NORTH AMERICAN ENERGY INVENTORY

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IER INSTITUTE FOR ENERGY RESEARCH

ABOUT IER

The Institute for Energy Research (IER) is a not-for-profit organization that conducts intensive research and analysis on the functions, operations, and government regulation of global energy markets. IER believes that freely-functioning energy markets provide the most efficient and effective solutions to today's global energy and environmental challenges and, as such, are critical to the well-being of individuals and society.

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LETTER FROM THE PRESIDENT

In the last 100 years, America's population has tripled. Life expectancy has increased by 70 percent. The productivity of the American people, measured in terms of real per-capita Gross Domestic Product (GDP), has increased by 600 percent. At the same time, we have consumed more than 340 billion barrels of oil, almost 60 billion short tons of coal, and more than 1,090 trillion cubic feet of natural gas.

These things are linked. Affordable and reliable energy is a crucial factor in making these and many other significant human, social and technological achievements possible.

Yet even with steadily increasing rates of economic and population growth, as well as increasing energy consumption, the United States today possesses greater recoverable supplies of oil, natural gas and coal than at any point in its recorded history. How can that be? Have vast new sources of hydrocarbon fuels magically materialized beneath our feet over the past 100 years? Or is it possible that, despite what you've read, heard and have been told, our continent has always had a lot more energy available to it than some would have us believe?

The answers lie in the data. In 1980, official estimates of proved oil reserves in the United States stood at roughly 30 billion barrels. Yet over the past 30 years, more than 77 billion barrels of oil have been produced here. In other words, over the last 30 years, the United States produced more than two and a half times the proved reserves we thought we had available in 1980. Thanks to new and continuing innovations in exploration and production technology, there's every reason to believe that today's estimates of reserves are only a fraction of what will be produced and delivered tomorrow—not only here in the United States, but across the entire North American continent.

Unfortunately, even as updated data show plentiful future supplies of domestic energy, driven by new technologies, a significant movement has emerged. This movement's mission is to advance and perpetuate falsehoods and inaccuracies with respect to the volume and availability of energy resources in and under our country and continent.

The movement is coordinated, orchestrated and well-funded to create the illusion of scarcity that empowers government to deny citizens access to affordable, reliable and much-needed energy. Furthermore, using supposed scarcity as an excuse, politicians and government agencies justify increasing the power and budget of government while substituting their politically-favored energy choices for those chosen by consumers.

"If America only possesses two to three percent of the world's oil," they ask, "why bother to unlock additional acreage for future exploration?" If the world is running out of hydrocarbon fuels, why not insist that government spend billions of dollars to subsidize politically well-connected sources of "alternative" energy? This, they argue, is the justification for spending and mandating the use of energy supplies that otherwise could not survive in a market economy where consumers make their own energy decisions based upon availability and price.

For some, the benefits associated with advancing this agenda are financial. For others, they are ideological. Access to affordable, abundant energy is, fundamentally, a means of freedom. But for those seeking to create a crisis that provides an opportunity to direct the way we live, work and act, affordable, reliable, abundant, domestic energy is a threat. In a very real sense, the more energy we have, the less power they will have. Energy abundance ends the justification for central energy decision-making.

Against that backdrop, the Institute for Energy Research (IER) is proud to release the following report. It is the culmination of months of research and investigation by IER experts, drawing on a broad array of government, industry and university data—all of it public information—to provide the reader a more accurate description of what is available in North America now and what will likely be available in the future.

America's energy future can be bright. Converting that potential into something real and transformative will not be easy—nor is success guaranteed. This report describes in detail what is possible and should serve once-and-for-all to shatter the myth of energy scarcity, and in so doing, empowers American citizens rather than politicians.

Thomas J. Pyle
President, Institute for Energy Research
Washington, D.C.
December 2011

NORTH AMERICA'S MASSIVE RESOURCE POTENTIAL

	OIL	NATURAL GAS	COAL
UNITED STATES			
	• Total: 3.745 trillion barrels • Recoverable: 1.442 trillion barrels • Proved Reserves: 20.6 billion barrels	• Total: 14 quadrillion cubic feet • Recoverable: 2.744 quadrillion cubic feet • Proved Reserves: 272 trillion cubic feet	• Total Resources: 10.3 trillion short tons • Recoverable: 486.1 billion short tons • Proved Reserves: 260.6 billion short tons
CANADA			
	• Total: 1.8 trillion barrels • Recoverable: 320 billion barrels • Proved Reserves: 175 billion barrels	• Total: 31.1 quadrillion cubic feet • UTRR: 758 trillion cubic feet • Proved Reserves: 62 trillion cubic feet	• Total Resources: 353 billion short tons • Recoverable: 9.6 billion short tons • Proved Reserves: 7.3 billion short tons
MEXICO			
	• Total: 99 billion barrels • Recoverable: 31.2 billion barrels • Proved Reserves: 10.5 billion barrels	• Recoverable: 742.4 trillion cubic feet • Proved Reserves: 12 trillion cubic feet	• Recoverable: 1.34 billion short tons • Proved Reserves: 1.3 billion short tons

INTRODUCTION

Affordable energy is the lifeblood of a strong and vibrant economy. Fortunately, for the United States and all of North America, there are vast quantities of the most affordable energy resources beneath our feet. Whether the United States, Canada and Mexico choose to safely and responsibly develop these resources will determine the quality of life and the future for their citizens. Will North America take the path of additional domestic energy production, bringing massive new wealth creation and job opportunities for all of its citizens? Or will it ignore this enormous opportunity and pursue an uncertain economic future caused by government policies that promote expensive energy? As this report shows, North America's energy potential—and with it the potential for economic growth—is larger than many policymakers have suggested.

This massive supply of available resources means that North America's access to affordable energy is limited only by the government policies we choose to adopt. Unlike intermittent wind and solar power, these sources are reliable. Specifically, coal and natural gas are relied upon to generate baseload power, and natural gas in particular can be ramped up or down to increase generation when consumers use electricity the most.

The consequent benefits of recognizing and developing this domestic energy potential is enormous. Across America, states that have committed to producing their energy resources—coal, oil, and natural gas—regularly enjoy stronger job growth, a stronger economy and a stronger position with respect to their state budgets.

North Dakota, for example, was barely among the top ten oil producing states less than ten years ago. Today it is the fourth largest producer due to rapid growth in developing the massive oil resources in the Bakken formation in the western portion of the state. North Dakota's unemployment rate is 3.5 percent,[1] compared to a 9.1 percent unemployment rate for the United States.[2] While the U.S. economy grew at an anemic 2.6 percent in 2010, North Dakota's grew more than twice as fast at an impressive 7.0 percent.[3] Similarly, Wyoming, the nation's largest coal producer, has an unemployment rate (5.8 percent),[4] well below the national rate.

Other states like Pennsylvania, where natural gas production in the Marcellus Shale formation has boomed in the past three years, also have much better employment situations than the nation as a whole. There have been 72,000 new hires in Pennsylvania since the end of 2009 thanks to the economic impact of shale gas production.[5]

Energy-related jobs, particularly those producing coal, oil, and natural gas, are also high paying, with average starting salaries well above the national average and higher than many other large industries (See Fig. 2 appendix). Producing these resources means creating strong economic foundations for millions of American families.

Despite these clear benefits, expanded or even continued energy production in the United States faces major challenges, primarily from over-regulation and new taxes imposed at the federal level. For decades prior to 1970, U.S. oil production increased, and consistently exceeded, imports. But throughout the 1970s and 1980s, federal government policies retarded domestic energy production, most directly through the enactment of the Alaska National Interest Lands Conservation Act of 1980—the largest land withdrawal in U.S. history—and the imposition of an offshore energy development moratorium in 1982.

Just as significantly, lawmakers passed numerous laws enabling the massive expansion of regulations affecting the production of energy. Many of these laws increased administrative requirements on energy producers and included multiple opportunities for opponents of energy projects to challenge, appeal and litigate an agency's decision, or even the adequacy of their decision-making documents. As delays in permitting increased, the cost of compliance increased along with the uncertainty of a project's economic viability, and domestic production subsequently fell. By the early 1990s, oil imports exceeded domestic production.

This reduction was not caused by a lack of resources, although opponents used decreasing domestic production to justify more government to solve the "problem." In 1980, the federal government estimated that the United States had 30 billion barrels of proved oil reserves,[6] yet from 1980 through 2010 the U.S. produced over 77 billion barrels of oil,[7] or more than twice as much as the government estimated the country held.

The story was similar for natural gas. By the late 1990s, experts were predicting a coming price spike for natural gas due to a decline in proved reserves. Accordingly, Congress responded in 2005 by passing legislation to speed construction of liquefied natural gas (LNG) import terminals. At that time, increased natural gas imports were seen as the inevitable result of declining U.S. supplies. But toward the end of the decade, U.S. natural gas production began to increase dramatically on account of technological innovations that made extraction of natural gas from shale and other tight reservoirs economical. Furthermore, the technological success that brought about the natural gas revolution is only now beginning to affect shale oil deposits like those in the Bakken Field in North Dakota and Eagle Ford in Texas, with many more prospects spread throughout the United States.

The lesson is simple. Government policies built on flawed and static assumptions about energy resources and technology contributed to a 40-year decline in energy production. It is not a coincidence that domestic oil production fell dramatically during a quarter century of government moratoriums on nearly 90 percent of available acreage offshore. Nor is it a coincidence that as increasing amounts of government lands onshore were withdrawn from energy exploration and regulations were heaped on energy explorers, there was less exploring and fewer discoveries.

Conversely, the growth of new technology in the field of shale gas and oil exploration and production came in the absence of federal bans and onerous restrictions on their development. As explorers shunned the troubles associated with government lands, they embraced new geological and technological innovations on private and state lands, where the federal government's policies were limited. When producers are allowed to innovate, greater energy production will always be possible.

Unfortunately, coal is now facing its own threat from the federal government, particularly through overly broad and restrictive regulations from the U.S. Environmental Protection Agency (EPA) consistent with President Obama's pre-election commitment to "bankrupt" the coal business. There are also increasing restrictions on coal production, including issuing and then later denying and withdrawing permits, as in the case of the Spruce No. 1 mine in West Virginia.

A country's ability to produce affordable energy can also determine its ability to grow economically. North America is blessed with hundreds of years of supplies of affordable energy, and the ability to produce these valuable resources safely and responsibly is clearly a matter of choice as expressed through government policy. It is not a matter of geology. The argument that North America is running out of oil, coal, and natural gas because of inadequate domestic supplies is false, as this report will enumerate below.

NORTH AMERICA'S VAST RESOURCES

OIL

Total Recoverable Resources: 1.79 trillion barrels.

- Enough oil to fuel every passenger car in the United States for 430 years
- Almost twice as much as the combined proved reserves of all OPEC nations
- More than six times the proved reserves of Saudi Arabia

NATURAL GAS

Total Recoverable Resources: 4.244 quadrillion cubic feet.

- Enough natural gas to provide the United States with electricity for 575 years at current natural gas generation levels
- Enough natural gas to fuel homes heated by natural gas in the United States for 857 years
- More natural gas than all of the next five largest national proved reserves (more than Russia, Iran, Qatar, Saudi Arabia, and Turkmenistan)

COAL

Total Recoverable Resources: 497 billion short tons.

- Provide enough electricity for approximately 500 years at coal's current level of consumption for electricity generation
- More coal than any other country in the world
- More than the combined total of the top five non-North American countries' reserves. (Russia, China, Australia, India, and Ukraine)
- Almost three times as much coal as Russia, which has the world's second largest reserves.

