conventional oil trapped in shale rock. These shale rock formations can also hold natural gas. The natural gas produced from these formations is called shale gas. Unlike oil shale, the oil produced from shale oil formations is conventional oil and does not require special processing.

Oil shale, however, is neither conventional oil nor is it necessarily found in shale rock. Oil shale is sedimentary rock that contains kerogen, a solid organic material. When the kerogen is heated to high temperatures, it releases petroleum-like liquids that can be processed into liquid fuels.

Another difference between oil shale and shale oil is the location of the resources. Shale oil (and shale gas) resources are spread over much of North America,[125] but oil shale is concentrated in the western United States in Utah, Wyoming, and Colorado.




## The Shale Oil Revolution

According to the chairman of Cambridge Energy Research Associates, Daniel Yergin, the biggest energy breakthroughs over the past decade were not new solar cells or better wind turbines but the unlocking of oil and gas in shale rock formations.[127] Ten years ago, shale oil formations produced about 200,000 barrels of oil a day. Today, these formations produce over one million barrels and production could reach three million barrels a day by 2020.[128]

This new oil production is occurring in a number of places around the country, including the Bakken formation in North Dakota, the Eagle Ford formation in Texas, and the Niobrara formation in Colorado. Unlike the large oil fields of the past few decades such as the fields in the Gulf of Mexico or Prudhoe Bay, Alaska, these new shale fields are mostly on private and state lands. As a result, total U.S. oil production has increased despite the federal government leasing fewer and fewer acres for energy production.[129]

The development that made it possible to produce large amounts of oil and natural gas from shale formations was the combination of directional drilling with hydraulic fracturing, also known as "fracking." Hydraulic fracturing has been in use since the 1940s, but combining fracturing with directional drilling allows much more of the oil and natural gas to be extracted than if the hydraulic fracturing was only done in vertical wells.

To understand the difference that hydraulic fracturing makes, in 1995 the U.S. Geological Survey (USGS) estimated that the Bakken formation held 151 million barrels of technically recoverable oil. But in 2008, after the impact of hydraulic fracturing and direction drilling were included in the USGS's assessment, the estimate of recoverable oil in the Bakken jumped 25 fold. [130]

Some interest groups have expressed concern about hydraulic fracturing's environmental impact, but to date, those concerns are unfounded. Hydraulic fracturing has been used more than one million times over the past 60 years and despite this widespread use, there is not a single confirmed case of groundwater contamination. The Environmental Protection Agency (EPA) recently released a preliminary report that claims that shallow hydraulic fracturing has contaminated some ground water in Wyoming. One early report indicates that EPA may have used lax testing methods that could have contaminated EPA's samples.[131] Since then, EPA has withdrawn all studies regarding contaminated water from "fracking", without being able to prove a single case of contamination.

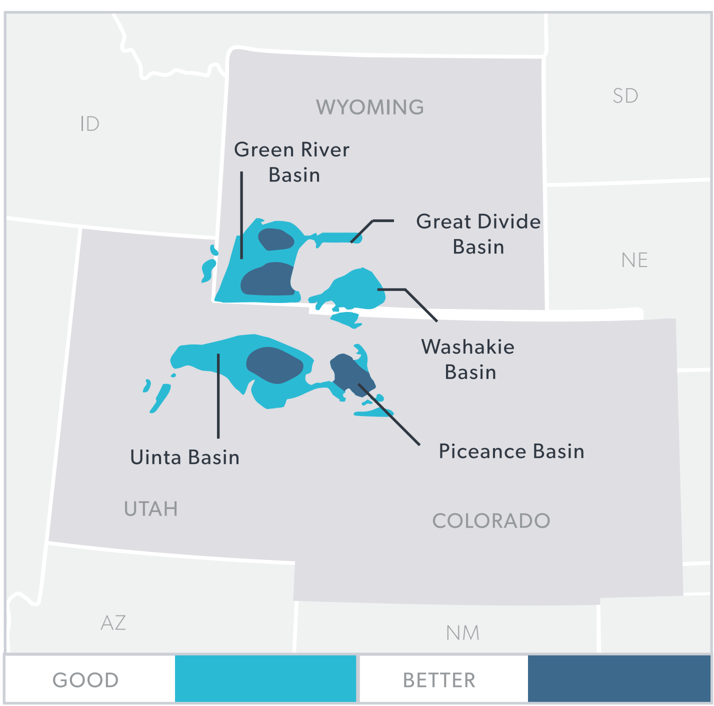
Nevertheless, the hydraulic fracturing track record is clear—it has been in use for over 60 years in more than one million wells, and there has never been a scientifically substantiated claim of groundwater contamination due to the technology. That is an impressive safety record.

## Oil Shale

The United States Geological Survey estimates that U.S. oil shale resources hold 2.6 trillion barrels of oil, with about 1 trillion barrels that are considered recoverable under current economic and technological conditions.[132] These 1 trillion barrels are nearly four times the amount of Saudi Arabia's proven oil reserves—a large enough supply for over 140 years at America's 2013 rate of oil use.

### Petroleum U.S. Oil Shale Resources

*1945-2013 (trillion cubic feet )*

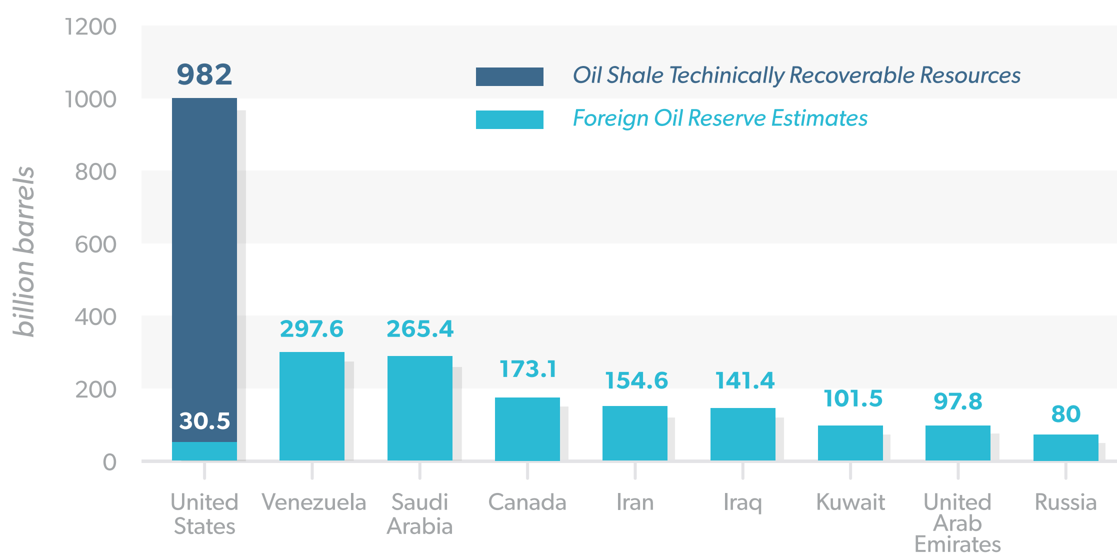



Source: Institute for Energy Research[133]

Despite the great promise these resources hold, one of the first acts of the Obama administration was to withdraw the research and development oil shale leases that the Bush administration had offered.[134] Private sector research and development is necessary to bring these resources to market. Without these leases, companies will not invest the hundreds of millions of dollars required to develop the necessary technology. In Jordan, for example, Shell pledged to spend $500 million in exploration of the country's vast oil shale resources.[135] But this large expenditure was only possible because Shell would be able to develop the resources if the exploration proves successful.

It is important for people to be able to secure the rights to explore and then produce oil shale resources because of the potential these resources hold. Oil shale could radically shift the center of world oil production. The following graph shows how the production of U.S. oil shale could change the world oil market: [136]

U.S. Oil Shale Techincally Recoverable Resources
Vs. Foreign Oil Reserve Estimates




## Oil Sands

Oil sands are another source of petroleum. Oil sands are a heavier form of oil that is mixed with sand, water, and clay. Because of its thickness, this oil (also called bitumen) does not flow like conventional oil, so extraction requires heating or the addition of other fluids to break apart the constituent materials.

Deposits of oil sands are found in more than 70 countries, but the largest deposits in the world are located in Canada. The inclusion of oil sands increased Canada's proved oil resources in 2003 by a factor of 37.[138] Oil sands resources in the United States are not as great those in Canada, but the Department of Energy estimates that U.S. oil sands hold 10 billion barrels of recoverable oil. [139]

## **FOOTNOTES:** UNCONVENTIONAL OIL PRODUCTION

*[124]U.S. Department of Interior, U.S. Geological Survey, Technical Announcement: U.S. Oil Shale Assessment Updated, Apr. 2, 2009, http://www.usgs.gov/newsroom/article.asp?ID=2182 .*

*[125]Energy Information Administration, North American Shale Plays, May 2011, http://205.254.135.7/oil_gas/rpd/northamer_gas.jpg*

*[127]Marc Gunther, Daniel Yergin: How 'The Walmart Effect' Applies to Shale Gas, http://www.greenbiz.com/blog/2011/11/09/daniel-yergin-how-walmart-effect-applies-shale-gas .*

*[128]Daniel Yergin, America's New Energy Security, Wall Street Journal, Dec. 12, 2011, http://online.wsj.com/article/SB10001424052970204449804577068932026951376.html .*

*[129]Institute for Energy Research, Fossil Fuel Production on Federal Lands Dropped by 7 Percent, June 27, 2014, http://instituteforenergyresearch.org/analysis/eia-fossil-fuel-production-federal-lands-dropped-7-percent-2/ .*

*[130]U.S. Geological Survey, 3 to 4.3 Billion Barrels of Technically Recoverable Oil Assessed in North Dakota and Montana's Bakken Formation—25 Times More Than 1995 Estimate, Apr. 10, 2008, http://www.usgs.gov/newsroom/article.asp?ID=1911 .*

*[131]Jeremy Fugleberg, EPA Report: Pavillion water samples improperly tested, Star-Tribune, Dec. 27, 2011, http://trib.com/news/state-and-regional/epa-report-pavillion-water-samples-improperly-tested/article_99512ef4-6d23-5c9b-9038-c676eedd33c2.html .*

*[132]Task Force on Strategic Unconventional Fuels, Development of America's Strategic Unconventional Fuels Resources—Initial Report to the President and the Congress of the United States (Sept. 2006), p. 5, Task Force on Startegic Unconventional Fuels, December 2009, https://www.hsdl.org/?view&did=696499 and US Geological Survey, Oil Shale and Nahcolite Resources of the Piceance Basin, Colorado p. 1, Oct. 2010, http://pubs.usgs.gov/dds/dds-069/dds-069-y/ . The Task Force on Strategic Unconventional Fuels estimated that U.S. oil shale resources were 2.1 trillion barrels. In 2010, the USGS estimated that in-place resources in the Piceance Basin were 50 percent larger than previously estimated (1.5 trillion barrels versus 1.0 trillion barrels). The addition of these 0.5 trillion barrels makes U.S. in-place oil shale resources a total of 2.6 trillion barrels. Previous estimates put the total economically recoverable oil shale resources at 800 billion barrels. Assuming the same rate of recovery for these additional 0.5 trillion barrels brings the total recoverable resources to 982 billion barrels of oil resources.*

*[133]Institute for Energy Research, U.S. Oil Shale Resources, September 2014, v http://instituteforenergyresearch.org/wp-content/uploads/2014/09/U.S.-Oil-shale-resources.png*

*[134]Daniel Whitten, Salazar to rewrite Bush's oil-shale plan, BLOOMBERG NEWS, Feb. 25, 2009, http://www.chron.com/disp/story.mpl/headline/biz/6280852.html .*

*[135]Hassan Hafidh, Shell: More Than 100 Oil Wells Drilled in Jordan in 2 Years, Wall Street Journal, Oct. 5, 2011, http://royaldutchshellplc.com/2011/10/06/shell-more-than-100-oil-wells-drilled-in-jordan-in-2-years/.*

*[136]Institute for Energy Research, U.S. Oil Shale Technically Recoverable Resources vs. Foreign Oil Reserve Estimates, September 2014, http://instituteforenergyresearch.org/wp-content/uploads/2014/09/U.S.-Oil-Shale-Foreign-Oil-Reserve-Estimates-revised.png*

*[138]Energy Information Administration, International Energy Statistics: Crude Oil Proved Reserves, http://tonto.eia.doe.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=regions&syid=1980&eyid=2010&unit=BB .*

*[139]Advanced Resources International, Undeveloped Domestic Oil Resources: The Foundation for Increasing Oil Production and a Viable Domestic Oil Industry, Feb. 2006, p. 20.*

# NATURAL GAS

- Natural gas provides 27 percent of our total energy.
- Natural gas produces 27 percent of our electricity.
- In 2013, the United States produced 24.3 trillion cubic feet of natural gas, making it the world's largest natural gas producer. [140]
- The United States has 2,744 trillion cubic feet of technically recoverable natural gas resources,[141] enough to power America for the next 105 years at current rates of consumption.
- The federal government leases less than 1.9 percent of federal offshore areas and less than 6 percent of federal onshore lands for oil and natural gas production.

Natural gas is a mixture of methane, ethane, and propane gases. Methane makes up 70 to 90 percent of raw natural gas before it is refined. Natural gas is a plentiful and versatile fossil fuel, providing 27 percent of U.S. energy needs.[142] It fuels electricity generation, manufacturing, vehicles, home heating, and appliances. Natural gas provides 27 percent of U.S. electricity and heats more than half of American homes. [143]

Natural gas is also used in a large number of industrial applications including the manufacturing of fertilizer, plastics, pharmaceuticals, and methanol. It is the cleanest-burning hydrocarbon-based fuel, emitting less carbon dioxide, nitrogen oxides, and sulfur dioxide than coal or oil on a per unit of output basis.[144]

Historically, the United States has had some of the highest natural gas prices in the world. In the past, these high natural gas prices, coupled with high U.S. labor costs, have led to an outsourcing of U.S. manufacturing jobs, particularly in Asia.[145] Thanks to hydraulic fracturing,[146] however, U.S. natural gas prices have declined as domestic natural gas production has risen. U.S. natural gas reserves grew by 80 percent over the last decade, and the United States is now the largest natural gas producer in the world. [147]

## Natural Gas Reserves

The United States had 354 trillion cubic feet (Tcf) of proven natural gas reserves at the end of 2013 (about five percent of the world's total).[148] In comparison, Russia has reserves of 1,688 Tcf (25 percent of world reserves) and Iran of 1193 Tcf (17 percent of world reserves).[149]

Proved reserves are not the total natural gas endowment, but the natural gas that is recoverable under existing economic and technological conditions. As technology improves, more natural resources are found, and as currently used sources of natural gas become more expensive, additional natural gas resources will become viable reserves. In total, the United States has 2,744 Tcf of technically recoverable natural gas—enough to satisfy current U.S. natural gas demand for 105 years at the present rate of use. So-called technically recoverable resources are resources that are recoverable with current technology, regardless of cost or other economic factors.[150] These 2,744 Tcf of natural gas resources include unconventional natural gas (shale gas, tight sands, and coalbed methane). [151]

Even though the United States has produced natural gas for decades, our proved reserves have actually grown. At the end of 2003, the United States had 197 Tcf of proved natural gas reserves. A decade later, despite 10 years of production, the U.S. had 354 Tcf of natural gas reserves. U.S. natural gas reserves had grown by 80 percent because of improved technology such as hydraulic fracturing and horizontal drilling.[152]

The Obama administration could easily expand U.S. natural gas reserves by allowing access to the Outer Continental Shelf, the Arctic National Wildlife Refuge, and other federal lands. The Bureau of Ocean Energy Management estimates that the OCS contains 420 trillion cubic feet of natural gas.[153] The U.S. Geological Survey estimates that ANWR contains 3.6 trillion cubic feet of natural gas, but the federal restrictions on these resources are symptomatic of much broader restrictions on resource development in the United States.[154] Overall, 97 percent of government-owned lands are not leased for energy exploration and development.[155] In fact, the Obama administration leased fewer onshore acres for energy development in fiscal year 2013 than in any other year on record.[156]

Similarly, more than 98 percent of offshore government-owned lands are not leased for energy exploration and development.[157] More than one-third of all undiscovered natural gas resources in the United States are estimated to be in federal offshore areas. [158]