EXECUTIVE SUMMARY

- North America is blessed with enough energy supplies to promote and sustain economic growth for many generations. The government's own reports detail this, and Congress was advised of our energy wealth when the Congressional Research Service of the Library of Congress released a report showing that the United States' combined recoverable oil, natural gas, and coal endowment is the largest on Earth.
- The amount of oil that is technically recoverable in the United States is more than 1.4 trillion barrels, with the largest deposits located offshore, in portions of Alaska, and in shale in the Rocky Mountain West. When combined with resources from Canada and Mexico, total recoverable oil in North America exceeds 1.7 trillion barrels.
- That is more than the world has used since the first oil well was drilled over 150 years ago in Titusville, Pennsylvania. To put this in context, Saudi Arabia has about 260 billion barrels of oil in proved reserves. For comparative purposes, the technically recoverable oil in North America could fuel the present needs in the United States of seven billion barrels per year for around 250 years.
- Moreover, it is important to note that that "reserves" estimates are constantly in flux. For example, in 1980, the U.S. had oil reserves of roughly 30 billion barrels. Yet from 1980 through 2010, we produced over 77 billion barrels of oil. In other words, over the last 30 years, we produced over 150 percent of our proved reserves.
- Restrictions in the form of federal bans and leasing combined with declining offerings of lease acreage mean only about 2.2 percent of America's offshore acreage is currently leased for production.
- Proved reserves of natural gas in the United States and throughout North America are enormous, and the total amount of recoverable natural gas is even more impressive. The EIA estimates that the United States has 272.5 trillion cubic feet of proved reserves of natural gas. The total amount of natural gas that is recoverable in North America is approximately 4.2 quadrillion (4,244 trillion) cubic feet.
- Given that U.S. consumption is currently about 24 trillion cubic feet per year, there is enough natural gas in North America to last the United States for over 175 years at current rates of consumption.
- Total supplies of natural gas in North America dwarf those of other countries. The United States, Canada, and Mexico have more technically recoverable natural gas resources than the combined total proved natural gas reserves found in Russia, Iran, Qatar, Saudi Arabia, and Turkmenistan.

- With respect to total recoverable resources, however, North America's combined coal supplies are even more staggering. The United States, Canada, and Mexico have over 497 billion short tons of recoverable coal, or nearly three times as much as Russia, which has the world's second largest reserves. North America's recoverable coal resources are bigger than the five largest non-North American countries' reserves combined (Russia, China, Australia, India, Ukraine).
- North American recoverable coal could provide enough electricity for the United States for about 500 years at current levels of consumption.
- While the United States and North America contain enormous energy wealth, U.S. policies have increasingly made exploration, development, production and consumption of that energy more difficult.
- Therefore, a scarcity of good policies, not a scarcity of energy, is responsible for U.S. energy insecurity.

RESOURCES AND RESERVES: WHY TERMS MATTER WHEN JUDGING ENERGY POTENTIAL

A frequent source of confusion about America's energy potential is the terminology used, primarily the enormous yet poorly understood difference between "resources" and "reserves." The term "reserves" typically refers to a country's known, proved and presently economic energy supplies, but a country's resources are much larger, representing a nation's total potential energy. The debate over whether a country has only a few years' supply of a particular energy source or centuries' worth can hinge upon the terms employed. It is merely semantics—not a scientific assessment of what America has the capacity to produce—that allows critics to claim repeatedly that America is running out of energy.

GLOSSARY

COAL QUANTITY DEFINITIONS

Demonstrated Reserve Base (DRB): Refers to 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.

DEMONSTRATED RESERVE BASE > TECHNICALLY RECOVERABLE > ECONOMICALLY RECOVERABLE

OIL AND NATURAL GAS QUANTITY DEFINITIONS

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

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

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

Proved Reserves: Refers to oil and natural gas that have already been discovered, typically through actual exploration or drilling, and which can be recovered economically today. (This is the smallest number of the four terms and commonly used by those promoting an energy scarcity story.)

UNDISCOVERED > UNDISCOVERED TECHNICALLY RECOVERABLE > UNDISCOVERED ECONOMICALLY RECOVERABLE > PROVED RESERVES

OTHER KEY TERMS

Coalbed Methane (CBM): Natural gas found in underground coal seams. It has been produced since the early 1970s. CBM may be extracted in existing coal mines and/or through the use of hydraulic fracturing.

Conventional Deposit: Layered geological arrangement of natural gas, oil, and/or water within a given reservoir. Because the resource is confined in a single reservoir, extraction is simpler than producing unconventional deposits.

Crude Oil: Naturally-occurring liquid hydrocarbon that can be refined into commonly known petroleum products, including gasoline and diesel but also a variety of plastics and pharmaceuticals.

Heavy Oil: A biodegraded form of conventional oil, where the lighter parts of the oil are gone, often by being consumed by bacteria in the reservoir.

Hydraulic Fracturing: Procedure for stimulating the flow of oil and natural gas wells. A mixture of mostly water and sand with some chemicals 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.

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

In Situ Production: Process for extracting unconventional oil (i.e., oil sands and oil shale) where underground heating (typically by using steam) separates the petroleum from rock, sand, or other components and diverts the oil to wells for extraction, leaving the non-petroleum elements in place underground. One important example of existing in-situ production is Steam Assisted Gravity Drainage (SAG-D), which is employed in the Athabascan oil sands in Alberta, Canada.

Methane Hydrates: Natural gas locked in ice. Found in areas of low temperature and high pressure, including on sea floors and in arctic permafrost. Though estimates vary, the United States could hold nearly 700 quadrillion (700,000 trillion) cubic feet of methane hydrates, enough to meet U.S. natural gas demand for almost 30,000 years or global natural gas demand for more than 6,500 years at present rates of natural gas use.

Oil Sands: Heavier form of oil that contains naturally occurring deposits of 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.

Oil Shale: Sedimentary rock that is dark brown to black in color and contains significant quantities of a substance known as kerogen, which is a fossilized organic material that can be distilled into liquid and gaseous hydrocarbons. Specifically, kerogen can be converted into petroleum products such as gasoline, diesel, high quality jet fuel, and kerosene.

Shale Oil and Gas: Crude oil and natural gas that are trapped in sedimentary rock formations (shale). Production typically requires well stimulation procedures, including the use of hydraulic fracturing.

Unconventional Deposit: Natural gas or oil that is distributed throughout a geologic formation instead of confined to a single reservoir. Examples include oil shale, oil sands, coalbed methane, and heavy oil.

A NOTE ON UNITS: RESOURCES AND RESERVES

Throughout this report there are frequent comparisons of North America's recoverable resources to other countries' proved reserves. This may seem like an apples-to-oranges comparison, as reserves are by definition much smaller than in-place resources or even recoverable resources. But the potential to produce oil, natural gas, or coal is constantly under attack by critics in the U.S. who rely on the lowest estimates available (proved reserves) to suggest that America's resources are declining, and that any further production is merely delaying an inevitable energy shortage and growing imports.

It is, however, often the policies of these critics (the moratoria, the bans on production, the land withdrawals and the overly burdensome regulations) which limit the movement of recoverable energy resources into the proved reserves category. Recoverable resources in the U.S. would become reserves but for these policies, which seek to make all the claims of energy scarcity a self-fulfilling prophecy.

For example, if oil "reserves" constituted the full capacity for the United States, we would have long ago lost the ability to produce even a single barrel of oil. That we are today still producing oil is a testament not only to ongoing exploration for additional fields but also, and more importantly, the rapid advance of technology in the United States, including the latest procedures used to unlock vast quantities of oil and gas in shale.

Comparisons to other well-known reserves around the world, such as Chinese coal and Saudi Arabian oil, thus merely serve as reference points to show that North America has an enormous capacity to produce energy, a capacity that rivals and indeed exceeds reserves around the world commonly referred to as the largest.

OIL

"THE PROBLEM IS WE ONLY HAVE ABOUT 2 TO 3 PERCENT OF THE WORLD'S OIL RESERVES."

—PRESIDENT BARACK OBAMA, APRIL 19, 2011

"THE MATH IS SIMPLE: AMERICA HAS JUST 3 PERCENT OF THE WORLD'S OIL RESERVES, BUT AMERICANS USE A QUARTER OF ITS OIL."

—SENATOR HARRY REID (D-NEV.) OCTOBER 27, 2009

"UNLESS PROFOUND CHANGES ARE MADE TO LOWER OIL CONSUMPTION, WE NOW BELIEVE THAT EARLY IN THE 1980'S THE WORLD WILL BE DEMANDING MORE OIL THAN IT CAN PRODUCE."

— PRESIDENT JIMMY CARTER, ADDRESS TO THE NATION, APRIL 18, 1977

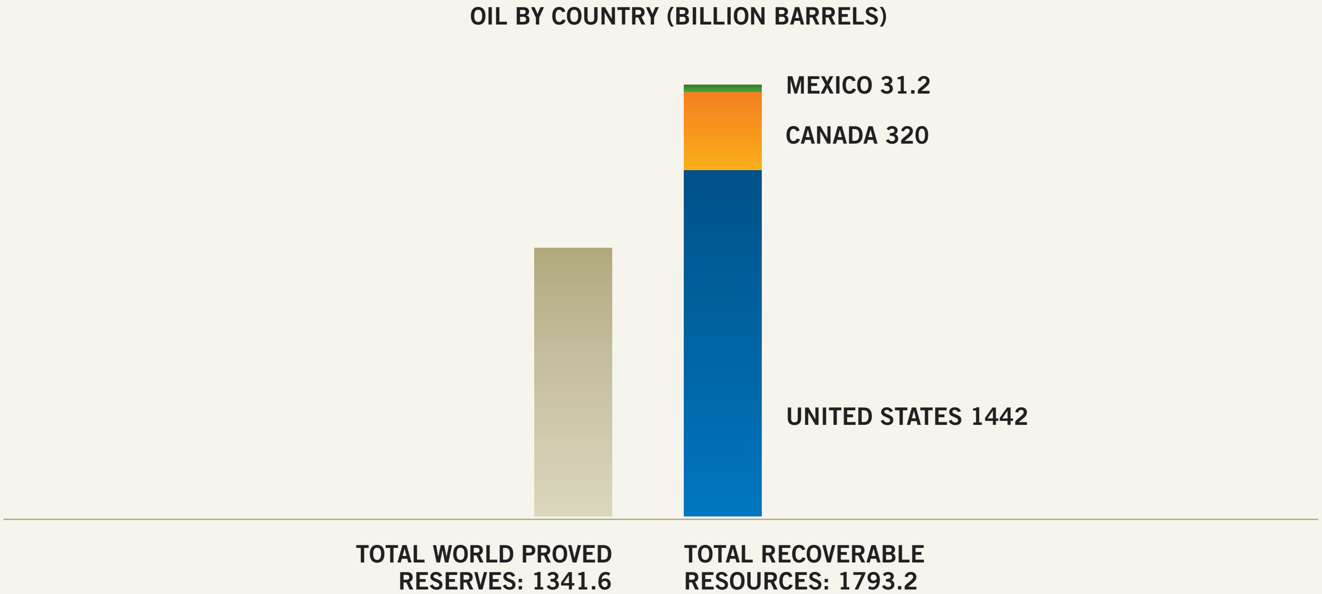
North America currently consumes 23 million barrels of oil per day,[9] and most of that oil is used to produce transportation fuels like gasoline, diesel, and jet fuel. In the United States alone, oil and its derivative products constitute 93 percent of all transportation fuels.[10]

According to the Energy Information Administration (EIA), the United States has about 20 billion barrels of oil in proved reserves, while Canada has more than 175 billion barrels and Mexico has about ten billion barrels.[11] These proved reserves represent quantities of oil that are known to exist in places where development is already occurring at current economic prices. In the U.S., the proved reserves figures are the source of the claim that America has just two to three percent of the world's oil. These figures do not, however, account for the massive quantities of oil that exist in areas where development is not permitted to take place or where new technology will add to the reserve base.

For example, although the United States is said to have only 20 billion barrels of oil in reserves, the amount of oil that is technically recoverable in the United States is more than 1.4 trillion barrels, with the largest deposits located offshore, in portions of Alaska, and in shale in the Rocky Mountain West.[12] When combined with resources from Canada and Mexico,[13] total recoverable oil in North America exceeds 1.7 trillion barrels, or more than the world has used since the first oil well was drilled over 150 years ago in Titusville, Pennsylvania. To put this in context, Saudi Arabia has about 260 billion barrels of oil in proved reserves.[14]

One reason to view "reserves" estimates with caution is the fact that they are constantly in flux. In 1980, the U.S. had oil reserves of roughly 30 billion barrels.[15] Yet from 1980 through 2010, we produced over 77 billion barrels of oil.[16] In other words, over the last 30 years, we produced over 150 percent of the proved reserves we had in 1980. If the massive quantities of U.S. oil are made available to explore and produce, the current estimated reserves of 20 billion barrels would certainly increase, providing much more production over decades to come. In other words, reserves are not a stagnant number.

NORTH AMERICAN OIL V. WORLD'S OIL



SOURCE: U.S. Department of Energy: "Undeveloped Domestic Oil Resources" (February 2006) and "Development of America's Strategic Unconventional Fuels Resources" (September 2006); EIA: *Annual Energy Review* (2009), "International Energy Statistics" (2011), and *Annual Energy Outlook* (2011); Natural Resources Canada: "Oil Sands: A strategic resource for Canada, North America and the world" (2010); and Government of Mexico: "Crude Oil Market Outlook" (2008)

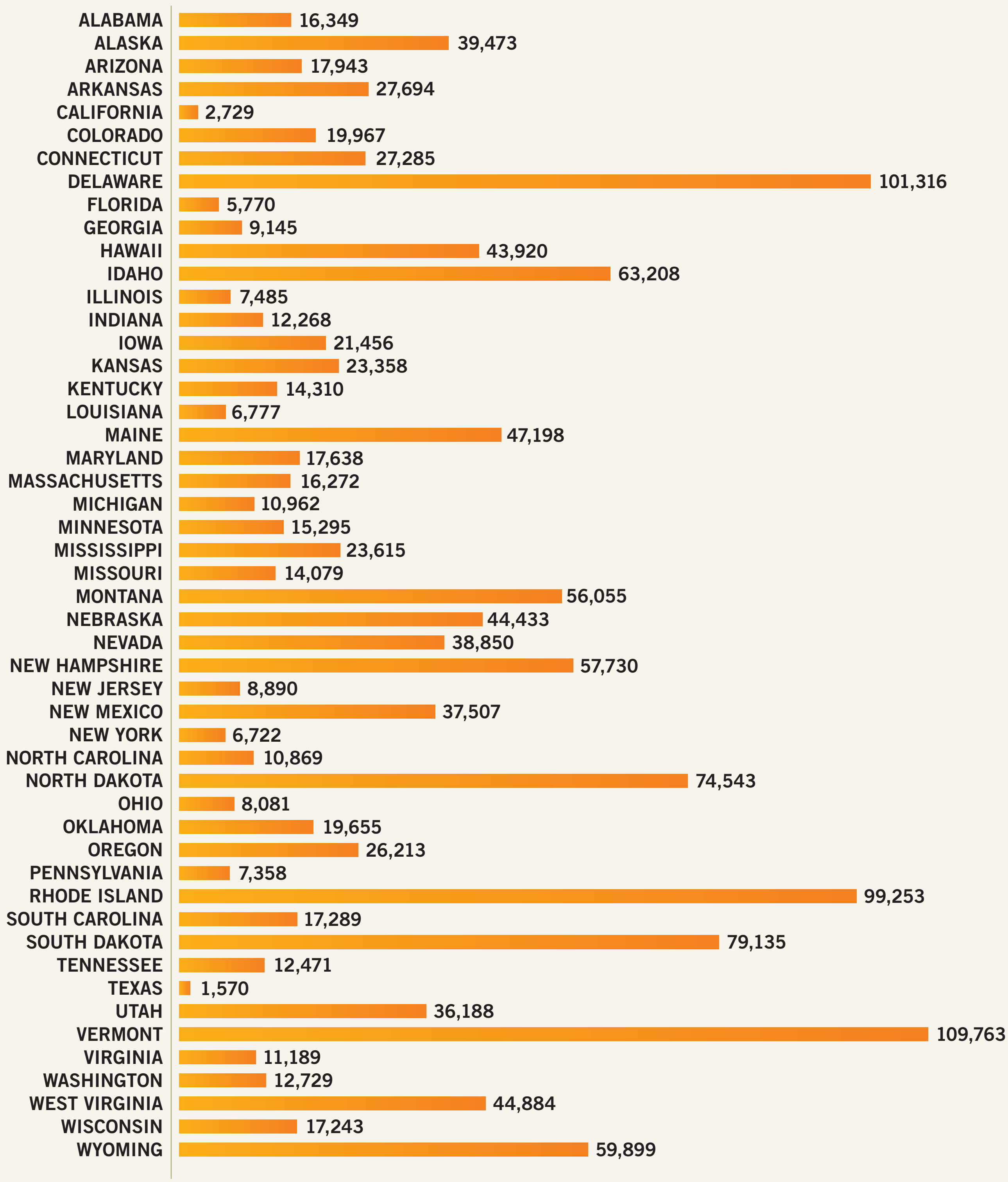
A current example of how reserves can grow is the Marcellus shale deposit that runs through the Appalachian basin. In 2002, the United States Geological Survey (USGS) estimated the area held about two trillion cubic feet of natural gas and .01 billion barrels of natural gas liquids. By 2011, however, the USGS estimated the area held 84 trillion cubic feet of natural gas and 3.4 billion barrels of liquids. Within a span of 9 years, technology increased estimated natural gas supplies in the Marcellus 42-fold, and liquids 340-fold.[17] Similarly, the Bakken formation in North Dakota and Montana was estimated to have 151 million barrels of oil in 1995, but by 2008, the USGS had increased its estimate to between three and 4.3 billion barrels, 25 times the 1995 estimate. History is rampant with these types of increased estimates of resources as improved technology enables more resources to be produced.[18]

As you can see, North America's technologically recoverable 1.79 trillion barrels are well within the range of reserve growth already demonstrated to have occurred in the Marcellus shale. But what does that number mean? It means the United States could fuel our present needs of seven billion barrels per year[19] for around 250 years. For illustrative purposes, total recoverable North American oil could meet the demands of Texas—the largest energy consuming state in the country—for more than 1,500 years. It could meet California's for over 2,700 years. Nine states—Delaware, Idaho, Montana, New Hampshire, North Dakota, Rhode Island, South Dakota, Vermont, and Wyoming—could each use North America's total recoverable oil resources to meet their current demand for over 56,000 years.[20] If it were used solely for transportation purposes, its energy could fuel every passenger car in the United States for 430 years.[21]

Additionally, these 1.79 trillion barrels in North America's total technically recoverable oil resources are about 70 percent higher than the total proved oil reserves in every Organization of Petroleum Exporting Countries (OPEC) nation combined.[22] In fact, according to the International Energy Agency, during the next five years

WHAT NORTH AMERICA'S OIL RESOURCES MEAN FOR EACH STATE

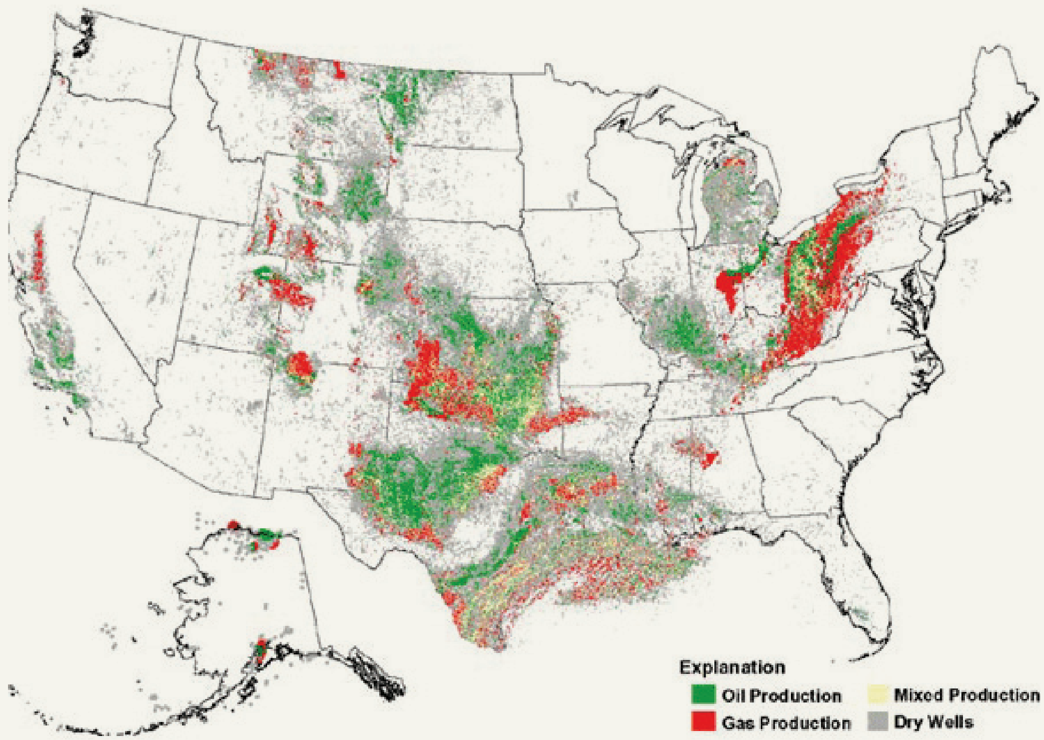
YEARS STATE COULD MEET ITS CURRENT DEMAND FOR OIL WITH NORTH AMERICA'S TOTAL RECOVERABLE OIL



NOTE: The District of Columbia could meet its current demand for oil for 463,096 years using North America's total recoverable resources.

SOURCE: Calculations made using EIA's State Energy Data System, based upon 2009 consumption data

OIL IN THE USA



SOURCE: U.S. Geological Survey

North America will become the fastest growing oil producing region in the world outside of OPEC, driven largely by increased production in the Canadian province of Alberta and in U.S. shale oil formations.[23]

OIL RESOURCES IN THE UNITED STATES

The United States currently has 1.4 trillion barrels of technically recoverable oil, from a total of more than 3.7 trillion barrels of in-place resources.[24]

In 2010, Texas was the largest oil producing state, producing 427 million barrels of oil. Texas was followed by Alaska (219 million barrels), California (201 million barrels), North Dakota (113 million barrels) and Oklahoma (70 million barrels).[25]

North Dakota's level of production is particularly striking when one considers that in 2004 the state was producing only 31 million barrels of oil,[26] or less than a third of what it produces today. In less than a decade, North Dakota has gone from the ninth largest oil producing State to the fourth largest. Increased energy production has also kept North Dakota's unemployment rate among the lowest in the country.

This occurred because of major technological innovations of oil and gas production in shale.

Furthermore, North Dakota's experience helps explain how the large numbers for North American energy potential in this report can become reality. In 1995, the U.S. Geological Survey (USGS) estimated that the Bakken Shale formation in the western part of North Dakota and eastern Montana held 151 million barrels of recoverable oil. But with advances in drilling and production technologies, including the expanded use of techniques such as hydraulic fracturing and horizontal drilling, the USGS in 2008 had to revise upward its estimates 25-fold.