## Hydraulic Fracturing and Other Technological Improvements in Natural Gas Production

Technological progress is unlocking new natural gas resources. Access to traditional natural gas resources has been significantly improved by horizontal drilling and hydraulic fracturing, which are also greatly increasing output from existing wells, particularly from shale gas. Hydraulic fracturing, also known as "hydrofracking" or just "fracking," refers to the injection of water (usually mixed with high-viscosity additives) at high pressures into either oil or natural gas wells. This results in the fracturing of rock in the wells, yielding continued or higher oil and gas production. [159]

Hydraulic fracturing has led to an increase in both U.S. natural gas reserves and an increase in natural gas production. As noted earlier, because of hydraulic fracturing, U.S. natural gas reserves grew by 80 percent over the last decade and the United States is now the largest natural gas producer in the world. [160]

In addition to the United States' conventional natural gas resources, unconventional resources such as coalbed methane and shale gas can also be utilized for natural gas. Coalbed methane is natural gas produced from coal deposits. These natural gas resources can store six or seven times as much gas as a conventional natural gas reservoir of equal volume, and are accessible at shallow depths. They are also especially affordable to locate.[161] In 2013, proven reserves of coalbed methane totaled 12.4 Tcf while about 1.5 Tcf of natural gas was produced from coalbed methane. [162]

Shale gas is natural gas found in sedimentary rock.[163] These resources have completely revolutionized natural gas production in the United States, greatly increasing the nation's supply of natural gas. In particular, the Marcellus and Barnett formations offer the promise of vast new natural gas reserves. With the increased use of technologies such as hydraulic fracturing, U.S. proven reserves of shale gas increased from 23.3 Tcf in 2007 to 159.1 Tcf in 2013.[164] In 2013, 11.4 Tcf of shale gas was produced in the United States; an increase of 783 percent from 2007 production levels. [165]

Almost all of the natural gas consumed in the United States is produced domestically. The largest natural gas producing areas, in descending order of production, are Texas, Pennsylvania, Louisiana, Oklahoma, Wyoming, Colorado, and federal offshore areas.[166] Of the 26.1 Tcf of natural gas that

Americans consumed in 2013[167], just 1.3 Tcf, or 5 percent, was provided from net imports.[168] Natural gas imported into the United States comes primarily from Canada through pipelines, although it can also be imported from other countries as liquefied natural gas (LNG). LNG is cooled to approximately -260 degrees Fahrenheit to be transported in ships.[169] Natural gas is compressed and transported across the country through a massive network of pipelines. The nation's total natural gas pipelines are so long they could stretch to the moon and back, twice. [170]

## Threats to Natural Gas Production

The outlook of natural gas production in the United States has dramatically changed over the last decade. Just a few years ago, there was a push to build more liquefied natural gas terminals in the United States to allow greater importation of natural gas. At the time, the U.S. had relatively high natural gas prices. Now, energy companies are building liquefied natural gas terminals to export natural gas.[171] The Department of Energy (DOE) must approve the export terminals if the exports are being sold to non-Free Trade Agreement countries. To date, eight such LNG export terminals have been approved. [172] The companies must also get authorization from the Federal Energy Regulatory Commission for siting and construction. FERC prepares environmental assessments for proposed LNG facilities under its jurisdiction and provides oversight while the facility is in operation. [173]

The boom in natural gas production, brought about by hydraulic fracturing, has completely changed the natural gas landscape and has greatly lowered prices for consumers and industrial users. The increase in hydraulic fracturing has led to new attacks on natural gas production. Many special interest groups have launched anti-hydraulic fracturing campaigns, claiming that it is a new, dangerous technology that contaminates groundwater. But the reality is far different. Hydraulic fracturing has been used for over 60 years in over one million wells. Despite this widespread use, there are no confirmed cases of groundwater contamination. This is not to say that we should not study the possible environmental impacts of hydraulic fracturing, but so far it has an enviable safety record.

Despite its safety record, the anti-hydraulic fracturing campaign has been met with some success. New York State imposed a ban on permitting high-volume hydraulic fracturing (i.e. hydraulic fracturing coupled with directional drilling), and the New Jersey legislature has also passed a ban.[174] The federal government would like to regulate hydraulic fracturing. Even though it is regulated at the state level, the federal government has multiple panels studying hydraulic fracturing and a proposed rule regarding its regulation on federal lands.

## Methane Hydrates: A Vast Potential Natural Gas Resource

The world's supply of natural gas can be significantly enhanced by the use of methane hydrates. Methane hydrates, also called methane clathrate or methane ice, is methane trapped in ice. This occurs under conditions of high pressure and low temperature, in places such as an outer continental shelf or under permafrost.

Methane hydrates are the most extensive fossil fuel energy resource in the world. Conservative estimates place the reserves of methane hydrates at double the amount of all other hydrocarbon fuels.[175] Nations like Japan and Canada are pursuing the commercial development of methane hydrates because they would represent a quantum shift in the world's energy picture if commercially developed.[176]

In the United States, methane hydrates are found on the Outer Continental Shelf and under the Alaskan permafrost. Methane hydrates have not yet been studied extensively, but the best current estimates suggest that the United States has enough methane hydrate resources to supply natural gas at current consumption levels for between 350 and 3,500 years.[177] The U.S. Geological Survey estimates that the United States has about 320,000 Tcf of methane hydrate resources.[178] To put that number in perspective, in 2012 the entire world consumed 119.6 Tcf of natural gas.[179] In other words, there are enough methane hydrate resources in the United States alone to meet the world's current natural gas demand for almost 2,675 years.

The estimates of recoverable methane hydrates will certainly increase as further research is conducted and as extraction technology improves. As energy expert Vaclav Smil explains:

*Needless to say, the world's natural gas industry would be radically transformed even if we were to recover just a very small share of all of the hydrates in shallow sediments. Tapping just 1% of the resource would yield more methane than is currently stored in the known reserves of natural gas.* [180]

Though there is still much to learn about methane hydrates, they offer an incredible future energy potential.

**FOOTNOTES:** NATURAL GAS

---

[140]*Energy Information Administration, http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm .*

[141]*See Institute for Energy Research, North American Energy Inventory, December 2011, http://energyforamerica.org/inventory/, Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec4_3.pdf .*

[142]*Energy Information Administration, Monthly Energy Review, Table 1.3: Primary Energy Consumption by Source (Quadrillion Btu), November 2014, http://www.eia.doe.gov/emeu/mer/pdf/pages/sec1_7.pdf .*

[143]*Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total (All Sectors) (Million Kilowatthours), November 2014, http://www.eia.doe.gov/emeu/mer/pdf/pages/sec7_5.pdf ; Energy Information Administration, Energy Kids' Page- Natural Gas—A Fossil Fuel, http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/naturalgas.html#WHATITISUSEDFOR .*

[144]*Energy Information Administration, Energy Kids' Page- Natural Gas—A Fossil Fuel, http://tonto.eia.doe.gov/kids/energy.cfm?page=natural_gas_home-basics#natural_gas_environment-basics .*

[146]*Paul Cicio, Testimony before the House Natural Resources Committee, Subcommittee on Energy and Mineral Resources, "Implementation of Title III, the Oil and Gas Provisions, of the Energy Policy Act of 2005," April 17, 2007, http://www.gpo.gov/fdsys/pkg/CHRG-110hhrg34822/html/CHRG-110hhrg34822.htm -HouseNaturalResourcesWrittenTestiony041707.pdf citing "…high natural gas prices since year 2000 have significantly contributed to the shutdown of manufacturing plants throughout the country."*

[146]*Institute for Energy Research, U.S. Oil and Gas Production on the Rise Thanks to Hydraulic Fracturing, September 19, 2014, http://instituteforenergyresearch.org/analysis/u-s-oil-gas-production-continues-increase-due-hydraulic-fracturing/*

[147]*See Energy Information Administration, U.S. Natural Gas Reserves, http://www.eia.gov/dnav/ng/hist/rngr21nus_1a.htm and EIA, International Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=3&pid=24&aid=1&cid=regions&syid=2008&eyid=2012&unit=BCF*

[148]*Energy Information Administration, U.S. Natural Gas Reserves Summary, http://www.eia.gov/dnav/ng/ng_enr_sum_a_EPG0_r21_BCF_a.htm.*

[149]*Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=3&aid=6*

[150]*Institute for Energy Research, North American Energy Inventory, December 2011, http://instituteforenergyresearch.org/wp-content/uploads/2013/01/Energy-Inventory.pdf .*

[151]*Id.*

[152]*Information Administration, U.S. Natural Gas Reserves Summary, http://www.eia.gov/dnav/ng/hist/rngr21nus_1a.htm*

[153]*Bureau of Ocean Energy Management, Regulation and Enforcement, Outer Continental Shelf Oil & Gas Assessment 2006, http://www.boem.gov/About-BOEM/BOEM-Regions/Alaska-Region/Resource-Evaluation/RedNatAssessment.aspx*

[154]*Energy Information Administration, The Effects of the Alaska Oil and Natural Gas Provisions of H.R.4 and S.1766 on U.S. Energy Markets, http://www.eia.doe.gov/oiaf/servicerpt/aong/anwr.html .*

[155]*Institute for Energy Research, Who Benefits from Federal Lease Hoarding (July 16, 2008), http://www.instituteforenergyresearch.org/2008/07/16/who-benefits-from-federal-lease-hoarding/ .*

[156]*Bureau of Land Management, Source: BLM, Table 4, ht http://www.blm.gov/style/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/oil___gas_statistics/data_sets.Par.80157.File.dat/numberofacresleasedeachyear.pdf*

[157]*Bureau of Ocean Management, Combined Leasing Report, November 3, 2014, http://www.boem.gov/Combined-Leasing-Report-November-2014/ and Institute for Energy Research, Outer Continental Shelf Statistics, http://instituteforenergyresearch.org/analysis/outer-continental-shelf-ocs-statistics/ .*

[158]*See Gene Whitney et. al., U.S. Fossil Fuel Resources: Terminology, Reporting, and Summary, Congressional Research Service, p. 9–10, http://epw.senate.gov/public/index.cfm?FuseAction=Files.view&FileStore_id=04212e22-c1b3-41f2-b0ba-0da5eaead952 .*

[159]*Energy Information Administration, Technology drives natural gas production growth from shale gas formations, July 12, 2011, http://www.eia.gov/todayinenergy/detail.cfm?id=2170*

[160]*Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=26&aid=1*

[161]*Energy Information Administration, Coalbed Methane Basics.*

[162]*Energy Information Administration, Coalbed Methane Proved Reserves, http://www.eia.gov/dnav/ng/ng_enr_coalbed_a_EPG0_R51_Bcf_a.htm ; Energy Information Administration, Coalbed Methane Production, http://www.eia.gov/dnav/ng/ng_prod_coalbed_s1_a.htm .*

[163]*Energy Information Administration, Natural Gas Explained: Where Our Natural Gas Comes From, http://tonto.eia.doe.gov/energyexplained/index.cfm?page=natural_gas_where .*

[164]*Energy Information Administration, Shale Gas Proved Reserves, http://www.eia.gov/dnav/ng/hist/res_epg0_r5301_nus_bcfa.htm .*

[165]*Energy Information Administration, Shale Gas Production, http://www.eia.gov/dnav/ng/hist/res_epg0_r5302_nus_bcfa.htm.*

[166]*Energy Information Administration, Natural Gas—Natural Gas Gross Withdrawals and Production, http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm.*

[167]*Energy Information Administration, Monthly, Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec4_3.pdf.*

[168]*Id..*

[169]*Energy Information Administration, Natural Gas Navigator-U.S. Natural Gas Imports by Country , http://tonto.eia.doe.gov/dnav/ng/ng_move_impc_s1_m.htm .*

[170]*Department of Energy, The History of Natural Gas, http://www.fe.doe.gov/education/energylessons/gas/gas_history.html .*

[171]*Ted Sickinger, Oregon LNG terminal plans reverse from importing to exporting gas, THE OREGONIAN, Jul. 16, 2011, http://www.oregonlive.com/business/index.ssf/2011/07/oregon_lng_terminal_plans_reve.html .*

[172]*Department of Energy, November 14, 2014, http://energy.gov/sites/prod/files/2014/11/f19/Long%20Term%20LNG%20Export%20Concise%20Summary%20Table%20 11-14-14.pdf*

[173]*Federal Energy Regulatory Commission, LNG, January 23, 2013, http://www.ferc.gov/industries/gas/indus-act/lng.asp*

[174]*Jim Efstathiou Jr., New Jersey Lawmakers Send Christie Ban on Hydraulic Fracturing, Jun. 30, 2011, http://www.bloomberg.com/news/2011-06-30/new-jersey-lawmakers-send-christie-ban-on-hydraulic-fracturing.html .*

[175]*Energy and Marine Geology, Gas (Methane) Hydrates—A New Frontier, http://physics.oregonstate.edu/~hetheriw/projects/energy/topics/doc/fuels/fossil/methane_hydrate/methane_hydrate_japan_geo_survey/usgs_hydrate.html*

[176]*William Pentland, "Methane hydrates: Energy's most dangerous game," Forbes Magazine, Sept. 2, 2008, http://www.forbes.com/2008/08/29/energy-methane-hydrates-biz-energy-cx_wp_0902gashydrates.html .*

[177]*Department of Energy, Oak Ridge National Laboratory, Methane Hydrates, http://www.ornl.gov/info/reporter/no16/methane.htm.*

[178]*U.S. Geological Survey, Natural Gas Hydrates—Vast Resource, Uncertain Future (March 2001), http://pubs.usgs.gov/fs/fs021-01/fs021-01.pdf.*

[179]*Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=26&aid=2.*

[180]*Vaclav Smil, ENERGY AT THE CROSSROADS: GLOBAL PERSPECTIVES AND UNCERTAINTIES , p. 220–221 (2005) https://escholarship.org/uc/item/15354984.*

# COAL

- Coal is the world's most plentiful fossil fuel currently in use (only methane hydrate resources are estimated to be greater). The United States has 259 billion tons of coal in its proved coal reserves.[181] These are the world's largest coal reserves and over 26 percent of the world's proved coal reserves.
- Coal generated over 39 percent of the electricity in the United States in 2013—the most of any generating technology.[182]
- The United States produced almost 1.0 billion short tons of coal in 2013, making it the world's second largest coal producer.[183] China produces over 4.0 billion short tons a year.[184]
- The United States (in the lower 48 states) has 481 billion tons of coal in the demonstrated reserve base, enough to power America for the next 520 years at current rates of consumption.[185]
- Alaska coal reserves are larger than those in the lower 48 states and they have not been tapped.

Coal is the world's most plentiful fossil fuel currently in use,[186] and the United States has the world's largest coal reserves. In fact, there is enough mineable coal in the lower 48 states alone to supply the U.S. for the next 520 years at current rates of coal consumption. Besides being plentiful, coal is also energy dense, which means that a lot of energy is concentrated in a small space. These factors help make coal one of the most cost-effective, affordable fuels for electricity generation.

Coal helped create the modern era by powering the latter part of the Industrial Revolution. Today, coal is the backbone of U.S. electricity generation, accounting for 39 percent of the nation's electricity in 2013.[187] Overall, coal provided 18.5 percent of energy used in the United States in 2013.[188] While coal use has slightly decreased over the last few years in the United States, its share of world energy consumption has increased to 30 percent in 2013, the highest since 1970.[189]

## The United States Has Vast Coal Reserves—Energy for Hundreds or Even Thousands of Years

The Energy Information Administration categorizes coal resources in three categories:

**Total Coal Resources:** The most inclusive category of coal resources is called in-place coal resources. EIA estimates that there are approximately four trillion short tons of coal in the lower 48 United States.[190] Four trillion tons of coal would last more than 4,000 years at current domestic rates of coal use.[191]

EIA's estimate of four trillion short tons of coal does not include an estimated six trillion short tons in Alaska.[192] In other words, the United States contains an estimated 10 trillion short tons of coal.

**Demonstrated Reserve Base:** Given that it is not feasible to mine all four trillion tons of coal that makes up EIA's total coal resources, EIA defines the total coal resources that may be mined commercially as the demonstrated reserve base.