The agency now estimates that the Bakken holds as much as 4.3 billion barrels of oil.[27] Just three years after the latest USGS report, oil analysts are saying that Bakken could potentially hold more than 20 billion barrels of recoverable oil,[28] representing an increase in the Bakken of 132 times over the estimate 15 years ago. A similar effect on U.S. proven oil reserves would increase our 20 billion barrels to more than 2.6 trillion barrels of oil. While this example cannot be used to project eventual supplies of energy in the U.S., it does serve to illustrate what is possible with the application of technology; it has already happened in the Bakken.

A similar story recently unfolded in South Texas, where the discovery of the **Eagle Ford Shale** formation has led to a considerable increase in production that would have been considered improbable just a few short years ago. In 2009, 94 drilling permits were issued to companies operating in the Eagle Ford. The next year the number of permits exceeded 1,000. In that same period, the combined production of crude oil and other liquids nearly quadrupled.[29] With technology continuing to advance, more and more companies are moving into the Eagle Ford, which will turn out to be one of the most prolific oil fields in the United States.

HYDRAULIC FRACTURING AND HORIZONTAL DRILLING

Hydraulic fracturing is a form of well stimulation that has been used safely and effectively for more than 60 years. Companies drill into the shale—which is located typically a mile or deeper below the surface and thousands of feet below the water table—and then inject a mixture consisting mostly of water and sand at very high pressure to break open, or fracture, the shale. The trapped oil and gas is released and then pumped to the surface.

Horizontal drilling is, as the name implies, a technique whereby a well is drilled down and then outward (horizontally), often for miles in a given direction. This not only allows energy producers to access more resources, but also to leave a dramatically smaller environmental footprint. A single oil or gas well today utilizing horizontal drilling techniques can have production levels that would have required dozens of wells just a few decades ago.

Some analysts compare the **Niobrara Shale**, which spans parts of Colorado, Wyoming, Nebraska, and Kansas, to the Bakken. The formation could hold more than two billion barrels of oil. In one county in Colorado, the number of drilling permit applications for the Niobrara was 12 times higher in 2010 than in 2009, and the pace throughout the region is expected to increase as early returns show high potential.[30]

Another recent major oil discovery was made in the Utica Shale in eastern Ohio. Chesapeake Energy announced in July 2011 that it had made an oil-rich discovery in the Utica that could hold up to 25 billion barrels of oil equivalent (BOE) in the form of oil, natural gas, and natural gas liquids. Since Chesapeake's announcement a multitude of companies have signed contracts to begin production in eastern Ohio.[31]

The Energy Information Administration currently estimates that there are a total of 24 billion barrels of recoverable shale oil in the Bakken and four other formations across the country.[32] That number, however, has been growing rapidly and is expected to grow more as exploration of shale oil deposits accelerates, tracking the experience of the "shale gas revolution."

In addition, throughout the entire U.S., there are over 982 billion barrels of oil shale estimated to be technically recoverable.[33] Oil shale is a fine-grained sedimentary rock which is very rich in organic material called "kerogen," an oil precursor which can be converted to jet fuel, diesel fuel, kerosene, and other high value products. Oil shale is different from shale oil, which is being actively produced in the United States using hydraulic fracturing and horizontal drilling technology.

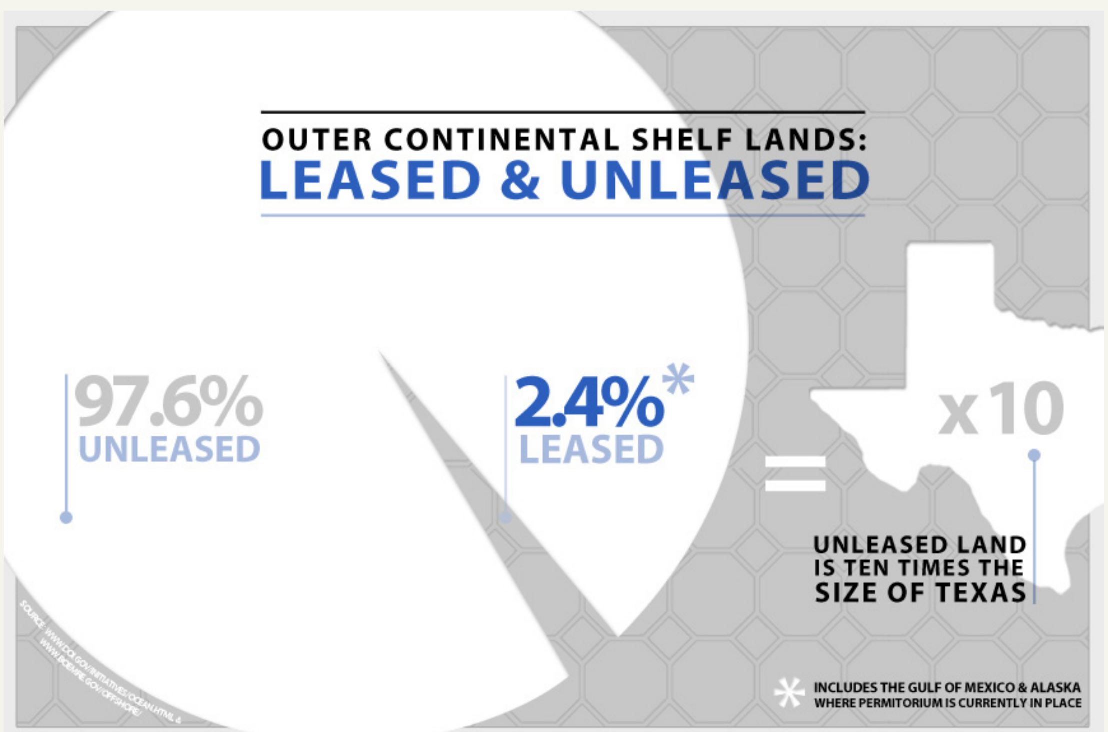
The richest, most concentrated deposits of oil shale in the U.S. are found in the Green River Formation in western Colorado, eastern Utah, and southern Wyoming.[34] Not much progress has been made in producing oil shale, however, as most of these deposits are located on federal lands that have yet to be leased. Many countries, including China and Jordan, have active programs to develop their oil shale resources, but the US has the largest oil shale deposits in the world. Combined, these unconventional energy resources could fundamentally transform the North American liquid fuels situation and petroleum geopolitics, something that has caught the attention of the head of the Saudi Arabian oil company.[35]

Meanwhile, conventional oil and gas production, including offshore, continues to be a major source of U.S. oil. For example, offshore production in the Gulf of Mexico (1.6 million barrels per day in 2010) accounts for about 30 percent of total U.S. crude oil production. Total production in America's federal waters, known as the Outer Continental Shelf, is about 588 million barrels annually. In terms of state waters, Alaska produced the most offshore in 2010 with over 21 million barrels.[36]

The United States could be producing much more energy offshore, however. Restrictions in the form of federal bans and leasing combined with declining offerings of lease acreage mean only about 2.2 percent of America's offshore acreage is currently leased for production.

According to conservative estimates from the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE), the United States has about 86 billion barrels of undiscovered oil in its Outer Continental Shelf.[37] Offshore Alaska alone has about 24 billion barrels of oil in unleased federal waters.[38]

U.S. OUTER CONTINENTAL SHELF (OCS) LEASED V. UNLEASED

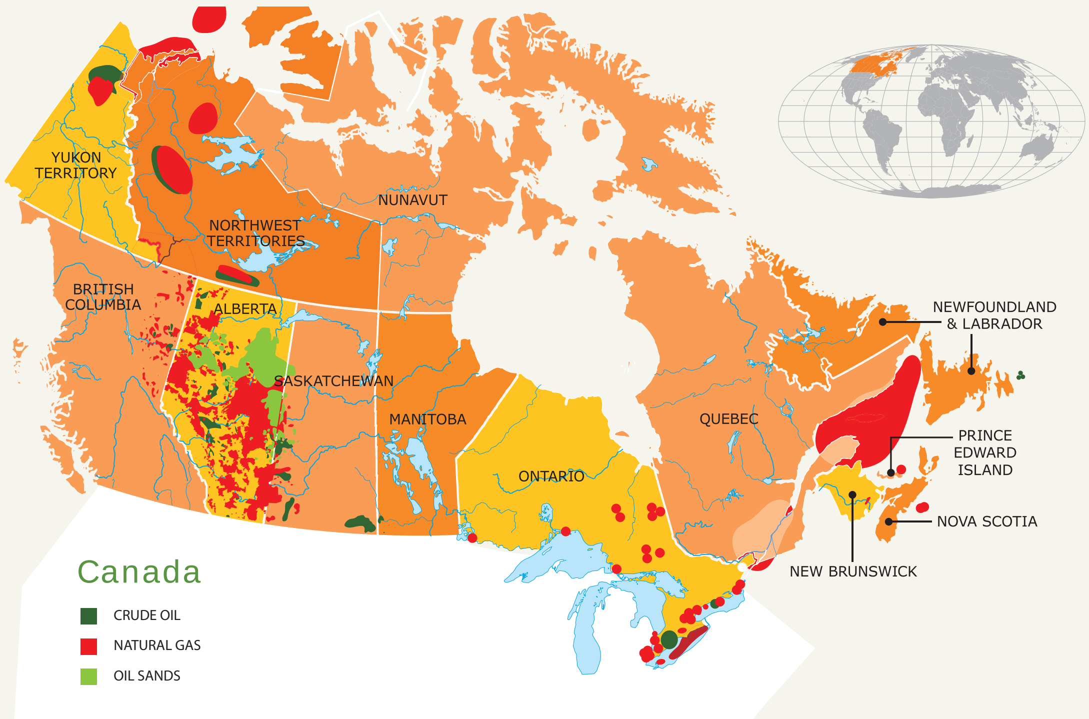


SOURCE: Bureau of Ocean Energy Management (BOEM), 2011

OIL RESOURCES IN CANADA

In Canada, there are about 320 billion barrels of technically recoverable oil, from a total of more than 1.8 trillion barrels of in-place resources.[39] In 2010, Canada produced about 3.5 million barrels per day.[40]

OIL IN CANADA



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Until 2006, the largest source of oil production in Canada was in the **Western Canada Sedimentary Basin**, which stretches from British Columbia to Manitoba. Today, the largest source of Canadian oil is in the **Alberta Oil sands**,[41] the largest oil sands deposit in the world. Oil sands production has allowed Canada to increase its proved reserves of oil from five billion barrels to 170 billion barrels, making its oil reserves third only to those of Saudi Arabia and Venezuela.[42]

Oil sands are a naturally occurring mixture of sand, clay, water, minerals, and bitumen. Bitumen is a viscous form of oil that requires heating (typically and increasingly underground) before it can be extracted. While oil sands deposits can be found around the world, Alberta's Athabasca deposit is the largest, the most developed, and utilizes the most advanced—and environmentally-safe—technologies, including an in-situ method known as **Steam Assisted Gravity Drainage**, or **SAG-D**.

Canada also produces oil off the eastern shores of Newfoundland and Labrador. Currently, the largest offshore field is the **Hibernia oil**

SAG-D

Steam Assisted Gravity Drainage (SAGD, "sag-dee"), involves drilling two separate wells down and then horizontally, with one injected into the formation above the other. Steam is pumped through the top well, which heats and releases the bitumen (oil), which then flows by gravity down into the bottom well. The oil and spent water then flow to the surface wellhead, where the oil is piped to a processing facility, and the water is either treated or, as is the case increasingly, recycled and reused.

field, which has proved reserves of roughly 1.3 billion barrels. By 2017, production will begin in the nearby **Hebron oil field**, which is said to have recoverable resources of up to 700 million barrels. Total offshore production in Newfoundland and Labrador stood at about 300,000 barrels per day in 2010.[43]

The International Energy Agency predicts that Alberta's oil resources will be a major component of North America's oil production becoming the largest non-OPEC producing region in the world over the next decade. By 2035, according to the EIA oil production in Canada will be 6.6 million barrels per day, which is almost twice what it is today.[44]

OIL RESOURCES IN MEXICO

Mexico produces about three million barrels per day[45] from a technically recoverable resource base of more than 30 billion barrels.[46] Total in-place resources in Mexico are nearly 100 billion barrels.[47]

The largest producing oil field in Mexico is the Ku-Maloob-Zaap (KMZ) offshore field in the Gulf of Campeche, which produces more than 830,000 barrels per day. The neighboring Cantarell offshore field in the Gulf of Mexico was once one of the largest oil fields in the world, but in the past decade production has declined considerably. In 2004, Cantarell produced over two million barrels per day, but by 2010 production had dropped to 558,000 barrels per day. Still, recent discoveries in the Gulf of Mexico suggest that another major source of offshore oil could be available to PEMEX, Mexico's state-run oil company. The largest producing onshore field is currently **Puerto Ceiba** in the southern region of the country, which produced about 50,000 barrels per day in 2009.[48]

Much of Mexico's known oil is considered heavy (largely found in the **Chicontepec Basin** located northeast of Mexico City), which has long been considered too costly to produce. But recent technological development coupled with rapidly growing global demand for oil means that Mexican production has the potential to increase substantially under the right conditions, especially if PEMEX can utilize new technologies to make heavy oil production more economical.[50] The same arguments made about heavy oil in Mexico—that it is too costly and too difficult to extract—were made ten years ago about the Bakken Shale in North Dakota, which has proved to be one of the most prolific onshore oil fields in North America.

NATURAL GAS

"THE U.S. IS RUNNING OUT OF NATURAL GAS—PRODUCTION IS DECLINING AND DEMAND GROWING—SO THE EXPECTATION IS THAT THE IMPORT LEVELS WILL GO FROM 3 PERCENT TODAY TO ABOUT 24 PERCENT IN 2020."

—PAUL HANRAHAN, CEO OF AES POWER, JANUARY 6, 2007

Natural gas can be used for home heating and cooking, in industrial boilers, to generate electricity and even as a transportation fuel. Moreover, natural gas—like oil—is a key building block of the petrochemical and agricultural chemical industries, including fertilizer.

Natural gas produces one-quarter of both our total energy consumption[50] and electricity production.[51] Because rapidly increasing reserves and production have led to low prices, many analysts predict natural gas will continue to gain a greater market share in the United States.

Proved reserves of natural gas in the United States and throughout North America are enormous, and the total amount of recoverable natural gas is even more impressive. The EIA estimates that the United States has 272.5 trillion cubic feet of natural gas,[52] but these are proved reserves and not total recoverable resources. The total amount of natural gas that is recoverable in North America is approximately 4.2 quadrillion (4,244 trillion) cubic feet,[53] while U.S. consumption is currently about 24 trillion cubic feet per year.[54] This is enough gas to provide the United States with 175 years of natural gas at current rates of consumption, or with electricity for 575 years at current natural gas generation levels, or for residential use for 857 years at current usage rates.[55]

Even those numbers are conservative estimates, as vast amounts of untapped natural gas exist in the Arctic. Methane hydrates are the most recent form of unconventional natural gas to be discovered and researched. These formations are made up of a lattice of frozen water, which forms a sort of cage around molecules of methane. These hydrates look like melting snow and were first discovered in permafrost regions of the Arctic. Research into methane hydrates has revealed that they may be much more plentiful than first expected—as much as 676 quadrillion (676,110 trillion) cubic feet,[56] or 48 times more than the other in-place natural gas resources in the United States alone, and another 28.5 quadrillion (28,500 trillion) cubic feet in Canada.[57] However, research into harvesting methane hydrates is relatively new, with Japan and South Korea currently in the forefront. Still, if we could tap just 5 percent of North America's hydrates, it would be enough natural gas to supply the entire United States for approximately 1,500 years.[58] If the entire North American endowment of hydrates were used to supply global natural gas demand, it would last over 6,500 years at current world consumption rates.[59]

On a global scale, total supplies of natural gas in North America dwarf those of other countries. In fact, the 4.2 quadrillion cubic feet of recoverable natural gas in North America exceeds the total of the next five largest national gas proved reserves combined. This means that the United States, Canada, and Mexico have more natural gas technically recoverable resources than the combined total proved natural gas reserves found in Russia, Iran, Qatar, Saudi Arabia, and Turkmenistan.[60]

NORTH AMERICAN SHALE GAS

SOURCE: Energy Information Administration

GAS RESOURCES IN THE UNITED STATES

Total recoverable gas resources in the United States are astounding: 2.7 quadrillion (2,744 trillion) cubic feet from a total of more than 14 quadrillion barrels of in-place resources.[61]

When the authoritative Potential Gas Committee (PGC) at the Colorado School of Mines completed its most recent biennial resource evaluation in 2010, it found that total natural gas resources in the United States were at their highest level in the Committee's 46-year history (the PGC has slightly more conservative estimates of total U.S. resources—2.17 quadrillion cubic feet—although this still represents a multi-century supply of domestic natural gas.)[62]

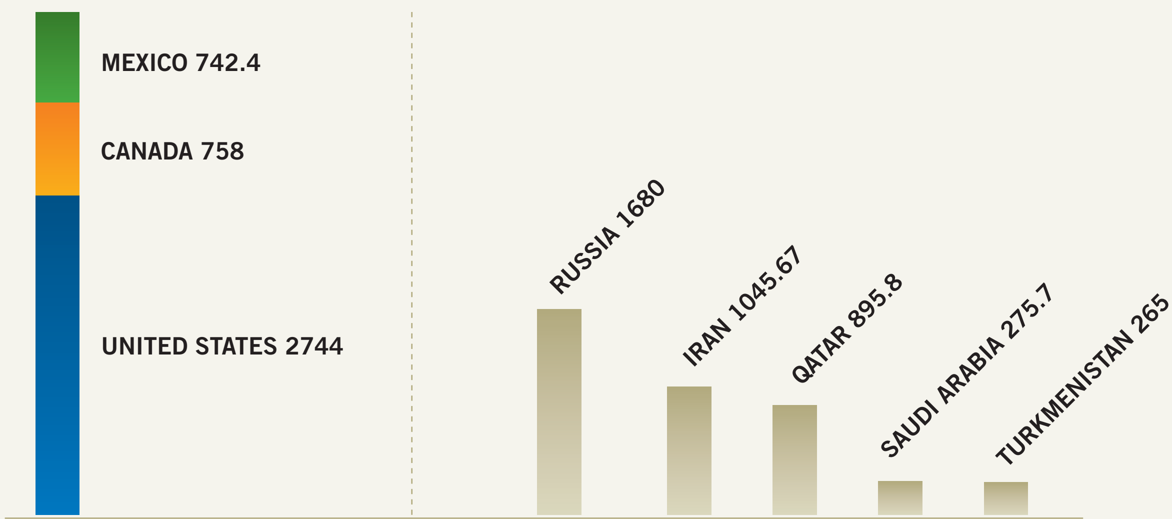
In terms of overall state production, Texas produces more natural gas (6,819 billion cubic feet) than any other state, accounting for more than 31 percent of the total gas produced in the United States. Wyoming is next with 2,335 billion cubic feet, followed by Oklahoma with 1,858 billion cubic feet.[63]

Most natural gas produced in the United States (and throughout North America) is known as conventional gas, which means it is typically in underground formations made of sandstone (these formations typically hold oil as well). This includes offshore deposits, most of which in North America are located in the U.S. Outer Continental Shelf (OCS), where technically recoverable resources are currently estimated to exceed 400 trillion cubic feet.[64] Over half of the natural gas resources in the OCS are in the Gulf of Mexico (233 trillion cubic feet), and offshore Alaska contains just under a third (132 trillion cubic feet), since there has been so little drilling offshore there. As Alaska's OCS is over one billion acres of the total U.S. OCS acreage of 1.76 billion acres, that number is expected to increase if drilling in federal waters is allowed.[65]

However, like the incredible increase in available oil, increasing quantities of natural gas—known as "unconventional"—are now recoverable in North America because of the improvements in hydraulic fracturing and the application of horizontal drilling. As the Energy Information Administration (EIA) noted in its Annual Energy Outlook for 2011: "The combination of horizontal drilling and hydraulic fracturing technologies has made it possible to produce shale gas economically, leading to an average annual growth rate of 48 percent over the 2006–2010 period."[66] Dr. John Curtis, Director of the Potential Gas Committee, made a similar observation: "[N]ew and advanced exploration, well drilling, completion and stimulation technologies are allowing us increasingly better access to domestic gas resources—especially 'unconventional' gas—which, not all that long ago, were considered impractical or uneconomical to pursue."[67]

NORTH AMERICAN NATURAL GAS V. WORLD'S NATURAL GAS

NATURAL GAS BY COUNTRY (TRILLION CUBIC FEET)