EIA estimates that the demonstrated reserve base is 481 billion short tons of coal.[193] This is enough coal to supply America for the next 520 years at current rates of coal consumption. This does not include coal resources in Alaska, which are larger than those in the lower 48 states, and which have not even been tapped. [194]

**Estimated Recoverable Resources:** Not all 481 billion short tons of coal can be mined with current mining technology, after accessibility constraints and recovery factors are estimated.[195] EIA defines this more restrictive category of coal resources as the "estimated recoverable resources." This is essentially the proved coal reserves.

EIA estimates that the estimated recoverable coal resources total about 259 billion short tons.[196] At current rates of domestic coal consumption, these reserves would last the country for roughly 280 years.[197]

As has happened with oil and natural gas production, technology can improve the recoverable amount of reserves, increasing the number of years that the U.S. coal reserve base could meet demand.

## Coal Generates Inexpensive Electricity

There are several ways to look at the cost of producing electricity. One way is to look at the cost of building and operating new electricity-generation facilities. Energy Information Administration (EIA) forecasts energy supply and demand, and their forecast includes estimates of:

- The cost of electricity that includes the capital cost.
- The cost of operating and maintaining the facilities (including fuel).
- The cost of the transmission to get the electricity to market.

EIA estimates these data for 2019, the most recent year that technologies can be compared due to the varying lead times for construction. The least expensive form of new electricity generation that is dispatchable is expected to be geothermal, followed by natural gas, conventional coal and nuclear. Dispatchable technologies are under the system operator's control and can be dispatched when needed. Non-dispatchable technologies are intermittent and dependent on variable conditions out of the system operator's control such as whether the sun is shining or the wind is blowing.

## Levalized Cost of New Dispatchable Generation Resources, 2019

| GENERATING TECHNOLOGIES | 2012 S/MWH |
|---|---|
| ADVANCED COMBINED-CYCLE NATURAL GAS | 64.4 |
| CONVENTIONAL COMBINED-CYCLE NATURAL GAS | 66.3 |
| GEOTHERMAL | 47.9 |
| ADVANCED CC WITH CCS NATURAL GAS | 91.3 |
| CONVENTIONAL COAL | 95.6 |
| ADVANCED NUCLEAR | 96.1 |
| BIOMASS | 102.6 |

Source: Energy Information Administration [198]

Note: EIA increases the cost of capital for new conventional coal plants to emulate the difficulty in getting financing for these plants to account for the possibility that they may eventually have to purchase allowances or invest in other GHG-emission-reducing projects to offset their emissions.

Besides EIA's estimates, there are other estimates of the cost of various sources of electricity generation. Economist Gilbert Metcalf of Tufts University compiled the data below comparing the cost of electricity from various sources.[199] Because the tax code treats different sources of electricity generation differently, Metcalf calculated a "level playing field," which shows the cost of electricity assuming all of the sources were treated equally by the tax code.

## Real Levelized Costs of Electricity

| GENERATING TECHNOLOGIES | PRICE (CENTS PER KWH) |
|---|---|
| CONVENTIONAL COAL | 3.79 |
| *CLEAN COAL (IGCC) | 4.37 |
| NATURAL GAS | 5.61 |
| NUCLEAR | 5.94 |
| BIOMASS | 5.95 |
| WIND | 6.64 |
| SOLAR THERMAL | 18.82 |
| SOLAR PHOTOVOLTAIC | 37.39 |

Source: Energy Information Administration

Metcalf explains that the costs of wind and solar shown here are actually too low because they do not reflect the fact that solar and wind are intermittent—the sun doesn't always shine on a locale and the wind doesn't always blow. Metcalf notes that the Royal Academy of Engineering calculates that the stand-by reserves required by wind power increases its real cost by nearly 50 percent.[200]

According to Metcalf, wind power costs 75 percent more than conventional coal, but because wind power necessitates back-up generation, its "true cost" would be 142 percent greater than the cost of coal. And if there were a "level playing field" with respect to tax treatment between different forms of electricity production, the true cost of wind would be 163 percent greater than the cost of coal. [201]

Another way to compare costs of generation is to evaluate the production costs of existing generating technologies. Production costs are the operating costs of existing generating technologies including operations and maintenance costs and fuel costs, but not capital and financing costs since most of the existing generating technologies have already paid off their capital costs. The Nuclear Energy Institute compiles these costs for coal-fired, natural gas-fired and nuclear plants. In 2013, the production costs for coal-fired plants totaled 3.24 cents per kilowatt-hour; for natural gas-fired plants 4.09 cents per kilowatt-hour, and for nuclear plants 2.3 cents per kilowatt hour. Between 1995 and 2013, the production costs for coal-fired facilities increased 16 percent and, for nuclear plants, they declined by 19 percent. For natural gas-fired units, production costs between 1995 and 2013 remained the same but had doubled during the intervening years. [202]

Another way to compare the relative price of electricity generation sources is to look at actual electricity prices in the states. The source of electricity generation is not the only factor, but it is the largest factor in determining electricity prices. What is clear is that states that generate the largest share of their electricity from coal or hydropower have the lowest electricity prices.

## States with the Lowest Residential Electricity Prices, 2013

| STATES | PRICE (CENTS PER KWH) | LARGEST SOURCE | PERCENTAGE OF SOURCE |
|---|---|---|---|
| WASHINGTON | 8.67 | HYDRO | 69 |
| NORTH DAKOTA | 9.10 | COAL | 79 |
| IDAHO | 9.37 | HYDRO | 58 |
| LOUISIANA | 9.39 | NATURAL GAS | 52 |
| ARKANSAS | 9.51 | COAL | 53 |
| WEST VIRGINIA | 9.52 | COAL | 95 |
| OKLAHOMA | 9.62 | NAT GAS, COAL | 41 EACH |
| KENTUCKY | 9.71 | COAL | 93 |
| OREGON | 9.94 | HYDRO | 56 |
| TENNESSEE | 10.04 | COAL | 41 |
| U.S. AVERAGE | 12.09 | COAL | 39 |

In fact, of the 15 states with the lowest electricity prices, only Louisiana does not generate the largest share of its electricity from coal or hydropower. [203]

By these measures—projections of future cost, estimates of current costs, and actual electricity prices in the states—coal is one of the most inexpensive sources of electricity generation.

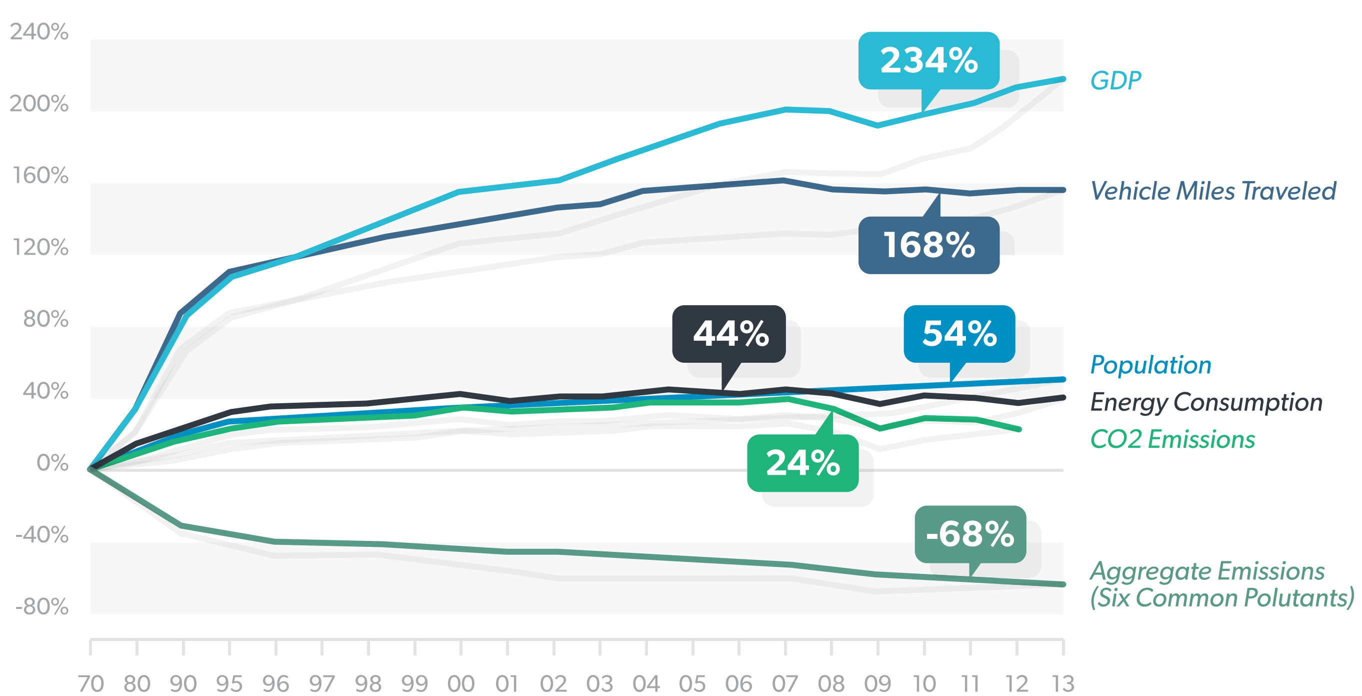
## Air Pollution and Coal

One of the biggest concerns about coal is air pollution. Coal is an inexpensive source of electricity, but it emits more pollution than natural gas when burned. But there is good news—our air quality is improving and new coal plants are cleaner than ever before.

Today's coal-fired electricity-generating plants produce more power, with less emission of pollutants, than ever before. The reason is because of pollution control technologies such as flue gas desulfurization, selective catalytic reducers, fabric filters, and dry sorbent injection, all of which have greatly reduced coal plant emissions. Coal plants can be built today with much lower emissions than they could in the past. For example, according to the National Energy Technology Laboratory (NETL), a new pulverized-coal plant (operating at lower, "subcritical" temperatures and pressures) reduces the emission of NOx (nitrogen oxides) by 86 percent, SO2 (sulfur dioxide) by 98 percent, and particulate matter by 99.8 percent, as compared with a similar plant having no pollution controls. [204]

These advances in technology have enabled large improvements in air quality. Since 1970, the total emissions of the six criteria pollutants have declined by 68 percent, even though energy consumption has increased by 44 percent, vehicle miles traveled have increased by 168 percent, and the economy has grown by 234 percent.[205] (The "criteria pollutants" are carbon monoxide, lead, sulfur dioxide, nitrogen oxides, ground-level ozone, and particulate matter.) The following chart from EPA shows the increase in economic measures compared to the decrease in pollution emissions. [206]

Increase in economic measures compared to the decrease in pollution emissions.



As technology continues to advance, coal-fired power plants will become even cleaner, and air quality will continue to improve.

## Opposition to Coal

Although coal produces inexpensive energy (or maybe because it produces inexpensive energy), many activist groups adamantly oppose coal mining and coal-fired power plants. These groups exploit a number of different tactics to limit coal use in the United States.

The Sierra Club, for example, has worked particularly tirelessly to stop the construction of coal-fired power plants. They claim that they have prevented 150 coal-fired power plants from being built.[207] Coal mines, especially in Appalachia, are coming under increasing fire from environmental interest groups and the Obama administration. For example, EPA revoked a clean water permit that the Army Corps of Engineers had previously awarded, despite the fact that, according to the Army Corps, the permit complies with West Virginia state water law and the federal Clean Water Act.[208] The problem, according to EPA, is that granting the permit would lead to changes in the conductivity (or salinity) of the water that would be detrimental to mayflies, stoneflies, and caddis flies.[209] In other words, EPA denied the permit not because of impacts on human health, but because of impacts on mayflies.

There are a number of other threats to coal production and use, including:

- **Greenhouse gas regulations**. In 2009, the EPA determined that carbon dioxide and other greenhouse gases harm public health and welfare and subsequently promulgated regulations to limit carbon dioxide emissions from coal-fired power plants and other large emitters.
- **Ozone national ambient air quality regulations**. In 2008, the Bush administration tightened the ozone regulations. The Obama administration wants to tighten them further. If EPA tightens the regulations as much as some special interest groups want, it could cost 7.3 million jobs[210] and $90 billion a year by 2020.[211]
- **Boiler MACT (Maximum Achievable Control Technology).** EPA is also in the process of imposing new regulations on industrial boilers to tighten limits on hazardous air pollutants. These proposals would impose maximum available control technology on boilers for sources that emit as few as 10 or more tons per year.
- **"Conductivity" guidance.** As discussed above, the EPA used new conductivity standards to stop a new coal mine in West Virginia. But EPA is applying these standards across Appalachia. To get a Clean Water Act permit, mining companies must show that their project will not cause salt levels to increase to five times what EPA considers the "normal" level. But EPA Administrator Lisa Jackson admitted that there are "no or very few valley fills that are going to meet this standard."[212] Thus, by its own standard, EPA will not permit any mining that results in valley fills. In an unprecedented move, EPA is applying this guidance only to Appalachia.
- **Possible regulation of coal ash as a hazardous waste.** EPA is considering whether to regulate coal ash—used in cinder blocks and a number of other applications—as a hazardous waste.
- **Environmental interest group campaigns.** Environmental interest groups are waging a well-funded campaign to stop the production and use of coal. Such a campaign received a boost last year when New York Mayor Michael Bloomberg pledged $50 million to the Sierra Club to help eliminate coal-fired power plants.
- **Anti-coal industry interest group campaigns**. Chesapeake Energy, the second largest producer of natural gas in the United States, has spent millions of dollars opposing coal use. In 2007, they ran a campaign attacking coal as "filthy." Aubrey McClendon, Chesapeake's CEO, gave millions to the Sierra Club to oppose coal, and Chesapeake has funded a campaign to attack coal through the American Lung Association.[213]
- **Proposed Rule for Limiting Carbon Dioxide Emissions from New Plants.** EPA has proposed to limit the amount of carbon dioxide a new coal plant can release, forcing new coal plants to use expensive, unproven carbon capture and

storage (CCS) systems that have not yet been commercially demonstrated. The new proposed EPA rule will require new coal-fired plants to limit emissions of carbon dioxide to 1,100 pounds per megawatt-hour of electricity. The rule sets a threshold of 1,000 pounds per megawatt-hour for new, larger natural gas plants and a threshold of 1,100 pounds per megawatt-hour for smaller natural gas plants. For natural gas-fired power plants, the new rules limit their emissions to about what the new plants of their size would currently emit.[214] For coal-fired power plants, the rule require a substantial reduction in carbon dioxide emissions that can only be met by installing costly CCS technology that is not currently economically or commercially viable.[215]

- **Proposed Rule for Limiting Carbon Dioxide Emissions from Existing Plants.** EPA's proposed Clean Power Plan requires a 30 percent reduction in carbon dioxide emissions from power plants from 2005 levels by 2030 and establishes state-specific targets to do so. EPA's proposal sets state carbon dioxide emission rate targets for 49 states based on four EPA "building blocks." Those building blocks include heat rate improvements at coal units, increased utilization of existing combined cycle natural gas units from 44 percent today to 70 percent, increases in renewable and nuclear energy, and increases in end use efficiency. A study by NERA Economic Consulting estimates that the EPA carbon rule for existing power plants could cost at least $366 billion and that residents in 43 states would see double-digit percentage increases on average in their electricity bills over the 15-year period. Consumers and businesses would pay $41 billion or more a year, which is nearly five times the cost of all Clean Air Act rules for power plants prior to 2010.[216] The proposed rule would prematurely shutter 45,000 megawatts of coal-fired power generation capacity—more than New England's entire electric generating capacity—and as much as 169,000 megawatts if EPA cannot legally allow all options it specified for compliance. [217]

This is a partial list of threats to coal use and production in the United States. It is particularly noteworthy that while activist antipathy toward coal has grown in the United States, China's coal consumption has increased dramatically. China already uses four times as much coal as the United States, even though its coal reserves are much smaller than our own. In 2012, China consumed 4.15 billion short tons of coal while the United States consumed less than 1 billion short tons.[218] Because it is growing more difficult to use coal in the United States due to proposed environmental regulations, some U.S. mining companies are exporting coal to China and elsewhere.