TOTAL RECOVERABLE RESOURCES: 4244.4

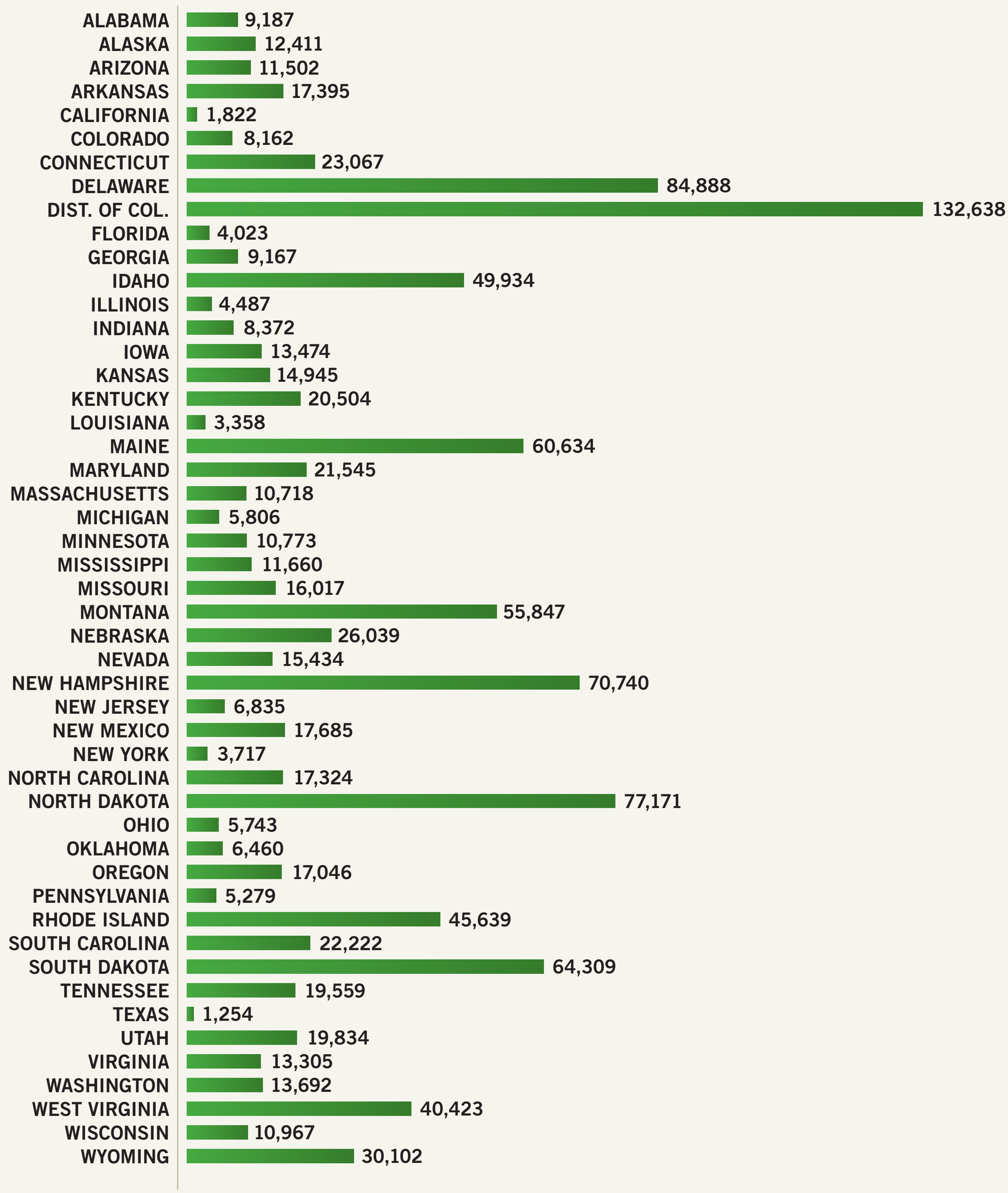
TOTAL PROVED RESERVES, TOP FIVE NON-NORTH AMERICAN COUNTRIES: 4162.2

SOURCE: U.S. Department of Energy: "Undeveloped Domestic Oil Resources" (February 2006), "Development of America's Strategic Unconventional Fuels Resources" (September 2006), and "Natural Gas Production from Tight Gas Accumulations"; USGS: "Circum-Arctic Resources Appraisal" and "Natural Gas Hydrates – Vast Resource, Unknown Future"; Petroleum Technology Alliance Canada: "Filling the Gap: Unconventional Gas Technology Roadmap" (June 2006); EIA: *Annual Energy Review* (2009), "International Energy Statistics" (2011), and *Annual Energy Outlook* (2011); Natural Resources Canada, "Oil Sands: A strategic resource for Canada, North America and the world" (2010); and Government of Mexico, "Natural Gas Market Outlook" (2008-2017)

One form of unconventional natural gas is "tight gas" that is stuck in a very tight formation underground, trapped in semi-permeable, hard rock, or in a sandstone or limestone formation. Tight gas represents over 15 percent of total recoverable natural gas in the United States, and represents almost half of the total in-place natural gas resources (excluding hydrates).

WHAT NORTH AMERICA'S NATURAL GAS RESOURCES MEAN FOR EACH STATE

YEARS STATE COULD MEET ITS CURRENT DEMAND FOR NATURAL GAS WITH NORTH AMERICA'S TOTAL RECOVERABLE NATURAL GAS



NOTE: Hawaii could meet its current natural gas demand for 1.4 million years with North America's total recoverable resources, and Vermont could meet its current demand for 471,600 years.

SOURCE: Calculations made using EIA's State Energy Data System, based upon 2009 consumption data

Another unconventional source is gas trapped in shale rock, or "**shale gas**," which arguably represents the most promising source of current and near-future production. In 2010, the EIA estimated the United States had 347 trillion cubic feet of technically recoverable shale gas resources,[68] but by 2011, that number is estimated to have almost doubled to 679 trillion cubic feet.[69]

In its Annual Energy Outlook 2010 (AEO 2010), EIA predicted that by 2035, shale gas would account for 26 percent of total U.S. natural gas production.[70] But in 2010, shale gas was already accounting for 23 percent of domestic production.[71] In its latest Annual Energy Outlook (AEO 2011), the EIA projects that by 2035, shale gas will account for an astounding 46 percent of total U.S. natural gas production.[72]

Among the many shale gas fields in the United States, the **Barnett Shale** in north Texas has been and continues to be one of the most productive, especially in recent years. In 1993, the Barnett produced just 11 billion cubic feet of natural gas per year, but by 2005 the field was producing 380 billion cubic feet. By 2010, annual production in Barnett exceeded 1,800 billion cubic feet, almost a five-fold increase over production levels just five years before, and more than 160 times as much as was produced less than two decades earlier.[73]

The **Haynesville Shale**—spanning parts of northern Louisiana, east Texas, and southern Arkansas—currently produces nearly six billion cubic feet of natural gas per day. Growth in the Haynesville has also been significant recently: the number of producing Haynesville wells in Louisiana alone increased by 134 percent between June 2010 and May 2011.[74] According to the EIA, Haynesville recently surpassed the Barnett Shale in Texas as the largest producing onshore gas field in the United States with both fields producing between five and 5.5 billion cubic feet per day.[75] Production in the Eagle Ford Shale in south Texas, however, where drilling activity is only beginning to ramp up, could soon surpass both the Haynesville and Barnett, and Eagle Ford is also very oil rich.[76]

The **Marcellus Shale** formation runs from West Virginia through Pennsylvania and into New York and could hold more than 500 trillion cubic feet of natural gas, according to geologists at Penn State University—making it potentially the second largest natural gas field in the entire world. Converted on a British thermal unit (Btu) basis to oil, 500 trillion cubic feet equates to more than 85 billion barrels of oil,[77] more than the proved oil reserves of Russia, and over 4 times as much energy as our own proved reserves.[78]

The Marcellus has experienced a rapid increase in development in the past few years, and the added economic growth that development brings—not only in terms of jobs in the energy sector but also in support industries and the creation or expansion of local businesses—allowed many areas of Pennsylvania to weather the recent recession better than the rest of the state and even the entire country.

Much of the recent development in the Marcellus has been in Pennsylvania, where production has grown significantly in the past two years. In 2009, the Marcellus produced 194 billion cubic feet, while by the end of 2010, it was producing 540 billion cubic feet on an annual basis—a 180 percent increase in just a year's time. Currently, operators are producing more than 3.2 billion cubic feet of natural gas each day—a staggering sum considering that barely 1,300 wells are currently tied into midstream infrastructure.[79]

By 2020, geologists at Penn State predict that Pennsylvania alone will produce as much as 13.5 billion cubic feet of natural gas a day, or near five trillion cubic feet per year.[80] Under that scenario, Pennsylvania would rank only behind Texas as the most prolific gas-producing state in the nation.[81]

Another significant source of unconventional natural gas is found in seams of underground coal, also known as **coalbed methane** (CBM). When coal forms underground over millions of years, the process also generates large quantities of methane, which remains locked in the coal formations. For decades this gas was a risk involved in coal production, but now—due to advancements in technology—companies are able to extract CBM itself in large quantities. The United States has an estimated 1.5 quadrillion (1,499 trillion) cubic feet of in-place coalbed methane resources,[82] and the U.S. Geological Survey has estimated that Alaska alone could hold as much as one quadrillion cubic feet of coalbed methane due to its enormous resources of coal in the ground.[83]

Thus, coal deposits now produce both coal *and* natural gas. Most coalbed methane in the lower 48 states is found in the Rocky Mountains, with significant development occurring in the nation's largest coal producing region, the **Powder River Basin** of Wyoming and Montana. The largest source of coalbed methane production since 1980 has been the **San Juan Basin** in Colorado and New Mexico, which has produced about 13 trillion cubic feet of CBM. The largest source of coalbed methane production outside of the Rocky Mountains is the **Black Warrior Basin** in northern Alabama, which has produced about two trillion cubic feet since 1980.[84]

Overall, when conventional and unconventional sources are combined, Texas has the largest proved onshore natural gas reserves in the United States with 80 trillion cubic feet. Wyoming is the second largest with more than 35 trillion cubic feet, followed by Colorado (23 trillion cubic feet), Oklahoma (22.7 trillion cubic feet), and Louisiana (20.7 trillion cubic feet).[85]

NATURAL GAS RESOURCES IN CANADA

Canada's proved reserves are just over 60 trillion cubic feet,[86] but technically recoverable natural gas resources exceed 750 trillion cubic feet, and total resources in the ground exceed 31 quadrillion cubic feet.[87] Canada is currently the world's third largest producer of natural gas, with average production exceeding five trillion cubic feet per year.[88] Most of Canada's natural gas resources to date have been found in British Columbia, Alberta, and Saskatchewan, as well as offshore Nova Scotia and Newfoundland.[89]

Most of Canada's production (75 percent) is in the **Western Canada Sedimentary Basin**.[90] The increasing application of hydraulic fracturing and horizontal drilling is unlocking new sources of gas, including shale and coalbed methane. Technically recoverable gas in shale exceeds 388 trillion cubic feet,[91] of which the largest source is the **Horn River** play, which covers parts of British Columbia and the Northwest Territories. Horn River has an estimated 132 trillion cubic feet of technically recoverable gas.[92]

Another enormous source of shale gas in Canada is the **Montney Shale**, which is located in British Columbia and western Alberta, just south of the Horn River play. This formation holds an estimated 222 trillion cubic feet of natural gas, of which about 69 trillion cubic feet is technically recoverable.[93]

Canada also has significant deposits of coalbed methane, primarily found in Alberta, which has an estimated 500 trillion cubic feet of CBM resources in place. Most of Alberta's CBM is found in the southern portion of the province, particularly in the **Horseshoe Canyon** region.[94]

Offshore, the largest gas production site is the **Sable Island Offshore Energy Project**, producing about 500 million cubic feet per day. Off the Pacific Coast, geological surveys show more than 40 trillion cubic feet of accessible gas, but Canada currently has an offshore drilling moratorium preventing exploration there, and with no drilling, there is no ability to find and produce gas.[95]

NATURAL GAS RESOURCES IN MEXICO

Mexico has about 12 trillion cubic feet of proved reserves,[96] but more than 740 trillion cubic feet in technically recoverable resources.[97] Of this recoverable natural gas, 681 trillion cubic feet is in shale,[98] which remains largely untapped in Mexico.

Most of Mexico's natural gas production (61 percent) is located onshore, where the largest producing fields are currently in the northern part of the country, in particular the **Burgos Basin**, which accounts for about a quarter of Mexico's total natural gas production. Still, offshore natural gas production has grown substantially in recent years. Although oil production is declining in the **Cantrell field**, natural gas production has increased substantially in recent years, from 278 billion cubic feet in 2005 to more than 450 billion cubic feet in 2010.[99]

COAL

"PEAK COAL IS THE NEXT ENERGY CRISIS YOU NEED TO START PAYING ATTENTION TO"

—*BUSINESS INSIDER*, NOVEMBER 29, 2010[1]

"STUDY: WORLD'S 'PEAK COAL' MOMENT HAS ARRIVED"

—HEADLINE FOR *NEW YORK TIMES* ARTICLE, SEPTEMBER 29, 2010[2]

"[P]EAK COAL LOOKS LIKE IT'S OCCURRED IN THE LOWER 48 (US STATES)."