## Coal-To-Liquids

Because the United States has the world's largest coal reserves, liquid fuel could be created from coal through coal-to-liquids technology, which the Germans used in World War II and which is in use in South Africa, home to the largest coal-to-liquids facility. [219]

There are two main processes used to make liquid fuel from coal: indirect and direct liquefaction. In indirect liquefaction, coal is gasified and the resultant gases are recombined to make liquid fuel.[220] This process is similar to the process used to create fuel from biomass gasification. In direct liquefaction, coal is heated to high temperatures at high pressure in order to liquefy it.[221] Direct liquefaction is more efficient than indirect liquefaction at creating liquid fuel, but it requires additional refining to make fuel of an acceptable quality.[222]

Is coal liquefaction economical? It depends on the price of liquid fuels compared to coal input costs, and only the market can properly make those comparisons. The Chinese claim that they are making large profits from their first commercial-scale coal-to-liquids project, which is profitable at $60 per barrel.[223]

## **FOOTNOTES:** COAL

*[181]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=6.*

*[182]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[183]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_3.pdf.*

*[184]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=1*

*[185]Energy Information Administration, U.S. Coal Reserves, December 16, 2013, http://www.eia.gov/coal/reserves/*

*[186]There are more methane hydrate resources around the world than even coal resources.*

*[187]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[188]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf*

*[189]BP, Statistical Review of Energy 2014, http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf .*

*[190]Energy Information Administration, Coal Explained: How Much Coal is Left, http://tonto.eia.doe.gov/energyexplained/index.cfm?page=coal_reserves .*

*[191]In 2013, the United States consumed 925 million tons of coal. Energy Information Administration, Monthly Energy Review, Table 6.1, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_3.pdf .*

*[192]USGS, Alaska Coal Geology, Resources, and Coalbed Methane Potential, http://pubs.usgs.gov/dds/dds-077/ .*

*[193]Energy Information Administration, U.S. Coal Reserves, December 16, 2013, http://www.eia.gov/coal/reserves/*

*[194]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_3.pdf*

*[195]Energy Information Administration, Coal Explained: How Much Coal is Left, http://tonto.eia.doe.gov/energyexplained/index.cfm?page=coal_reserves.*

*[196]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=6*

*[197]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_3.pdf*

*[198]Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014, April 17, 2014, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm .*

*[199]See Gilbert Metcalf, Federal Tax Policy Toward Energy, p. 22, Oct. 2007,*

*http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt142.pdf .*

*[200]Id.*

*[201]Id.*

*[202]Nuclear Energy Institute, U.S. Electricity Production Costs and Components, August 14, 2014, http://www.nei.org/Knowledge-Center/Excel-Files/US-Electricity-Production-Costs-and-Components*

*[203]Energy Information Administration, Electric Power Monthly, Table 5.6.B., Average Retail Price of Electricity, February 2014, http://www.eia.gov/electricity/monthly/current_year/february2014.pdf*

*[204]Email from J. Kukielka, NETL to Mary Hutzler, Institute for Energy Research, Jan. 9, 2009. See also Institute for Energy Research, The Facts About Air Quality and Coal-Fired Power Plants, http://www.instituteforenergyresearch.org/2009/06/01/the-facts-about-air-quality-and-coal-fired-power-plants/.*

*[205]Environmental Protection Agency, Air Quality Trends, Sept. 3, 2013, http://www.epa.gov/airtrends/aqtrends.html.*

*[206]Environmental Protection Agency, Air Quality Trends, http://www.epa.gov/airtrends/aqtrends.html. The specific graphic is available here: http://www.epa.gov/airtrends/images/y70_13.png.*

*[207]Sierra Club, 150 Coal Plants Unplugged, http://www.sierraclub.org/coal/150plants/. Also, many other environmental groups have fought coal-fired power plants. See e.g. U.S. Chamber of Commerce, Project, No Project, http://www.projectnoproject.com/category/project/coal .*

*[208]Juliet Eilperin, Obama administration cracks down on mountaintop mining, WASHINGTON POST, Jan. 13, 2011, http://www.washingtonpost.com/wp-dyn/content/article/2011/01/13/AR2011011307095.html .*

*[209]Environmental Protection Agency, Final Determination of the U.S. Environmental Protection Agency Pursuant to § 404(c) of the Clean Water Act Concerning the Spruce No. 1 Mine, Logan County, West Virginia, http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/upload/Spruce_No-_1_Mine_Final_Determination_011311_signed.pdf . See e.g. p. 7.*

*[210]Paul Bedard, New Fears EPA Smog Rule Will Cost 7.3 Million Jobs, July 19, 2011, http://www.usnews.com/news/washington-whispers/articles/2011/07/19/new-fears-epa-smog-rule-will-cost-73-million-jobs-new-fears-epa-smog-rule-will-cost-73-million-jobs .*

*[211]Business Roundtable, Aggressive Emissions Regulations Will Cast 85 Percent of U.S. Counties with ozone monitors into "non-attainment", http://businessroundtable.org/uploads/studies-reports/downloads/2011_07_15_National_Ambient_Air_Quality_Standard_for_Ozone.pdf .*

*[212]Patrick Reis, EPA sets water standards in bid to curb mountain-top mining pollution, E&E News PM, April 1, 2010.*

*[213]Anna Palmer & Robin Bravender, Gas company, lung association team up, POLITICO, Dec. 14, 2011, http://www.politico.com/news/stories/1211/70470.html .*

*[214]John Barrasso, Barrasso: EPA Rules will Destroy Jobs, Communities, & Affordable Energy, News Releases, September 20, 2013, http://www.barrasso.senate.gov/public/index.cfm/2013/9/post-3be71667-ce55-62ff-8684-a321ac41bd2c*

*[215]Institute for Energy Research, Obama's War on Coal Continues While Global Demand Increases, January 27, 2014, http://instituteforenergyresearch.org/analysis/obamas-war-on-coal-continues-while-global-demand-increases/*

*[216]NERA Economic Consulting, Potential Energy Impacts of the EPA Proposed Clean Power Plan, October 2014, http://americaspower.org/sites/default/files/NERA_CPP%20Report_Final_Oct%202014.pdf*

*[217]Institute for Energy Research, EPA's Power Plant Rule to Cost At Least $366 Billion, October 23, 2014, http://instituteforenergyresearch.org/analysis/epas-power-plant-rule-cost-least-366-billion/*

*[218]Energy Information Administration, International Energy Statistics: Coal Consumption, http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=1&aid=2 .*

# NUCLEAR

- The United States is the world's largest producer of nuclear power.
- Nuclear power provides 19 percent of the electricity in the United States.
- Today there are 100 nuclear reactors in the United States.
- Because of regulatory hurdles, it costs 200–250 percent more to build a nuclear power plant in the United States than in China.

The United States was the world's first, and remains the world's largest, producer of nuclear power. Today, nuclear electric power provides 19 percent of the nation's electricity.[224] Although the United States produces more nuclear power than any other country, other countries generate a larger percentage of their electricity from nuclear power. France, for example, generates 77 percent of its electricity from nuclear energy. [225]

The first commercial power generation from a nuclear plant in the United States occurred in 1957, in Santa Susana, California.[226] The United States now has 100 nuclear power reactors, located in 31 states.[227] The last new nuclear reactor in the United States was brought on line in 1996.[228] Between 1973 and 2010, electricity generated from nuclear power rose from 80 billion kilowatt hours to over 800 billion kilowatt-hours.[229] Since then, it has declined slightly, as some nuclear reactors have been taken off line and retired permanently.

After a nearly 30 year-long hiatus on licensing new plants, the Nuclear Regulatory Commission (NRC) granted Southern Co. and Scana Corp. licenses in 2012 to build new facilities.[230] In February 2012, the NRC approved a license allowing for the construction and conditional operation of two new nuclear reactors at the Vogtle nuclear power plant in Georgia, marking the first time the commission green-lighted construction for a new reactor since 1978. Then, in March 2012, the NRC approved a second license allowing construction and conditional operation of two new reactors at Scana Corp.'s Virgil C. Summer nuclear power plant in South Carolina. The licensing process, however, remains slow and cumbersome for new designs due to the NRC's inexperience with non-Light Water Reactors (LWRs).

Uranium is the most commonly used fuel in nuclear power plants. In a nuclear reactor, subatomic particles called neutrons strike atoms of Uranium-235 (U-235),[231] breaking them apart. This split, known as nuclear fission, releases an incredible amount of energy in the form of heat and radiation.

One ton of natural uranium can produce as much electricity as burning 16,000 tons of coal or 80,000 barrels of oil.[232] In a nuclear power plant, this heat is used to boil water, produce steam, and turn the turbines that generate electricity.

## Nuclear Challenges in the United States

The main obstacles to nuclear power are its relatively high cost, disposal of the spent nuclear fuel, and activist opposition to the construction of new plants.

New nuclear power plants are expensive. The EIA estimates that the cost of generating electricity from a new nuclear plant in 2019 will be 9.61 cents per kilowatt-hour (in 2012 dollars), 49 percent higher than that of a natural gas combined cycle plant. [233]

The United States has also placed numerous regulatory obstacles in the way of new nuclear power plants. For example, China can build a Western-designed nuclear reactor in 46 months, or less than four years. That is quite a feat considering that it takes France almost six years to build a new reactor and it costs the Chinese 40 percent less, around $4 billion, compared to almost $7 billion for France.

In the United States, environmental and regulatory approvals lengthen the time from initiation of the project until operations begin, increasing financing costs and making capital more difficult to obtain. The EIA estimates the overnight capital cost (the estimate of capital costs if the plant could be constructed in one day)[234] for an advanced nuclear reactor at $5,530 per kilowatt (in 2012 dollars).[235] The construction costs of nuclear units undergoing the permit process that include these other charges (financing and contingencies) are estimated at around $8,000 to $10,000 per kilowatt.[236] This means that the fully loaded capital costs for domestic nuclear plants could potentially be 200 to 250 percent more expensive than a new Chinese nuclear plant.

Nuclear power does not emit greenhouse gases, making it a viable alternative to coal or natural gas for electricity generation in the view of some governments. Many environmentalists, however, have vigorously opposed nuclear power because they allege concerns about nuclear reactor safety and the storage of used nuclear fuel, thus creating another impediment to new nuclear plant construction in addition to cost. 23 nuclear projects to expand the generation of electricity at already existing nuclear plants or to build new plants are facing either prolonged delays or indeterminate completion dates, owing to opposition from environmental activist groups. [237]

## Nuclear Accidents

Nuclear power plants have an impressive safety record, but their safety record is not perfect. In the United States, the worst nuclear accident occurred at the Three Mile Island nuclear power plant in 1979.

At Three Mile Island, human and mechanical failures led to a core meltdown in one of the reactors. This led to a release of radioactive gas and radioactive water as the reactor was brought under control. Even though this was the worst nuclear accident in the United States, no deaths occurred and no adverse effects from the radiation release could be found on human, animals, or plant life in the area. [238]

In 1986, a nuclear accident occurred at the Chernobyl plant in the Soviet Union. A strong explosion caused the reactor vessel to rupture allowing the melting reactor core to spew large amounts of radioactive materials directly into the atmosphere for ten days.

The World Health Organization estimates that, as of 2005, the official death toll from the Chernobyl disaster is less than 50 people.[239] Eventually, a total of 4,000 radiation-related deaths of emergency workers and residents from the area may be linked to the accident. [240]

Unlike nuclear reactors in the United States and other industrialized countries, the Chernobyl reactor did not have a strong containment building around the reactor vessel. This design flaw allowed a large amount of radiation to escape containment when the explosion occurred.

In 2011, problems at the Fukushima Daiichi nuclear plant in Japan were caused by a huge earthquake and subsequent large tsunami. The 9.0 earthquake that hit the plant was the largest known earthquake to hit Japan and was one of the five largest earthquakes since 1900.[241] After the earthquake, a tsunami of 45 feet hit the plant. Because the plant was designed to withstand an 18-foot tsunami, it was overwhelmed, and critical cooling equipment was flooded.[242] The earthquake and tsunami disabled the cooling pumps, as well as the emergency backups for the reactors. This led to a partial meltdown in three of the reactors.

The Fukushima reactors are boiling water reactors. This type of reactor requires active cooling after a shutdown. At Fukushima, the damage from the earthquake and tsunami knocked out the pumps that cool the reactor core and possibly damaged the primary containment vessel.

The damage to the plant led to a release of radioactive material from the plant, but unlike at Chernobyl, no one died at Fukushima as a result of the radiation. Two workers suffered tsunami related deaths at the Fukushima plant. The Japanese authorities established a 20 kilometer exclusion zone around the beleaguered plant because radiation had spread. About 300,000 people were evacuated from the area[243], 15,884 people (as of February 10, 2014) died due to the earthquake and tsunami, and, as of August 2013, approximately 1,600 deaths were related to the evacuation conditions, such as living in temporary housing and hospital closures. [244]

How likely is a Fukushima-like accident in the United States? The United States has 35 nuclear reactors of the same design as those at Fukushima.[245] It is possible to have a chain of events, such as huge earthquake, followed by a tsunami that wipes out cooling backups, but such an event is exceptionally unlikely. [246]

Newer nuclear power plants are safer than boiling water reactors because new plants do not require active cooling to keep the reactor core cool after shutdown. Boiling water reactors were designed more than 50 years ago, and nuclear technologies have greatly advanced since then.

## Reprocessing of Spent Nuclear Fuel

While reprocessing of used nuclear fuel occurs in most countries, in the United States, it does not. Reprocessing consists of separating and conditioning the components of spent nuclear fuel for recycling. When nuclear fuel leaves the reactor, approximately 97 percent of it can be recycled—96 percent as uranium and one percent as plutonium, leaving three percent as non-reusable waste material.[247] Thus, reprocessing allows for the conservation of natural uranium resources and reduces both the volume and toxicity of the final waste materials.

The United States had a few private reprocessing facilities in the 1960s and 1970s, but they were terminated for a number of reasons—the cost of regulation compliance, equipment problems, technical failures, and concern about nuclear proliferation. Since the 1970s, the federal government has not allowed nuclear reprocessing. [248]

Rather than reprocess, the United States opted to store the spent nuclear fuel at a disposal site, with the last attempt being Yucca Mountain in Nevada. The Obama administration, however, has withdrawn the majority of funding for that project, which leaves the United States in limbo regarding the treatment of spent nuclear fuel. Allison MacFarlane, the head of the NRC, proposed as a possible model for future repositories, the Waste Isolation Pilot Plant in Carlsbad, New Mexico, where the radioactive leftovers from U.S. defense facilities are housed. [249]

## **FOOTNOTES:** NUCLEAR

[224]*Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total (All Sectors), November 2014, http://www.eia.doe.gov/emeu/mer/pdf/pages/sec7_5.pdf .*

[225]*Spero News, France: Energy Profile, June 8, 2007, http://www.speroforum.com/site/article.asp?idarticle=9839&t=France%3A+Energy+profile and Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.m?tid=2&pid=27&aid=12&cid=regions&syid=2008&eyid=2012&unit=BKWH*

[226]*Energy Information Administration, Energy Timelines: Nuclear, http://www.eia.gov/kids/energy.cfm?page=tl_nuclear .*

[227]*Energy Information Administration, State Nuclear Profiles, http://www.eia.doe.gov/cneaf/nuclear/state_profiles/nuc_state_sum.html ; Energy Information Administration, Monthly Energy Review, Nuclear Energy Overview, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec8_3.pdf .*

[228]*Congressional Research Service, CRS Report for Congress; Nuclear Power: Outlook for New U.S. Reactors, Page CRS-5, March 9, 2007, http://www.fas.org/sgp/crs/misc/RL33442.pdf .*

[229]*Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf*

[230]*World Nuclear Association, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA--Nuclear-Power/#.UayfmECThf0 .*

[231]*U-235 is Uranium that has been enriched to the point that it can be used in a fission reactor. Federation of American Scientists, Uranium Production, http://www.fas.org/programs/ssp/nukes/fuelcycle/centrifuges/U_production.html .*

[232]*Argonne National Laboratory, Uranium Quick Facts, http://web.ead.anl.gov/uranium/guide/facts/ .*

[233]*Energy Information Administration, Levelized Cost of New Generation Resources from the Annual Energy Outlook 2014, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm .*

[234]*These costs exclude contingencies. The American Association of Cost Engineers defines a contingency allowance as the "specific provision for unforeseeable elements of costs within a defined project scope, particularly important where previous experience has shown that unforeseeable events which will increase costs are likely to occur." See footnote 2 at this link for EIA's definition of "overnight capital costs." http://www.eia.gov/oiaf/beck_plantcosts/index.html#2 .*