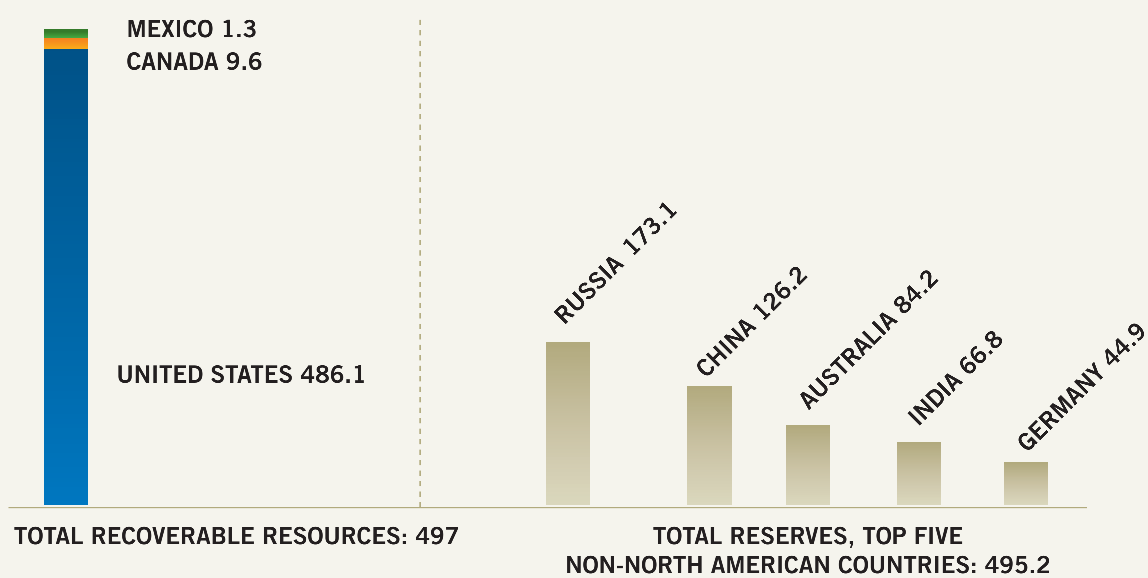
—DAVID HUGHES, GEOLOGIST FOR THE GEOLOGICAL SURVEY OF CANADA, 2007[3]

North American coal reserves are by any conceivable measure enormous, easily dwarfing those found in other countries around the world. The United States alone has the largest coal reserves of any country in the world, leading some observers to refer to the United States as the "Saudi Arabia of coal."

In terms of total recoverable resources, however, North America's combined coal supplies are even more staggering. The United States, Canada, and Mexico have over 497 billion short tons of recoverable coal,[100]

NORTH AMERICAN COAL V. WORLD'S COAL

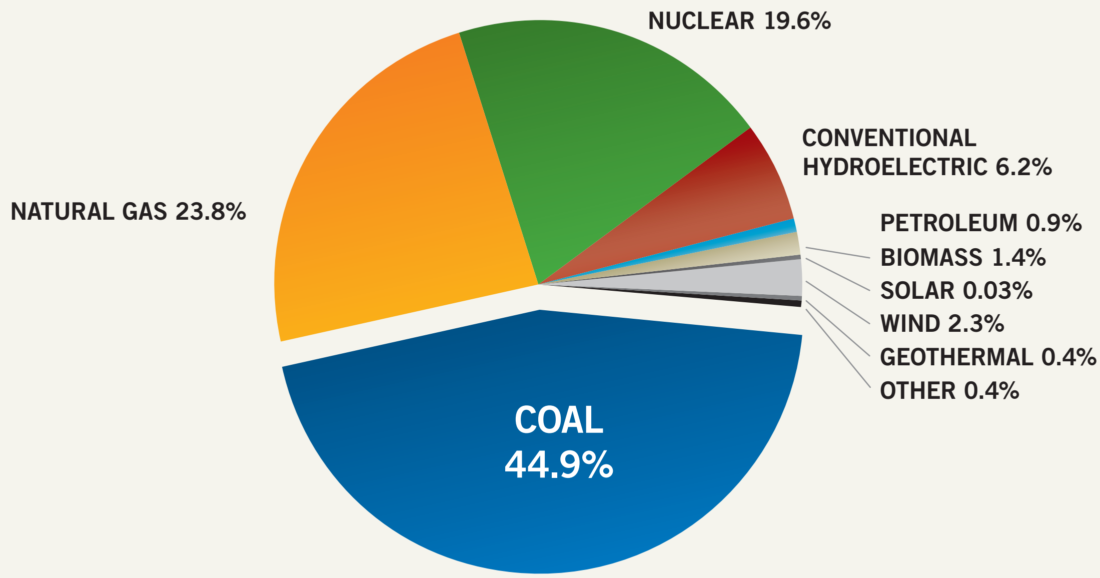
COAL BY COUNTRY (BILLION SHORT TONS)



SOURCE: EIA: "Recoverable Coal Reserves at Producing Mines" (2009) and *Annual Energy Review* (2009); USGS: "Alaska's Coal Geology, Resource, and Coalbed Methane Potential" (2004); and Natural Resources Canada: "Canada's Fossil Energy Future" (2008) or nearly three times as much as Russia, which has the world's second largest reserves.[101] North America's recoverable coal resources are bigger than the five largest non-North American countries' reserves combined (Russia, China, Australia, India, Ukraine).[102]

In terms of energy capacity, North American recoverable coal could provide enough electricity for approximately 500 years at coal's current level of consumption for electricity generation.[103] It is also enough to meet California's coal demand for more than 220,000 years. Two of the largest coal consuming states in the U.S.—Ohio and Pennsylvania—could each rely on North American coal for more than 8,800 years.

AMERICA'S ELECTRICITY MIX

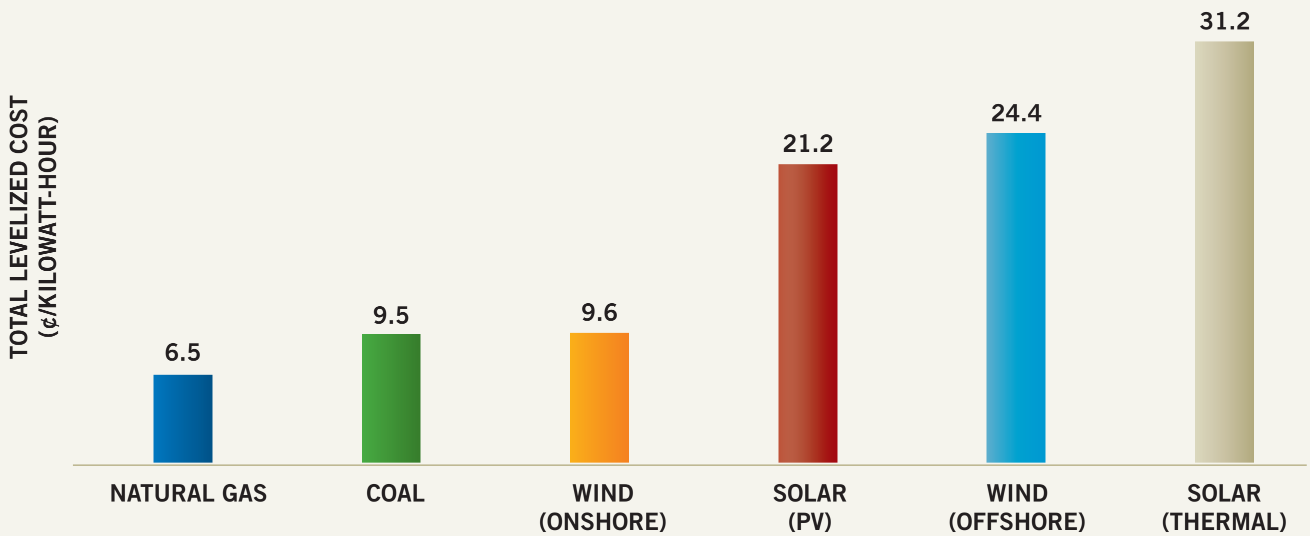


SOURCE: EIA Electric Power Data, June 2011

Since coal is also one of the most affordable forms of power, North America's large coal resources essentially guarantee that affordable and reliable energy will be available for centuries to come.

But coal is not just used for generating electricity; it is also a vital component of steel production. In fact, almost 70 percent of the steel produced worldwide relies on what is known as metallurgical coal, also called "**coking coal**." This differs from **thermal coal**, which is used for power generation. The steelmaking process involves first baking metallurgical coal into pure carbon ("coke"), which is then fed into a blast furnace with iron ore. After extremely hot air is blown into the furnace, the coke begins to burn, which melts the iron, and the molten iron is drained off. The iron is then processed with other compounds to create liquid steel.[104] For this reason, the US is exporting increasing amounts of coking coal to China and other major world steel producers.

COST OF ENERGY



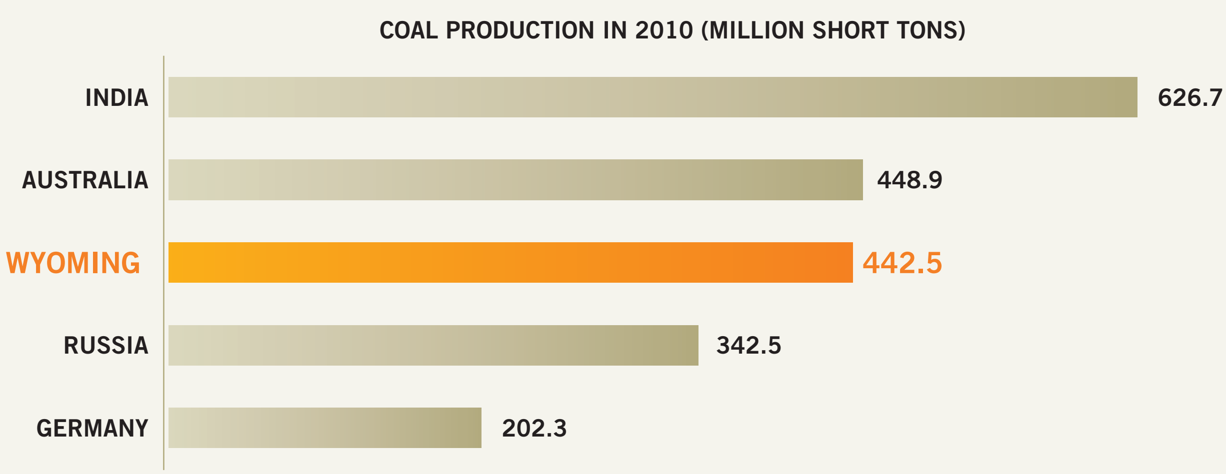
SOURCE: EIA, Annual Energy Outlook 2011

COAL RESOURCES IN THE UNITED STATES

The United States has 486 billion short tons of technically recoverable coal out of a total resource base of more than 10,320 billion short tons of in-place resources.[105]

In the United States, the largest coal producing state is Wyoming, home to the Powder River Basin. The **Powder River Basin**, which also covers parts of Montana, is one of the world's richest deposits of low-sulfur coal. In 2010 Wyoming produced over 440 million short tons of coal,[106] or 41 percent of the total amount of coal produced in the United States that year. The next largest coal producing state is West Virginia (137 million short tons, 13 percent of U.S. production), followed by Kentucky (107 million short tons), Pennsylvania (58 million short tons), and Montana (39 million short tons).[107] The largest producing mine in the United