[235]*Energy Information Administration, Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants, April 12, 2013, http://www.eia.gov/forecasts/capitalcost/*

[236]*Robert Peltier, What's the Price of Nuclear Power? (probably higher than you think), Master Resource, July 10, 2010, http://www.masterresource.org/2009/07/whats-the-price-of-nuclear-power-probably-higher-than-you-think/*

[237]*U.S. Chamber of Commerce, Project, No Project, http://www.projectnoproject.com/category/project/nuclear/ .*

[238]*Nuclear Regulatory Commission, Backgrounder on the Three Mile Island Accident, Aug. 2009, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html*

[239]*World Health Organization, Chernobyl: the true scale of the accident, Sept. 5, 2005, http://www.who.int/mediacentre/news/releases/2005/pr38/en/index.html .*

[240]*Nuclear Regulatory Commission, Backgrounder on Chernobyl Nuclear Power Plant Accident, Apr. 2009, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/chernobyl-bg.html .*

[241]*BBC, Japan earthquake: Tsunami hits north-east, BBC NEWS, Mar. 11, 2011, http://www.bbc.co.uk/news/world-asia-pacific-12709598 .*

[242]*World Nuclear News, Fukushima face 14-metre tsunami, Mar. 23, 2011, http://www.world-nuclear-news.org/RS_Fukushima_faced_14-metre_tsunami_2303113.html .*

[243]*Wikipedia, Emergency Evacuation, http://en.wikipedia.org/wiki/Emergency_evacuation*

[244]*Ryan Nakashima & Mari Yamaguchi, Tsunami killed 2 workers at Japan nuke plant¸ Associated Press, Apr. 2, 2011, http://www.boston.com/business/articles/2011/04/02/japanese_pm_on_1st_visit_to_tsunami_hit_villages/ and Wikipedia, Fukushima Daiichi nuclear disaster, http://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster .*

[245]*Tom Zeller, Jr., U.S. Nuclear Plants Have Same Risk, and Backups, as Japan Counterparts, N.Y. TIMES, Mar. 13, 2011, www.nytimes.com/2011/03/14/world/asia/14industry.html .*

[246]*Id.*

[247]*World Nuclear Association, Processing of Used Nuclear Fuel, Jan. 2011, http://www.world-nuclear.org/info/inf69.html .*

[248]*Anthony Andrews, Nuclear Fuel Reprocessing: U.S. Policy Development, Congressional Research Service, Mar. 27, 2008, http://fas.org/sgp/crs/nuke/RS22542.pdf .*

[249]*Macfarlane is leaving the NRC effective January 2015. Brad Plumer, What New Mexico Can Teach Us About Storing Nuclear Waste, June 13, 2012, http://www.washingtonpost.com/blogs/wonkblog/post/what-new-mexico-can-teach-us-about-storing-nuclear-waste/2012/06/13/gJQAxyEJaV_blog.html and Wall Street Journal, NRC Chairwoman Allison Macfarlane to Leave Agency, October 21, 2014, http://www.wsj.com/articles/nrc-chairwoman-allison-macfarlane-to-leave-agency-1413929095 .*

# BIOMASS

- Biomass, including ethanol, produces 4.7 percent of the total energy consumed in the United States.
- Biomass represents roughly 1.5 percent of U.S. electricity generation.
- Replacing U.S. gasoline consumption with corn ethanol would require planting 500 million acres with only corn—more than the current total U.S. cropland.
- Congress mandated the production of 100 million gallons of cellulosic ethanol in 2010, but not a drop of cellulosic ethanol was commercially blended with gasoline in 2010. Even in 2013, little cellulosic ethanol has been produced because the technology is not economic.

Biomass, especially wood, was the world's primary energy source until the widespread use of coal during the later part of the Industrial Revolution. In fact, in many poorer countries, biomass remains the most important source of heat. Biomass provides 80 percent of the energy in about 20 of the world's poorest countries.[250]

Biomass is a broad renewable energy category encompassing energy derived from a variety of biological materials, such as wood and corn (made into ethanol), as well as energy derived from such waste sources as municipal solid waste, manufacturing waste, and landfill gas.[251]

In the United States, biomass accounts for 1.5 percent of the nation's electricity.[252] In 2013, over 65 percent of biomass-generated electricity was derived from wood and wood-derived fuels; the rest from waste[253] All told, biomass produced 4.7 percent of energy in the United States in 2013. This is almost 50 percent of the total renewable energy consumed across the country.[254]

Even solar, hydro, and wind power produce 10 times the amount of energy per acre than biomass can produce from the world's most productive ecosystems.[255] And solar, hydro, and wind power take much more land to produce the same amount of energy as oil, coal, or natural gas.

Consider that, for biomass to replace the amount of energy produced by the use of coal in the year 2000, it would take cultivating the total forested land area of both the United States (including Alaska) and the European Union.[256] But even this would not be enough land today as global coal use has increased by 60 percent since 2000.[257] Replacing U.S. gasoline consumption with ethanol would require cultivating corn on all of the cropland in the United

States, plus an additional 20 percent.[258] In 2002, the U.S. Department of Agriculture reported that U.S. cropland totaled 442 million acres.[259] This means that replacing U.S. gasoline consumption with corn ethanol would require growing corn on more than 500 million acres.

## Ethanol and Other Biofuels

Biofuels consist of a wide range of fuels derived from biomass. The most widely used biofuel is ethanol (another name for alcohol) made from corn. Besides corn, biofuels are made from fermenting sugar-rich crops such as sugar cane and sugar beets.

Just a few years ago, some hailed ethanol as a savior.[260] Allegedly, ethanol production would reduce the carbon dioxide emissions from transportation fuels and reduce dependence on imported oil. As Congresswoman Nancy Pelosi put it, “Our plan will send our energy dollars to the Midwest, not the Middle East.”[261] In 2007, at the behest of President George W. Bush, Congress passed the Energy Independence and Security Act, which included a renewable fuels mandate. The mandate required the production of 20.5 billion gallons of renewable fuel in 2015 increasing to 36 billion gallons in 2022. The mandate also required 16 billion gallons of cellulosic biofuel to be produced by 2022.[262]

## Biofuel Production May Increase Greenhouse Gas Emissions

While one justification for the renewable fuel mandate was to decrease carbon dioxide emissions, some scientific research suggests otherwise. In fact, some corn-based ethanol production and other forms of ethanol production may actually increase carbon dioxide emissions rather than reduce them. According to a study published in Science by the Nature Conservancy and the University of Minnesota, many biofuels emit more greenhouse gases than gasoline. According to the researchers, these biofuels may produce “17 to 420 times more carbon dioxide than the fossil fuels they replace.”[263] Other research has come to similar conclusions. The Energy and Resources Group of the University of California, Berkeley found that “if indirect emissions [resulting from the production of ethanol] are applied to the ethanol that is already in California’s gasoline, the carbon intensity of California’s gasoline increases by 3% to 33%.”[264] Not only does ethanol production appear to produce more greenhouse gas emissions than petroleum production, but ethanol production and combustion may lead to worse air quality than petroleum production.[265]

But even if biofuel production reduces greenhouse gas emissions, producing ethanol is, nevertheless, a very expensive way to achieve this goal. According to the Congressional Budget Office (CBO), the production of corn ethanol costs $750 per metric ton of carbon dioxide emissions avoided. [266]

## Ethanol Production and Mandates

In 2013, out of the 13.93 billion bushels of corn produced, 5.05 billion were used for corn-based ethanol, indicating that 36percent of corn production was used to produce ethanol.[267] The drought in the Midwest in 2012 resulted in low corn production output, which rebounded in 2013 and set a new record.

While corn-based ethanol has rapidly grown, cost-effective cellulosic ethanol remains a dream. In 2010, E&E News reported that, instead of producing 100 million gallons as mandated by Congress, “not a drop” of cellulosic ethanol was “commercially blended with gasoline.”[268] In late 2011, the EIA was still unsure as to whether any cellulosic ethanol had been sold commercially despite Congress’ mandate to produced 500 million gallons in 2011.[269] Due to the unlikely commercial production of cellulosic ethanol to the mandated levels, in 2013, the EPA cut the required amount of cellulosic ethanol to six million gallons, which is less than half of the previously required amount of 14 million gallons.[270] If refineries are unable to purchase their required amount, they must purchase credits, called Renewable Identification Numbers.

## Renewable Identification Numbers

Not only do refiners need to purchase Renewable Identification Numbers if they cannot use the required level of cellulosic ethanol, but they also confront the fine if they cannot blend their share of the total ethanol requirement. This issue confronts U.S. refineries because the amount of ethanol required by the Renewable Fuel Standard is reaching a blend wall, the point where the required amount of ethanol is almost at the 10 percent blend level at which automobile manufacturers are willing to warranty their vehicles. Each Renewable Identification Number credit allows a refiner to reduce its blend amount by a gallon of ethanol. These increased costs are passed onto distributors, who then pass them onto consumers.

Renewable Identification Number credits have escalated in cost from a few pennies in 2012 to as much as $1.40 in 2013. Major refiners have had to spend hundreds of millions of dollars on them, passing along their additional costs by raising fuel prices. It is estimated that the cost to consumers is about 10 cents per gallon. According to the National Policy Research Association, by next year, when the renewable mandate will increase to 18.15 billion gallons from 16.55 billion gallons currently[271], the purchase of RIN credits is expected to increase the price of a gallon of gasoline by 20 cents to $1.[272] And, according to a study by NERA Economic Consulting, exceeding the blend wall could result in diesel fuel costs increasing by as much as 300 percent and a 30 percent increase in gasoline costs by 2015. [273]

Because of these issues, EPA has proposed reducing the 2014 mandated level of ethanol from the currently mandated level of 18.15 billion gallons.[274] However, while EPA is mandated to provide the required RFS values for a given year by November of the preceding year, it has yet to provide the final 2014 requirements and has indicated it will not provide them until some time in 2015.

## Other Favorable Treatments for Ethanol

Besides a federal mandate to produce billions of gallons of ethanol a year, ethanol received other favorable treatment designed to increase domestic ethanol production. From 1980 through 2011, U.S. ethanol producers were protected by a 54-cent per gallon tariff on imported ethanol. In recent years, ethanol blenders were eligible for a 45-cent tax subsidy for every gallon of corn ethanol blended with gasoline. At the end of 2011, both the ethanol tariff and the blenders' tax credit expired. [275]

These programs have been costly. The CBO reports that they cost taxpayers $1.78 per gallon for ethanol made from corn and $3.00 for cellulosic ethanol. [276]

## E10, E15, E85, and Ethanol Availability

Most U.S. ethanol has been used in E10, a blended fuel that is 10 percent ethanol and 90 percent gasoline. This fuel has been certified by the Environmental Protection Agency as suitable for use in typical gasoline-powered engines.[277] EPA recently certified E15 as safe for cars manufactured in 2001 or later. Some ethanol has been used as E85, a blended fuel that is 85 percent ethanol and 15 percent gasoline. In contrast to E10, E85 can be used only in specially designed Flexible Fuel Vehicles (FFVs). But EIA estimates that, of the 253 million registered vehicles in the United States in 2011, including the more than 15 million E85-compatible vehicles that have been sold, [278] just 862,837 vehicles, or 0.3 percent of all U.S. vehicles, are actually used as FFVs.[279] In addition to the limited use of E85, there is also limited distribution of it. Of the 157,393 retail gasoline stations in the U.S., only 2,639 stations, or 1.7 percent, offer E85. [280]

## Other Challenges for Ethanol

Ethanol is not as energy dense as gasoline. A gallon of ethanol contains about 34 percent less energy than a gallon of gasoline, which means that cars get fewer miles per gallon with ethanol than with gasoline.

The creation of ethanol also turns corn, a vital food stock, into motor fuel. This increases the price of a staple food and disproportionately affects the global poor. Because of this detrimental effect on the poor, Jean Zieglier, the former United Nations special rapporteur on the right to food, described ethanol as a "crime against humanity." [281]

Before the ethanol mandate became law, corn prices in the United States averaged less than $2.50 a bushel. Due mainly to growing demand by the ethanol industry, corn prices surged in 2008 to around $7 a bushel. Although the recession lowered those prices, they rebounded strongly hitting over $8 a bushel in 2012, remaining above $6 a bushel for the past 2 years. Prices, however, have begun to fall due to the nearness of the blend wall and a very strong corn crop in 2013. The 2013 corn harvest totaled 13.93 billion bushels, about 30 percent higher than last year's harvest of 10.8 billion bushels and more than 10 percent higher than the corn harvest in 2011 of 12.4 billion bushels. The record crop brought corn prices down to around $4.25 a bushel, still 70 percent higher than before the ethanol mandate. [282]

Even though ethanol can be used as a motor fuel, it cannot be transported in the same pipelines as petroleum products because it has an affinity for water. Instead, ethanol must be transported in specially designed trucks or trains and mixed with gasoline at the distribution center. This increases the cost of using ethanol over petroleum-based fuel and contributes to the argument that ethanol actually increases, rather than decreases, greenhouse gas emissions.

## Biofuel Failure

Despite the federal government's renewable fuel mandate and government loans, some renewable fuel producers have struggled. One such firm was the Colorado-based Range Fuels. The company received generous government assistance, including $76 million in federal grants, and $80 million in loan guarantees from the Department of Agriculture,[283] but the company failed, leaving taxpayers holding the bag.[284] More recently, KiOR filed for bankruptcy after receiving a $250 million loan guarantee from the Department of Agriculture and a $75 million loan from the state of Mississippi. KiOR was expected to turn wood chips into hydrocarbons that could be poured straight into a refinery, pipeline or vehicle. [285]

**FOOTNOTES:** BIOMASS

*[250]Vaclav Smil, ENERGY AT THE CROSSROADS p. 260 (2005), http://www.amazon.com/Energy-Crossroads-Global-Perspectives-Uncertainties/dp/0262693240 .*

*[251]Energy Information Administration, http://www.eia.gov/todayinenergy/detail.cfm?id=15451 .*

*[252]Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total (All Sectors), November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[253]Id.*

*[254]Energy Information Administration, Monthly Energy Review, Primary Energy Consumption by Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf*

*[255]Vaclav Smil, ENERGY AT THE CROSSROADS p. 264 (2005), http://www.amazon.com/Energy-Crossroads-Global-Perspectives-Uncertainties/dp/0262693240 .*

*[256]Id.*

*[257]Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=1&pid=1&aid=2&cid=regions&syid=2000&eyid=2012&unit=TST*

*[258]Vaclav Smil, ENERGY AT THE CROSSROADS p. 264 (2005), http://www.amazon.com/Energy-Crossroads-Global-Perspectives-Uncertainties/dp/0262693240 .*

*[259]U.S. Department of Agriculture, Major Uses of Land in the United States, 2002, May 2006, http://www.ers.usda.gov/media/250009/eib14f_1_.pdf.*

*[260]See Clifford Krauss, Ethanol, Just Recently a Savior, Is Struggling, N.Y. TIMES, Feb. 11, 2009, p. A1, http://www.nytimes.com/2009/02/12/business/12ethanol.html .*

*[261]Congresswoman Nancy Pelosi, Pelosi: Energy Bill Will Be 'Shot Heard 'Round the World' for Energy Independence for America, Dec. 6, 2007, http://pelosi.house.gov/news/press-releases/2007/12/releases-Dec07-EnergyBill.shtml .*

*[262]Energy Independence and Security Act of 2007, Pub. L. No. 110-140 (2007), http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf .*

*[263]Joseph Fargione et al., Land Clearing and the Biofuel Carbon Debt, 319 SCIENCE 1235 (2008), available at http://www.sciencemag.org/cgi/content/abstract/1152747 .*

*[264]Alex Farrell & Michael O'Hare, Greenhouse gas (GHG) emissions from indirect land use change (LUC), Energy & Resources Group University of California Berkley, Jan. 12, 2008, http://www.arb.ca.gov/fuels/lcfs/011608ucb_luc.pdf .*

*[265]Jason Hill et al., Climate change and health costs of air emissions from biofuels and gasoline, 106 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 2077 (2009) available at http://www.pnas.org/content/106/6/2077.full.pdf+htm l.*

*[266]Congressional Budget Office, Using Biofuel Tax Credits to Achieve Energy and Environmental Policy Goals, July 2010, http://www.cbo.gov/ftpdocs/114xx/doc11477/11477_Summary.pdf.*

*[267]U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/data/tab/all/data_set/10339 .*

*[268]Diane Fine Maron, Much-touted cellulosic ethanol is late in making mandated appearance, CLIMATEWIRE, Jan. 11, 2011, http://www.eenews.net/climatewire/stories/1059943863/search?keyword=Much-touted+cellulosic+ethanol+is+late+in+making+mandated+appearance .*

*[269]Oct. 15, 2011 letter by EIA Acting Administrator Howard Gruenspecht to EPA Administrator Lisa Jackson.*

*[270]Energy and the Environment: Clearing the Air, Reality Smacks Down Ethanol, August 7, 2013, http://environmentblog.ncpa.org/reality-smacks-down-ethanol/ .*

*[271]Energy Security and Independence Act of 2007, http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf*

*[272]USA Today, Ethanol quotas pump money from your pocket, August 18, 2013, http://www.usatoday.com/story/opinion/2013/08/15/ethanol-mandate-energy-editorials-debates/2663215/*

*[273]Michael Bastasch, Industries spar over the future of renewable fuel subsidies, Daily Caller, July 23, 2013, http://dailycaller.com/2013/07/23/industries-spar-over-the-future-of-renewable-fuel-subsidies*

*[274]Energy and the Environment: Clearing the Air, Reality Smacks Down Ethanol, August 7, 2013, http://environmentblog.ncpa.org/reality-smacks-down-ethanol/.*

*[275]Pierre Bertrand, Say Goodbye to U.S. Ethanol Tax Breaks and Tariffs, INT'L BUSINESS TIMES, Dec. 30, 2011, http://www.ibtimes.com/articles/274811/20111230/ethanol-tax-tariff-corn-sugarcane-brazil.htm .*

*[276]Congressional Budget Office, Using Biofuel Tax Credits to Achieve Energy and Environmental Policy Goals, July 2010, http://www.cbo.gov/ftpdocs/114xx/doc11477/11477_Summary.pdf .*

*[277]U.S. Department of Energy, Energy Efficiency & Renewable Energy, Ethanol Blends, http://www.afdc.energy.gov/afdc/ethanol/blends_e10.html .*

*[278]Wikipedia, Flex-Fuel Vehicles in the United States, http://en.wikipedia.org/wiki/Flexible-fuel_vehicles_in_the_United_States .*

*[279]U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, National Transportation Statistics-Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html ; Energy Information Administration, Alternative-Fuel Vehicle Data, http://www.eia.gov/renewable/afv/users.cfm?fs=a&uyear=2011&ufueltype=e85 .*

*[280]Alternative Fuels and Advance Vehicles Data Center, Alternative Fueling Station Total Counts by State and Fuel Type, http://www.afdc.energy.gov/data/10332 and American Petroleum Institute, Service Station FAQs, http://www.api.org/oil-and-natural-gas-overview/consumer-information/service-station-faqs .*

*[281]Grant Ferrett, Biofuels 'crime against humanity,' BBC NEWS, Oct. 27, 2007, http://news.bbc.co.uk/2/hi/americas/7065061.stm .*

*[282]Wall Street Journal, A Corn Boom Starts to Wilt, August 11, 2013, http://online.wsj.com/article/SB10001424127887323446404579006594160246998.html and U.S. Department of Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/data/tab/all/data_set/10339 and Bloomberg, Corn Caps Biggest Drop Since 1960 as Harvest Rises to Record, December 31, 2013, http://www.bloomberg.com/news/2013-12-31/corn-set-for-worst-drop-since-60-as-crop-prices-slump-on-output.html*

*[283]Tom Pyle, You Can't Make This Stuff Up, Jan. 21, 2011, http://instituteforenergyresearch.org/analysis/you-cant-make-this-stuff-up/ .*

*[284]Dan Chapman, Georgians on the hook for failed ethanol facility, ATLANTA JOURNAL CONSTITUTION, Jan. 5, 2012, http://www.ajc.com/news/news/local-govt-politics/georgians-on-the-hook-for-failed-ethanol-facility/nQP6H/*

*[285]Steven Mufson, Billionaire Vinod Khosla's big dreams for biofuels fail to catch fire, The Washington Post, November 18, 2014, http://www.washingtonpost.com/business/economy/billionaire-vinod-khoslas-big-dreams-for-biofuels-fail-to-catch-fire/2014/11/27/04899d12-69d7-11e4-9fb4-a622dae742a2_story.html*

# HYDROELECTRIC

- Hydroelectric power provides 2.6 percent of total U.S. energy supply.
- Hydroelectric power produces 6.6 percent of U.S. electricity.
- The United States is the world's fourth largest hydroelectric producer behind China, Brazil and Canada.[286]

Hydroelectric power is the second most significant source of renewable energy in the United States, providing 2.6 percent of total energy and roughly 28 percent of all renewable energy.[287] This energy is wholly dedicated to generating electricity, providing about 6.6 percent of U.S electricity.[288] Hydroelectricity generates 6 percent more electricity than all the other renewable energy sources combined.[289]

At first blush, hydroelectric power plants seem very attractive. Hydroelectric power can be used to cover peak loads in electrical grids, unlike other renewable energy, coal, nuclear, or combined cycle natural gas. Hydroelectric power plants do not create greenhouse gases and are environmentally friendly. Also hydroelectric dams serve multiple purposes: flood control, irrigation, the provision of drinking water, and recreation. Lastly, the states that generate a large percentage of their electricity from hydroelectric power have some of the lowest electricity prices in the country.

Hydroelectric dams, however, have an environmental impact. The reservoirs submerge large areas, migrating fish have a difficult time bypassing the dams, native fish populations frequently struggle to survive in reservoirs, and decaying vegetation in the reservoirs releases greenhouse gases.

Hydroelectric development has also been limited because hydroelectric power plants must be located on suitable waterways, and many locations have already been used. The Alaska Energy Authority, however, is currently working on the first large dam to be built in the United States since 1979.[290] The dam is currently scheduled to be completed in 2023.

FOOTNOTES: HYDROELECTRIC

[286] *Energy Information Administration, International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=33&aid=12&cid=regions&syid=2005&eyid=2013&unit=BKWH*

[287] *Energy Information Administration, Monthly Energy Review, Table 1.3: Primary Energy Consumption by Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf.*

[288] *Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total (All Sectors, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf*

[289] *Id.*

[290] *News Minor, Alaska pursuing major dam project, January 16, 2013, http://www.newsminer.com/alaska-pursuing-major-dam-project/article_e1ad5944-0c0e-59c7-bdab-5a1b5d49c032.html?mode=jqm and Bureau of Reclamation, The History of Hydropower Development in the United States, Aug. 12, 2009, www.usbr.gov/power/edu/history.html .*

# WIND

- Wind power provides 1.6 percent of our total energy.
- Wind power produces 4.1 percent of our electricity.
- The United States has the second largest wind capacity in the world, second to China.
- U.S. wind producers receive a tax credit for the wind generation that they produce for the first 10 years of operation.
- Wind is highly dependent on subsidies for new construction.

During the last decade, energy production from wind has dramatically increased. Today, wind produces about 15 times as much electricity in the United States as it did 10 years ago.[291] But even after this dramatic increase, wind produces only 1.6 percent of our energy[292] and 4.1 percent of our electricity.[293]

## Wind Generation

In 2010, China surpassed the United States as the country with the largest installed wind capacity. At the end of 2013, China had 50 percent more wind capacity than the United States,[294] but not all of China's wind capacity is connected to the grid.

While the United States has a large amount of wind capacity, other countries produce a larger share of their electricity from wind. One of these countries is Denmark. Denmark produced over 30 percent of its total electricity generation from wind in 2012[295] but cannot use all of this wind-produced electricity.[296] West Denmark cannot use, and therefore exports, over 50 percent of the wind power it generates.[297] Most of those exports are transmitted to Norway and Sweden, whose electricity is composed mainly of hydroelectric power, a zero-emitting greenhouse gas technology that can act as storage for Denmark's wind-generated electricity. In order to generate such a large percentage of its electricity from wind, Denmark provides large subsidies to wind producers. As a result, Danish residents pay more for their electricity than any other country in the European Union and more than 3 times what U.S. residential customers currently pay.[298]

## Subsidies, Mandates, and Preferential Tax Treatment

In an effort to boost wind generation in the United States, the federal government provides wind energy producers with substantial tax subsidies. Although fossil fuels receive larger total subsidies than wind power, when one compares the subsidies per unit of energy output, wind subsidies dwarf those of more conventional resources. According to EIA, total federal subsidies for wind-generated electricity for fiscal year 2007 were $23.37 per megawatt-hour, compared to $1.59 for nuclear, $0.67 for hydroelectric power, $0.44 for conventional coal, and $0.25 for natural gas and petroleum liquids.[299]

In fiscal year 2010, the subsidies for renewables were even higher. For solar power, the subsidies totaled $775.64 per megawatt hour, for wind $56.29, for nuclear $3.14, for hydroelectric power $0.82, for coal $0.64, and for natural gas and petroleum liquids $0.64.[300]

Wind power currently receives a production tax credit of 2.3 cents per kilowatt-hour for electricity generated over the first 10 years of operation.[301] The production tax credit has expired and been reinstated by Congress several times since it was first enacted in 1992. For example, the production tax credit expired at the end of 2012, and Congress extended it a few days later in the American Taxpayer Relief Act of 2012.[302] Because Congress broadened the definition of what qualifies, the Joint Tax Committee estimated the extension to cost the American taxpayer $12.1 billion.[303] Congress has approved another retroactive extension of the wind Production Tax Credit in the Tax Extenders bill.[304]

Previously, wind producers had an option to select the production tax credit or opt for the section 1603 grant program. The 1603 grant program provides a grant for 30 percent of the basis of the property. This federal subsidy was originally set to expire in 2010, but legislation during the lame duck session of 2010 extended the program for another year.[305]

Because wind energy is more expensive than natural gas combined cycle technologies, companies rely on these government subsidies and mandates to construct their units and to sell electricity generated from wind. These subsidies, however, have kept wind energy prices artificially lower than their true costs.[306]

Offshore wind costs 2.5 times as much as onshore wind but is still being promoted by some politicians in the United States. The Cape Wind project, off the coast of Cape Cod in Massachusetts, is expected to be the first offshore wind farm in the United States. The 130-turbine wind farm is estimated to cost at least $2 billion and was approved in 2010 by Interior Secretary Ken Salazar after more than eight years of federal review. National Grid, the state's largest utility, is to buy half of Cape Wind's power, starting at 18.7 cents per kilowatt-hour,[307] less than EIA's estimate of 22.15 cents per kilowatt hour, but increasing annually at 3.5 percent in a 15 year deal. But 18.7 cents per kilowatt-hour is still about twice what the utility had been paying for power from conventional sources and almost twice the average U.S. cost of electricity—10.08 cents per kilowatt in 2013.[308] Not surprisingly, the project was having trouble finding buyers for the other half of its output because of its high cost until NStar, the state's second largest utility, was pressured into buying power from Cape Wind in order to gain state approval for its merger with Northeast Utilities. Cape Wind also received a $150 million loan guarantee from the Department of Energy.[309]

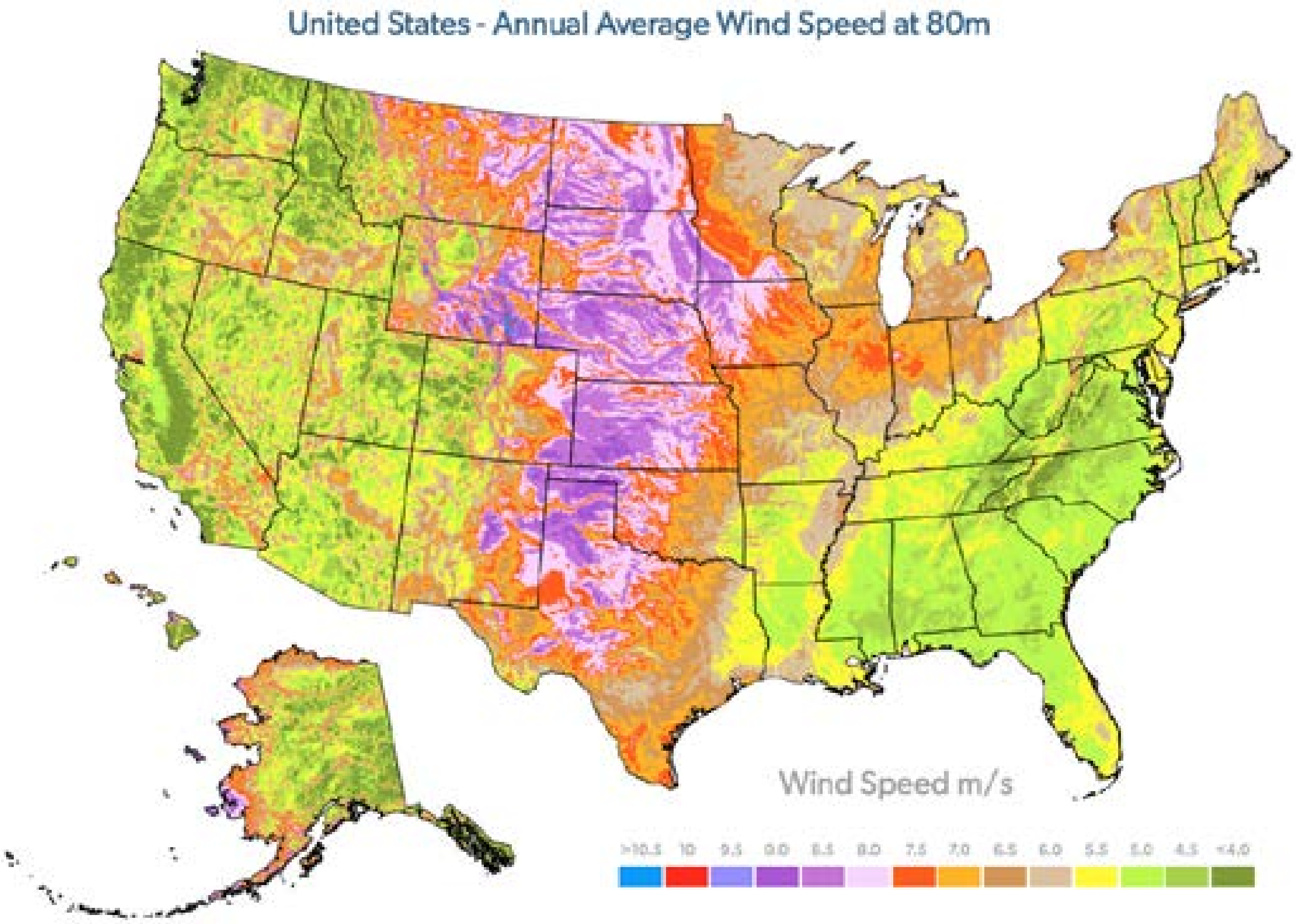
## Wind Challenges

One of the biggest challenges for wind is that the best wind resources are far from major population centers. Many states have areas of good wind potential, but the best area for wind in the United States is a corridor that extends from Texas to North Dakota. [310]

But while this corridor has good wind resources, it is far from population centers where electricity is needed. Long transmission lines would be needed to bring the power to market, and it is often difficult to secure permits to site new transmission lines.[312] For example, the Public Utility Commission of Texas estimates that it will cost $5 billion just to run a transmission line from the areas of good wind resources in west Texas to the population centers of east Texas.[313]

Wind turbines do not emit pollution as they produce electricity, but wind turbines nevertheless have negative environmental impacts. Wind turbines harm birds, bats, and other animal populations.[314] Many environmentalists are particularly concerned with the health of endangered raptor populations. There is also evidence that the vibrations and noise from wind turbines can cause negative health effects.[315] Lastly, many consider wind turbines to be unsightly and even unsettling in pastoral settings.

Because wind is a diffuse energy source, especially compared to fossil fuels, wind generation requires far more surface area to produce as much energy




as coal, oil, or natural gas. For example, it would take 7,700 3.6-megawatt wind turbines to produce as much energy per year as a high quality natural gas well.[316] That many wind turbines would cover an area of 1,475 square miles, or 65 times the size of Manhattan.[317]

Lastly, we like electricity to be always on and always on-demand. But the wind doesn't always blow. Weather forecasts are improving, and these improved forecasts are helping better predict when and how much the wind will blow, but that does not help balance the ups and downs of electricity demand.[318] As a result, wind power must have redundant backup such as natural gas turbines or hydropower to produce electricity when demand is high and wind power production is low.

The American Tradition Institute conducted a study to calculate wind's "hidden costs".[319] They found that when the hidden costs were taken into account—including the cost of fossil fuel power as back-up when the wind is dormant, the additional cost of transmission that frequently occurs with wind farms due to the inaccessibility of the best wind resources, the cost of wind's favorable tax benefits in 'accelerated depreciation', and a shorter estimated life of a wind turbine of 20 years (versus 30 years assumed in most cost estimates)—the cost of wind power is 15.1 cents per kilowatt hour if natural gas is used to back-up the wind energy or 19.2 cents per kilowatt hour if coal is used as the back-up fuel.[320] These costs are 1.9 to 2.4 times the 8.03 cents per kilowatt-hour[321] estimate the EIA is using for the average cost of generating electricity from wind in its models.

## **FOOTNOTES:** WIND

*[291]Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[292]Energy Information Administration, Monthly Energy Review, Table 1.3 Primary Energy Consumption by Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

*[293]Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

*[294]Global Wind Energy Council, Top 10 Cumulative Capacity Dec 2013, http://www.gwec.net/wp-content/uploads/2014/04/9_Top-ten-cumulative.jpg*

*[295]CleanTechnica, Wind Energy Hits Over 30% of Denmark's Electricity Consumption at the End of 2012, February 1, 2013, http://cleantechnica.com/2013/02/01/wind-energy-hits-over-30-of-denmarks-electricity-consumption-at-end-of-2012/*

*[296]Hugh Sharman & Henrik Meyer, Wind Energy: The Case of Denmark, p. 11, Sept. 2009, http://www.cepos.dk/fileadmin/user_upload/Arkiv/PDF/Wind_energy_-_the_case_of_Denmark.pdf .*

*[298]International Domestic Energy Prices, December 18, 2014, https://www.gov.uk/government/statistical-data-sets/international-domestic-energy-prices and Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec9_11.pdf*

*[299]Energy Information Administration, Federal Financial Interventions and Subsidies in Energy Markets 2007—Chapter 5: Electricity Subsidies Per Unit of Production (April 2008), p. 106, http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/chap5.pdf .*

*[300]Energy Information Administration, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010, July 2011, http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf and http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/*

*[301]Bloomberg, IRS Sets Wind Tax Regulations for 2013 Projects, April 15, 2013, http://www.bloomberg.com/news/2013-04-15/irs-sets-wind-tax-credit-regulations-for-2013-projects.html .*

*[302]Federal Electricity Production Tax Credit, http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F*

*[303]Institute for Energy Research, http://www.instituteforenergyresearch.org/2013/01/24/wind-industry-declares-war-on-plain-english-in-effort-to-expand-subsidies/*

*[304]Kelsey Snell, Senate approves tax extenders package without Ron Wyden, Politico, December 16, 2014, http://www.politico.com/story/2014/12/senate-approves-tax-extenders-package-113628.html*

*[305]Institute for Energy Research, Wind Finishes 2010 with Poor Showing in Capacity Increases, Jan. 26, 2011, http://www.instituteforenergyresearch.org/2011/01/26/wind-finishes-2010-with-poor-showing-in-capacity-increases/ .*

*[306]Energy Information Administration, Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook (April 2009), http://www.eia.doe.gov/oiaf/servicerpt/stimulus/index.html .*

*[307]Associated Press, Mass. court rejects challenge to Cape Wind permit, September 1, 2010, http://www.mysanantonio.com/news/environment/article/Mass-court-rejects-challenge-to-Cape-Wind-permit-694259.php .*

*[308]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalwanergy/data/monthly/pdf/sec9_11.pdf .*

*[309]Institute for Energy Research, http://www.instituteforenergyresearch.org/2010/12/29/expensive-offshore-wind-in-need-of-customers/ and http://instituteforenergyresearch.org/analysis/doe-provides-cape-wind-150-million-loan-guarantee/ .*

*[310]National Renewable Energy Laboratory, United States—Annual Average Wind Speed at 80 m, http://www.windpoweringamerica.gov/pdfs/wind_maps/us_windmap_80meters.pdf .*

*[312]Joey Peters, "Saudi Arabia of Wind" Has Trouble Figuring Out How to Get the Power Out, ClimateWire, Apr. 5, 2011, http://www.scientificamerican.com/article.cfm?id=saudi-arabia-wind-has-trouble-getting-power-out .*

*[313]Renewable Energy World, Texas PUC Approves Wind Transmission Plan, July 24, 2008, http://www.renewableenergyworld.com/rea/news/article/2008/07/texas-puc-approves-wind-transmission-plan-53138 .*

*[314]United States Government Accountability Office, Wind Power: Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife, Sept. 2005, p. 14, www.gao.gov/new.items/d05906.pdf .*

*[315]See e.g. Environmental Health Division, Minnesota Department of Health, Public Health Impacts of Wind Turbines, May 22, 2009, http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf "Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside noise levels above 35 dB(A). It has been hypothesized that direct activation of the vestibular and autonomic nervous system may be responsible for less common complaints, but there is scant evidence."*

*[316]Institute for Energy Research, Production from Developing Manteo Prospect Offshore North Carolina vs. Equivalent Wind Farm, Apr. 14, 2010, http://www.instituteforenergyresearch.org/2010/04/14/production-from-developing-manteo-prospect-offshore-north-carolina-vs-equivalent-wind-farm/ .*

[318]*Id.*

[318]*See Bonneville Power Administration, BPA Balancing Authority Load and Total Wind, Hydro, and Thermal Generation, Near-Real-Time, http://transmission.bpa.gov/business/operations/wind/baltwg.aspx .*

[319]*George Taylor & Tom Tanton, The Hidden Costs of Wind Electricity: Why the full cost of wind generation is unlikely to match the cost of natural gas, coal or nuclear generation, Dec. 2012, http://www.atinstitute.org/wp-content/uploads/2012/12/Hidden-Cost.pdf .*

[320]*Institute for Energy Research, http://www.instituteforenergyresearch.org/2013/01/04/the-hidden-costs-of-wind-power/*

[321]*Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014, April 17, 2014, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm .*

# GEOTHERMAL

- Geothermal power provides 0.2 percent of our total energy.
- Geothermal power produces 0.4 percent of our electricity.
- The United States is the largest geothermal producer in the world.

Geothermal energy is derived from the natural heat of the earth's core. Hot water or steam is extracted from underground to heat buildings or generate electricity. The United States generates more geothermal energy than any other country, but geothermal power provides only 0.2 percent of total U.S. energy[322] and 0.4 percent of U.S. electricity production.[323]

Most U.S. geothermal reservoirs are located in Alaska, Hawaii, and the western states. With current technology, reservoirs with temperatures of 300 to 700 degrees Fahrenheit are necessary for commercial power plants.[324] Hot water or steam is extracted from these reservoirs and piped to steam turbines that drive electricity generators.[325] Six states have geothermal power plants: California (49 plants), Nevada (27 plants), Utah (3 plants), Hawaii, Idaho, Alaska, New Mexico, Wyoming and Oregon (one plant each).[326]

Reservoirs with low or moderate temperatures can be used for direct-use applications such as space heating or for "district" heating (whereby a sole source of geothermal energy is used to heat multiple buildings or a wider community). Lower-temperature, shallow-ground geothermal resources can also be used by heat pumps to heat and cool individual buildings. This approach is becoming increasingly popular in new home construction.

## Geothermal is Renewable

Geothermal power is a renewable resource. The earth naturally produces heat, and whatever water is lost during the power generation process is replenished by rainfall.[327] Geothermal power has a negligible impact on the environment, as power plants do not burn fuel and therefore have very low emission levels. Steam from geothermal reservoirs naturally contains hydrogen sulfide, a hazardous air pollutant. This pollutant is removed from the hot water and steam through the use of scrubber systems.[328]

## Geothermal Challenges

Geography limits geothermal capacity. With current technology, there is a very limited number of high-grade locations where geothermal power can be affordably used. If geothermal technology improves, however, there is great potential. One study found that geothermal power could provide 10 percent of the electricity in the United States by 2050.[329] Currently, though, the technology to provide cost-effective geothermal outside of high-grade areas is not affordable.

**FOOTNOTES:** WIND

[322]*Energy Information Administration, Monthly Energy Review, Table 1.3 Primary Energy Consumption by Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

[323]*Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf .*

[324]*Energy Information Administration, Energy Kids' Page- Geothermal Energy—Energy from the Earth's Core, http://www.eia.doe.gov/kids/energyfacts/sources/renewable/geothermal.html .*

[325]*Id.*

[326]*Institute for Energy Research, Geothermal, http://instituteforenergyresearch.org/topics/encyclopedia/geothermal/ and Energy Information Administration, Energy Kids' Page—Geothermal, http://www.eia.doe.gov/kids/energy.cfm?page=geothermal_home-basics-k.cfm .*

[327]*Energy Information Administration, Energy Kids' Page—Geothermal, http://www.eia.doe.gov/kids/energy.cfm?page=geothermal_home-basics-k.cfm .*

[328]*Id.*

[329]*Massachusetts Institute of Technology, The Future of Geothermal Energy (2006), p. 1–33, http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf .*

# SOLAR

- Solar power provides 0.3 percent of our total energy.
- Solar power produces 0.2 percent of our central station electricity.
- Solar power is expensive—new photovoltaic solar is twice as expensive as new natural gas, and new thermal solar is almost four times as expensive.
- Solar power producers receive subsidies of $24.34 per megawatt hour of electricity produced.

Solar power has a longer history than some might imagine. American inventor Charles Fritts made the first solar cells in 1883.[330] The first photovoltaic cells powerful enough to run everyday electrical equipment were created in 1954.[331] The first utility-scale solar plants were built in the 1980s both by the Department of Energy and by private companies.[332] But because solar is the most expensive way to create electricity, solar market penetration has been very low.

Solar power production has increased by more than 395 percent during the past 10 years.[333] But even with this dramatic increase, solar provides only 0.3 percent of U.S. energy[334] and 0.2 percent of U.S. central station electricity.[335]

## Solar Technologies

There are a variety of solar energy technologies, including reflector mirrors for industrial electricity production, small water-heating panels, and photovoltaic cells. Photovoltaic cells, also called solar cells, are probably the most common solar technology. Today, the most efficient solar film panels are only about 12.8 percent efficient.[336] In real world conditions, however, this rate deteriorates over time.[337] Such low conversion rates explain part of the cost premium of solar over other sources of electricity generation.

## Subsidies, Mandates, and Preferential Tax Treatment

While solar power is older than many realize, it provides a very small percentage of energy today because it is very expensive compared to other sources of energy, even after generous taxpayer subsidies.

The Energy Information Administration estimates that the levelized cost per megawatt-hour is 130 dollars for a photovoltaic solar (solar PV) plant and 243.1 dollars for a thermal solar plant.[338] That is far more expensive than the 66.3 dollars per megawatt hour for conventional combined cycle natural gas and the 95.6 dollars per megawatt hour for conventional coal. Also, EIA inflates the cost of coal by the equivalent of $15 per metric ton of carbon dioxide emitted to represent the difficulty of obtaining financing for coal plants.

Solar receives substantial subsidies from the federal government. Total federal subsidies for electric production from solar power in fiscal year 2007 were $24.34 per megawatt hour, compared to $1.59 for nuclear, $0.67 for hydroelectric power, $0.44 for conventional coal, and $0.25 for natural gas and petroleum liquids.[339] In fiscal year 2010, they were even higher. For solar power, they were $775.64 per megawatt hour, for wind $56.29, for nuclear $3.14, for hydroelectric power $0.82, for coal $0.64 and for natural gas and petroleum liquids $0.64.[340] These subsidies include the federal investment tax credit, but do not include accelerated depreciation (a five-year tax write-off) and applicable state subsidies.

## Foreign Governments are Cutting Back on Unsustainable Solar Subsidies

Some U.S. politicians and renewable industry groups have pointed to the European governments' promotion of solar and other renewables through lavish subsidies as a model the United States should emulate.[341] Many European governments provide substantial subsidies for solar that increases their cost of electricity. For example, Germany pays $0.39 per kilowatt-hour for residential electricity.[342] In comparison, the average retail price of residential electricity in the United States is just $0.12 a kilowatt-hour.[343]

Spain's lavish solar subsidies paid up to 575 percent above the average electricity price for solar photovoltaic plants.[344] These high subsidies caused 40 percent of the world's total solar installation to occur in Spain in 2008.[345] As a result, the Spanish government's payout of subsidies for solar energy increased from $331 million in 2007 to $1.5 billion in 2008. [346]

The financial burden created by these subsidies has forced the German and Spanish governments to pull back and reduce their subsidies considerably. Germany has approved cuts to its solar subsides in an effort to bring solar construction subsidies to sustainable levels,[347] and Spain's subsidies from its solar growth have also become unsustainable. Spain has an electricity rate fund deficit because it has kept electricity rates too high while paying large solar subsidies.[348] In 2008, the Spanish government reduced its subsidies for solar, and it slashed subsidies by 30 percent in late 2010. [349]

Spain now has a growing deficit—about $40 billion now—due to its regulations and subsidization of renewable energy that does not pass on the costs to the ratepayers.[350] For perspective, Spain's economy is about 1/12th the size of the U. S. economy.[351] To pay off its debt, it is taxing owners of rooftop solar panels 6 Euro cents per kilowatt hour (about 8 U.S. cents per kilowatt hour), and the country is no longer allowing net metering of those solar panels.[352] That is, homeowners will no longer get paid for any excess power they produce. The tax, which will be imposed on all grid-connected rooftop solar panels, is to pay for the use of the electricity grid. If homeowners fail to connect their solar panels to the grid in an effort to avoid the tax they are fined exorbitantly.[353]

Because the cost of solar panels has decreased by half, more Spanish home owners are able to purchase the panels, saving themselves the high cost of electricity from the grid that runs 19.488 Euro cents per kilowatt hour in Spain[354] (25.9 U.S. cents per kilowatt hour), more than double the average residential price of electricity in the United States.[355] Under the old system, the payback period was about five years for a 1,600 to 2,100 Euro solar system ($2,127 to $2,791). But the tax increases the payback period to 17 years, which could make the purchase no longer viable given the economic life of the technology.[356]

Electric utility companies in the United States are now realizing a similar situation, particularly in the states with a greater amount of rooftop solar installations, such as California and Arizona. Utilities are indicating increasing amounts of home-based solar installations that feed electricity to the grid when excess power is generated could threaten their ability to maintain the nation's electricity grid. Arizona's largest electric utility company, Arizona Public Service, submitted two proposals to its public service commission in which solar rooftop owners would pay for the use of the electric grid.[357]

California is also facing similar issues. In California, the payments for excess electricity are tied to the daytime retail rates customers pay for electricity, which include the costs for maintaining the grid. Under the current program, it is estimated that California's three major utility companies could have to make up almost $1.4 billion a year in lost revenue from solar customers that could shift to about 7.6 million non-solar customers. If that lost revenue were evenly spread among customers, it would add $185 a year to each bill.[358]

## Subsidizing Solar is an Expensive Way to Create Jobs

Although solar and other renewables are expensive, some argue that we should subsidize renewables to create "green jobs." This has proven to be a very expensive proposition in places where it has been tried. In Spain, for every green job financed by Spanish taxpayers, 2.2 jobs were lost as an opportunity cost.[359] Since 2000, Spain committed $750,000 for every green job created.[360] The situation is similar in Germany. Financial aid to Germany's solar industry is as high as $240,000 per job created.[361] Over the last decade, Germany has provided $73 billion for solar and $28 billion for wind. A similar expenditure in the United States would equal half a trillion dollars. [362]

## Other Solar Challenges

Solar energy suffers from some of the same problems that plague wind energy, namely inconsistency, non-reliability, and the large land area required. The sun does not always shine on a given locale, and the strength of sunshine is not always sufficient during periods of peak energy demand. New photovoltaic plants produce their full capacity only 25 percent of the time, and new thermal solar plants produce their nameplate capacity only 20 percent of the time.[363] This unreliability means that solar energy is not commercially viable in many areas.

Solar energy is also land-intensive. Solar power production of the large amounts of electricity necessary to satisfy demand would require massive fields of reflectors or solar cells. These large fields are usually located in areas that are sunnier and drier than the rest of the country, such as the Southwest. Yet the reflectors or solar cells must be cleaned regularly, which pushes the limits of water resources in already water-scarce regions.

As with wind, the areas best suited for solar power are located far from population centers. The power lines to bring the electricity to market are expensive and it is frequently difficult to procure the necessary regulatory approvals. One example is the 120-mile Sunrise Powerlink in southern California. This power line will take years to secure the necessary permits and is estimated to cost $1.88 billion for construction.[364]

## Solar Company Failures

For years, the government has provided subsidies for solar firms as well as mandates that require the use of electricity from solar sources. But even with substantial subsidies and a guaranteed market, a number of solar companies have failed. The most high-profile of the solar failures was the Fremont, California-based company named Solyndra. The company received $530 million in loans from the federal government, as well as a visit from President Obama to tout the company's products. But in the end, the money and goodwill were not enough to keep the company afloat.

Solyndra wasn't the only solar company to fail in 2011. At least seven solar-panel manufactures went bankrupt or filed for insolvency in 2011.[365] These failures included the German firms Solar Millennium AG and Solon SE. The German firms failed despite feed-in tariffs that provide solar electricity providers with revenue in excess of market rates.

## **FOOTNOTES:** SOLAR

*[330]Department of Energy, The History of Solar, http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf .*

*[331]Id.*

*[332]Id.*

*[333]Energy Information Administration, Monthly Energy Review, Table 1.3 Primary Energy Consumption by Source, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_7.pdf .*

*[334]Id.*

*[335]Energy Information Administration, Monthly Energy Review, Table 7.2a Electricity Net Generation: Total, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.*

*[336]Tate Dwinnell, General Electric Announces Record Solar Efficiency, Plans to Build Largest U.S. Solar Factory, Apr. 8, 2011, http://greenstockscentral.com/general-electric-ge-announces-record-thin-film-solar-efficiency-plans-to-build-largest-us-solar-factory-4105.html .*

*[337]Vaclav Smil, Energy at the Crossroads, p. 170 (2005) , http://www.amazon.com/Energy-Crossroads-Global-Perspectives-Uncertainties/dp/0262693240 .*

*[338]Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm .*

*[339]Energy Information Administration, Federal Financial Interventions and Subsidies in Energy Markets 2007—Chapter 5: Electricity Subsidies Per Unit of Production (April 2008), p. 106, http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/chap5.pdf .*

*[340]Energy Information Administration, Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2010, July 2011, http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf and http://www.instituteforenergyresearch.org/2011/08/03/eia-releases-new-subsidy-report-subsidies-for-renewables-increase-186-percent/ .*

*[341]See e.g. Institute for Energy Research, Green Jobs: Lessons we can learn from Spain, http://www.youtube.com/watch?v=t3UebL-x-sw&feature=player_embedded . The video is a compilation of quotes from President Obama about how the U.S. should follow the lead of Spain, Germany, and other countries and their promotion of renewable energy through subsidies.*

*[342]International Domestic Energy Prices, December 18, 2014, https://www.gov.uk/government/statistical-data-sets/international-domestic-energy-prices and Institute for Energy Research, Germany's Green Energy Failure, April 2014, http://instituteforenergyresearch.org/wp-content/uploads/2014/04/German-Green-Energy-Study.pdf*

*[343]Energy Information Administration, Monthly Energy Review, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec9_11.pdf.*

*[344]Gabriel Calzada Álvarez, Study of the effects on employment of public aid to renewable energy sources, Universidad Rey Juan Carlos, Mar. 2009, http://www.juandemariana.org/pdf/090327-employment-public-aid-renewable.pdf ; Paul Voosen, Spain's Solar Market Crash Offers a Cautionary Tale About Feed-In Tariffs, GREENWIRE, Aug. 18, 2009, http://www.nytimes.com/gwire/2009/08/18/18greenwire-spains-solar-market-crash-offers-a-cautionary-88308.html .*

*[345]Paul Voosen, Spain's Solar Market Crash Offers a Cautionary Tale About Feed-In Tariffs, GREENWIRE, Aug. 18, 2009, http://www.nytimes.com/gwire/2009/08/18/18greenwire-spains-solar-market-crash-offers-a-cautionary-88308.html .*

*[346]Angel Gonzalez & Keith Johnson, Spain's Solar-Power Collapse Dims Subsidy Model, WALL STREET JOURNAL, Sept. 8, 2009, http://online.wsj.com/article/SB125193815050081615.html.*

*[347]Marc Roca & Brian Parkin, Germany to Speed Solar-Subsidy Cuts to Undercut Boom, Bloomberg, Jan. 20, 2011, http://www.bloomberg.com/news/2011-01-20/german-subsidies-for-solar-power-to-be-reduced-as-much-as-15-from-july-1.html .*

*[348]David Roman & Juan Montes, Spain Approves 30% Cut to Solar Subsidies, WALL STREET JOURNAL, Dec. 23, 2010, http://online.wsj.com/article/SB10001424052748704278404576037343359005376.html .*

*[349]David Roman & Juan Montes, Spain Approves 30% Cut to Solar Subsidies, WALL STREET JOURNAL, Dec. 23, 2010, http://online.wsj.com/article/SB10001424052748704278404576037343359005376.html .*

*[350]Susan Daley, Spain's Solar Pullback Threatens Pocketbooks, New York Times, Jan. 5, 2014, http://www.nytimes.com/2014/01/06/world/europe/spains-solar-pullback-threatens-pocketbooks.html .*

*[351]World Bank, Gross Domestic Product 2013, Data Bank, http://databank.worldbank.org/data/download/GDP.pdf*

*[352]Tracy Rucinski and Jose Elias Rodriguez, Spaniards rebel against solar panel levy, Reuters, August 14, 2013, http://www.reuters.com/article/2013/08/14/us-spain-energy-idUSBRE97D0FX20130814?feedType=RSS&feedName=environmentNews*

*[353]Salon, Facing Taxes, Spaniards tear down their solar panels, August 14, 2013, http://www.salon.com/2013/08/14/facing_taxes_spaniards_tear_down_their_solar_panels/*

*[354]Europe's Energy Portal, https://www.energy.eu/*

*[355]Energy Information Administration, Average Retail Prices of Electricity, Monthly Energy Review, December 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/sec9_11.pdf*

*[356]Reuters, Spaniards rebel against solar panel levy, August 14, 2013, http://www.reuters.com/article/2013/08/14/us-spain-energy-idUSBRE97D0FX20130814?feedType=RSS&feedName=environmentNews*

*[357]Sustainable Business, Arizona Mulls Solar 'Tax', August 1, 2013, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/25103?utm_*

*source=feedburner&utm_medium=email&utm_campaign=Feed%3A+SBGeneralNews+%28SustainableBusiness.com+General+News%29*

*[358]Diane Cardwell, On Rooftops, A Rival for Utilities, The New York Times, July 26, 2013, http://www.nytimes.com/2013/07/27/business/energy-environment/utilities-confront-fresh-threat-do-it-yourself-power.html .*

*[359]Gabriel Calzada Álvarez et. al., Study of the effects on employment of public aid to renewable energy sources, Universidad Rey Juan Carlos, Mar. 2009, http://www.juandemariana.org/pdf/090327-employment-public-aid-renewable.pdf*

*[360]Id.*

*[361]Manuel Frondel et. al., Economic impacts from the promotion of renewable energies: The German experience, Rheinisch-Westfälisches Institut für Wirtschaft sforschung, Oct. 2009, http://www.instituteforenergyresearch.org/germany/Germany_Study_-_FINAL.pdf .*

*[362]Id.*

*[363]Institute for Energy Research, Electricity Generation Costs for New Electricity Generating Technologies, http://www.instituteforenergyresearch.org/levelized-costs-of-new-electricity-generating-technologies/*

*[364]Onell R. Soto, Governor calls Sunrise Powerlink example to nation, SAN DIEGO UNION-TRIBUNE, Dec. 9. 2010, http://www.signonsandiego.com/news/2010/dec/09/governor-to-attend-sunrise-groundbreaking-today/ .*

*[365]Yuliya Chernova, Dark Times Fall on Solar Sector, WALL STREET JOURNAL, Dec. 27, 2011, http://online.wsj.com/article/SB1000142405297020455230457711714051196840.html .*

# CONCLUSION

America is an energy rich nation. We are the world's largest natural gas producer, the second largest coal producer, and the third largest oil producer. According to the Congressional Research Service, we have the most fossil fuel resources of any country on Earth, but most of these resources are off-limits due to federal policies. Sadly, many policymakers either do not understand these facts, or for various reasons, they try to reduce our ability to use America's vast energy sources.

The problem with making energy resources off limits is that energy is the lifeblood of the economy. Energy is an input into almost all economic activity. The use of energy makes our life better by magnifying our abilities and allowing us to do more with the one resource for which there is no substitute—time.

Americans should have more access to our domestic energy resources, and the market should enable energy consumers to pick winners and losers rather than politicians and unelected bureaucrats. Energy subsidies and preferential treatment are forms of discrimination that harm energy producers, consumers, and taxpayers alike through higher prices and higher taxes.  In doing so, they hurt the nation.

Because much of America's massive energy resources lie on federal land, production of these resources depends on the federal government. For too long, in both Republican and Democratic administrations, the federal government has denied access to many of these resources and created byzantine regulatory processes In many cases, these policies have been driven by those opposed to using the energy resources we have in abundance right here at home. The federal government needs to simplify and promote certainty in the permitting process instead of maintaining the current opaque regulatory framework. Today's rules simply discourage people who want to do business and produce energy in the United States.

Given the increasing demand for energy around the world, now is the time to seize America's great energy potential and unleash our creative abilities to solve today's and tomorrow's energy challenges. There is no shortage of energy in this country, but up to this point we have been hampered by governmental policies that restrict our ability to prosper. Allowing access to our own energy resources will grow the economy, lower energy prices, and create the necessary jobs to thrive during good and bad economic times.

# ACKNOWLEDGEMENTS

*Writing Hard Facts was far more difficult and time consuming than I ever dreamt it would be. This finished product was the result of many people's efforts. Without their help and guidance, it would never have been possible.*

*I'd like to thank Mary Hutzler for her expertise with energy facts and statistics, Rob Bradley for his historical insights, and Devin Drumheller and Clint Atkins for their invaluable help on the early drafts. I would also like to thank Dan Kish for his extensive knowledge of energy policy, Tom Pyle for his editorial help and encouragement, and Robert Murphy for his economic knowledge. Lastly, thanks to Kaavya Ramesh, Daniel Smith, Mike Morrison, John Mavretich, Jeff Hubbard, Robin Millican, Dave Bier, Bryan Williamson, Julia Bell, Hanh Vu, Kent Mottice, Hannah White, Dan Kruger, Andrew Garber, Joe O'Connor, Genevieve Thornton, Sean Clough, Cash Colburn, Michael Keegan, and Roger Donaway for their help along the way.*

Daniel Simmons

# GLOSSARY

**Barrel of Oil:** A unit of volume equal to 42 U.S. gallons (of oil)

**BOEM (Bureau of Ocean Energy Management):** Formerly the Minerals Management Service. BOEM is an agency of the Department of the Interior that manages natural gas, oil, and other mineral resources on the Outer Continental Shelf.

**Capacity factor:** The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

**Coalbed methane:** Unconventional natural gas found in underground coal seams. It can be extracted in existing coal mines or through the use of hydraulic fracturing.

**Conventional oil:** Crude oil that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil to readily flow to the wellbore.

**Criteria pollutants:** The Clean Air Act requires EPA to regulate six common air pollutants—ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead. These are known as the criteria pollutants.

**Greenhouse gas:** A gas absorbs and emits radiation within the thermal infrared range. Greenhouse gases include carbon dioxide, methane, nitrous oxide, fluorinated gases. These gases are sometimes erroneously called "carbon" emissions. Nitrous oxides and fluorinated gases, however, are greenhouse gases, but do not contain carbon.

**Heavy Oil:** Unconventional oil source that is thicker and heavier than conventional oil. Heavy oil is a biodegraded form of traditional oil, where the lighter parts of the oil are gone, often by being consumed by bacteria in the reservoir.

**Hydraulic Fracturing:** Procedure for stimulating and enhancing oil and natural gas wells. A mixture of mostly water and sand is injected under high pressure to wells thousands of feet below the surface to break apart, or "fracture," the surrounding shale rock, which releases trapped oil or natural gas and is then pumped to the surface. Sometimes referred to as "fracking" or "hydrofracturing."

**Levelized Cost:** The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

Methane hydrates: Methane hydrates, also known as natural gas hydrates are solid, crystalline, ice-like substances composed of water, methane, and usually a small amount of other gases, with the gases frozen in ice. They form under high pressure and at low temperatures and are located in ocean-bottom sediments and permafrost regions. It has been estimated that 270 million trillion cubic feet of natural gas could theoretical exist in hydrate deposits.

Natural gas: A gaseous mixture of hydrocarbon compounds, the primary one being methane.

OCS (Outer Continental Shelf): The submerged lands, subsoil, and seabed, lying between the seaward extent of the States' jurisdiction and the seaward extent of Federal jurisdiction. Generally, the OCS begins 3–9 nautical miles from shore (depending on the state) and extends 200 nautical miles outward, or farther if the continental shelf extends beyond 200 nautical miles.

Oil Sands: Naturally occurring thick heavy oil (bitumen) impregnated sands that yield mixtures of liquid hydrocarbon and that require further processing other than mechanical blending before becoming finished petroleum products.

Oil Shale: A sedimentary rock containing kerogen, a solid organic material.

Photovoltaic cells: An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting light directly into electricity (direct current).

Plutonium: A heavy, fissionable, radioactive, metallic element (atomic number 94) that occurs naturally in trace amounts. It can also result as a byproduct of the fission reaction in a uranium-fuel nuclear reactor and can be recovered for future use.

## Reserves (oil, natural gas, and coal):

In-Place Resources: All oil, natural gas, or coal in a given formation, regardless of economic or technical recoverability.

### Coal Resources:

Demonstrated Reserve Base (DRB): Coal resources that are known to exist (to a certain degree of accuracy) and could likely be recovered economically with current technologies.

Technically Recoverable Reserves (Coal): Portion of the demonstrated reserve base that can be recovered using existing technologies.

Economically Recoverable Reserves (Coal): Portion of the technically recoverable reserves that can be recovered under current economic conditions.

### Oil and Natural Gas Quantity Definitions:

Undiscovered Resources: Undiscovered oil and natural gas in currently unexplored areas that is estimated to exist based upon geologic characteristics.

Undiscovered Technically Recoverable Resources (UTRR): Portion of undiscovered resources that is recoverable with existing drilling and production technologies.

Undiscovered Economically Recoverable Resources (UERR): Portion of undiscovered technically recoverable resources that is recoverable under imposed economic or technical conditions.

Proved Reserves: Oil and natural gas that have already been discovered, typically through actual exploration or drilling, and which can be recovered economically.

Shale Oil and Gas: Unconventional oil and natural gas source that is trapped in sedimentary rock formations known as shale. Production typically requires the use of hydraulic fracturing.

**Unconventional Oil or Natural Gas Deposit:** When natural gas or oil is distributed throughout a geologic formation instead of confined to a single reservoir. Extraction typically requires technologies and procedures in addition to—or markedly different from—what is required to obtain conventional deposits. Key examples: shale gas, oil sands, coalbed methane, and heavy oil.

**Uranium:** A heavy, naturally radioactive, metallic element (atomic number 92). Its two principally occurring isotopes are uranium-235 and uranium-238. Uranium-235 is indispensable to the nuclear industry because it is the only isotope existing in nature, to any appreciable extent, that is fissionable by thermal neutrons. Uranium-238 is also important because it absorbs neutrons to produce a radioactive isotope that subsequently decays to the isotope plutonium-239, which also is fissionable by thermal neutrons.

**West Texas Intermediate:** A crude stream produced in Texas and southern Oklahoma which serves as a reference or "marker" for pricing a number of other crude streams and which is traded in the domestic spot market at Cushing, Oklahoma.