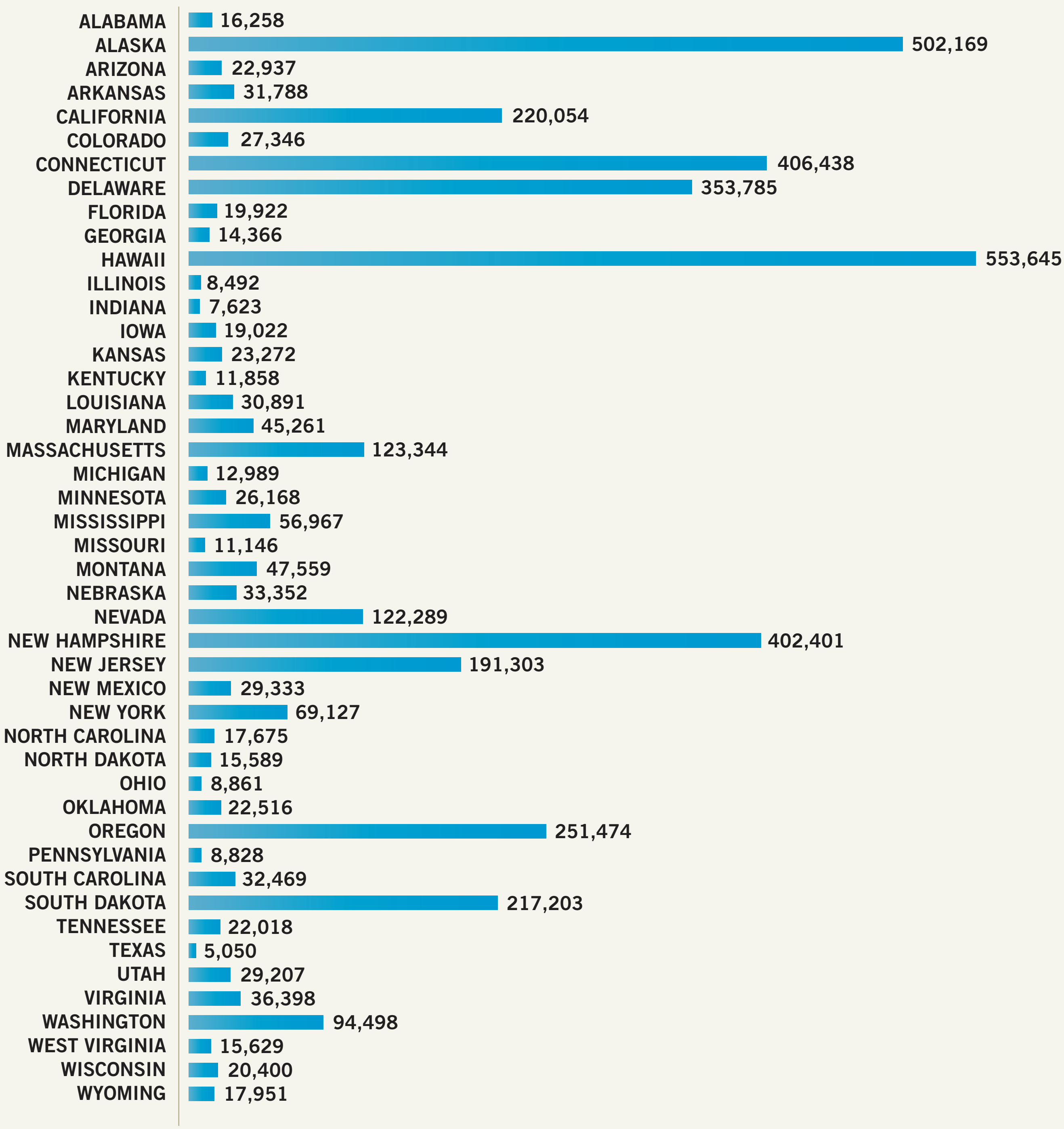
COAL PRODUCTION IN 2010



SOURCE: Wyoming State Geological Survey; EIA International Energy Statistics

WHAT NORTH AMERICA'S COAL RESOURCES MEAN FOR EACH STATE

YEARS STATE COULD MEET ITS CURRENT DEMAND FOR COAL WITH NORTH AMERICA'S TOTAL RECOVERABLE COAL



NOTE: Idaho and Maine could meet their current demand for coal for more than one million years with North America's total recoverable resources. Rhode Island and Vermont currently consume no coal for power generation.

SOURCE: Calculations made using EIA's State Energy Data System, based upon 2009 consumption data

States (98 million short tons in 2009) is the **North Antelope Rochelle Mine**, located 65 miles south of Gillette, Wyoming.[108] In 2010, Wyoming alone produced 100 million more short tons than all of Russia, which holds the world's second largest known reserves of coal.[109]

The U.S. Energy Information Administration breaks down coal production into three geographical regions: Western, Interior, and Appalachian. The Western Region includes not only Wyoming and Montana, but also New Mexico, Colorado, Arizona, Utah, the Dakotas, and portions of Washington and Alaska. In 2010, the Western Regional production 591.6 million tons of coal—over half of the coal produced in the United States.[110]

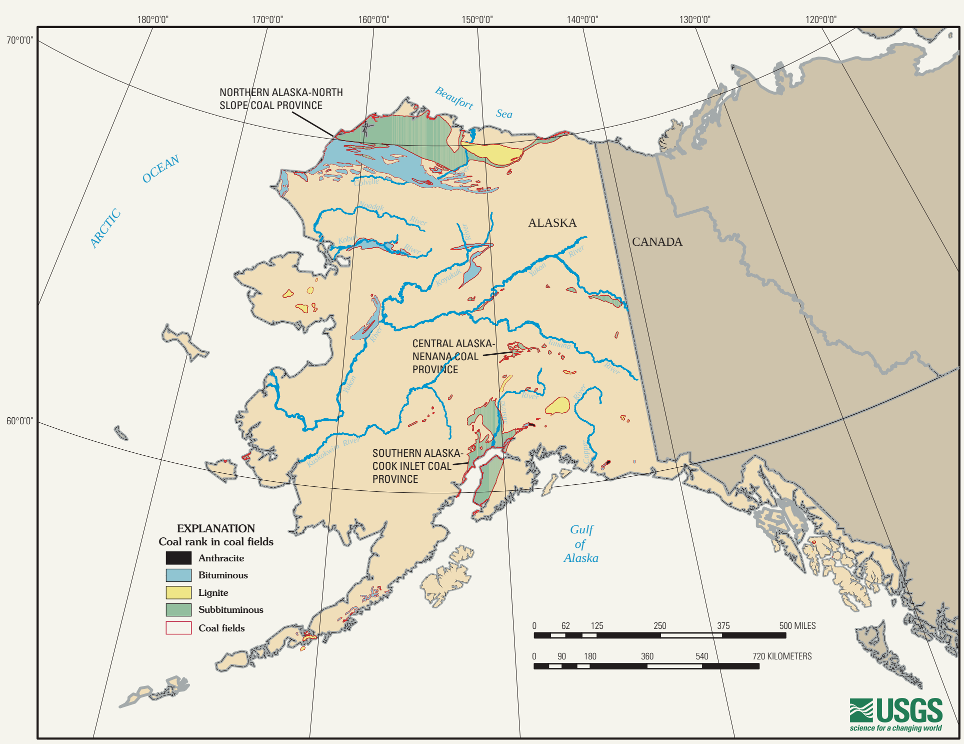
The Appalachian region, which includes Pennsylvania, West Virginia, Ohio, and eastern Kentucky, produced 334 million short tons in 2010.[111] The largest producing mine in this region is the **Enlow Fork Mine**, located in southwestern Pennsylvania, which produced 11 million short tons in 2010.[112] Of the states classified as Interior, where 156.7 million short tons were produced, Texas was the largest producer, accounting for over one-fourth of all production in the region.[113] The largest single producing mine in the region, however, is the **Cardinal Mine** in Hopkins County, Kentucky, which produces over six million short tons per year.[114]

TYPES OF COAL

There are four main types of coal based upon their carbon content:

- **Anthracite** has the highest carbon content (up to 97 percent) and has the highest heating value.
- **Bituminous coal** contains up to 86 percent carbon and accounts for about half of all U.S. coal production. It is used both for power generation and as a raw material in the steel industry.
- **Sub-bituminous coal** contains up to 45% carbon. Most sub-bituminous coal is mined in Wyoming.
- **Lignite** has the lowest energy content and accounts for about seven percent of all coal mined in the United States. It is used primarily for power generation.

ALASKA'S COAL DEPOSITS



SOURCE: USGS

Interestingly, Alaska's vast deposits of coal (6.4 trillion short tons) are almost 64 percent larger than those in the lower 48 states (3.9 trillion short tons), but they remain largely untapped and are not included when the U.S. is referred to as the "Saudi Arabia of coal."[115] A range of issues from lack of infrastructure to challenging terrains and the current relative abundance of coal mean that its resources will probably not be used soon in a major way, but its potential as a hydrocarbon source for Americans should not be underestimated.

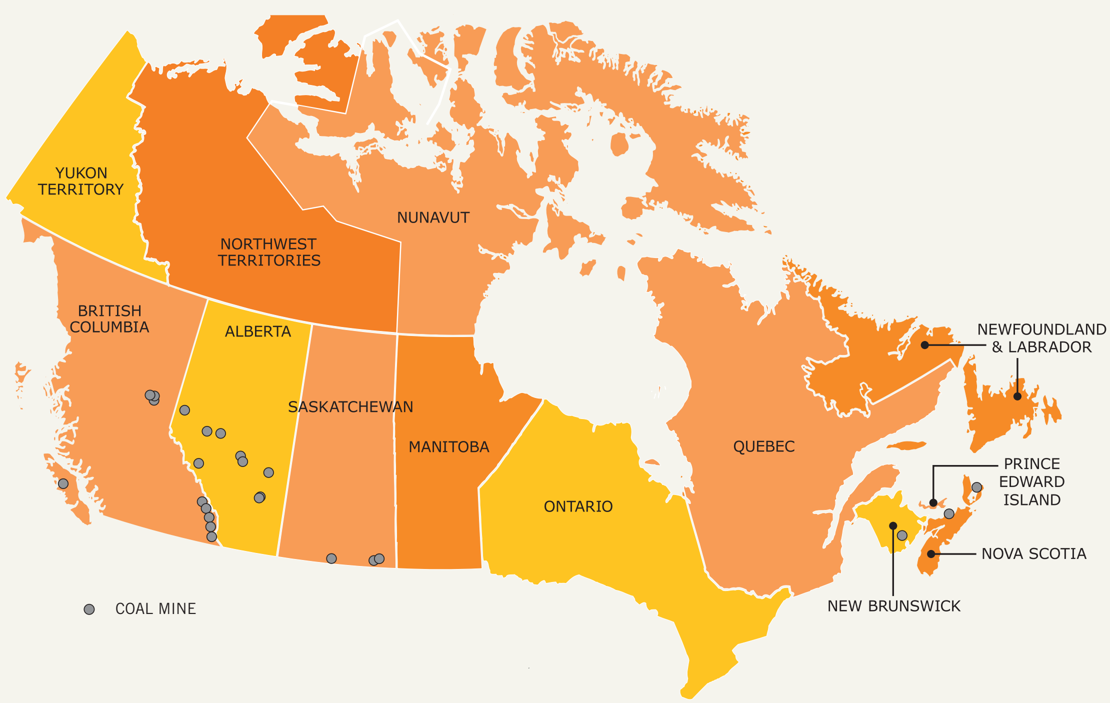
COAL RESOURCES IN CANADA

Canada has 9.6 billion short tons of recoverable coal out of a total resource base of more than 350 billion short tons.[116] The largest coal reserves are in British Columbia, Alberta, and Saskatchewan. Of the country's 22 coal mines, 17 are in British Columbia and Alberta, whose combined coal production accounts for more than 80 percent of Canada's overall production.[117] The largest producing mine is the **Highvale Mine** in Alberta, which has a production capacity of 13 million short tons per year.[118]

Most of the coal in British Columbia is metallurgical coal, and the largest producing mine in BC is the **Fording River Mine**, which has a production capacity of over eight million tons of coking coal per year.[119] Coal accounts for less than ten percent of Canada's total energy consumption (58 percent of electricity generated in Canada is from hydroelectric sources), although coal is the largest source of hydrocarbon fuel-generated electricity in the country.[120]

In 2010, Canada produced over 74.8 million short tons of coal.[121] In 2009, the largest provincial source of Canadian coal was Alberta (34.3 million short tons), followed by British Columbia (23.2 million short tons) and Saskatchewan (11.6 million short tons).[122]

COAL IN CANADA



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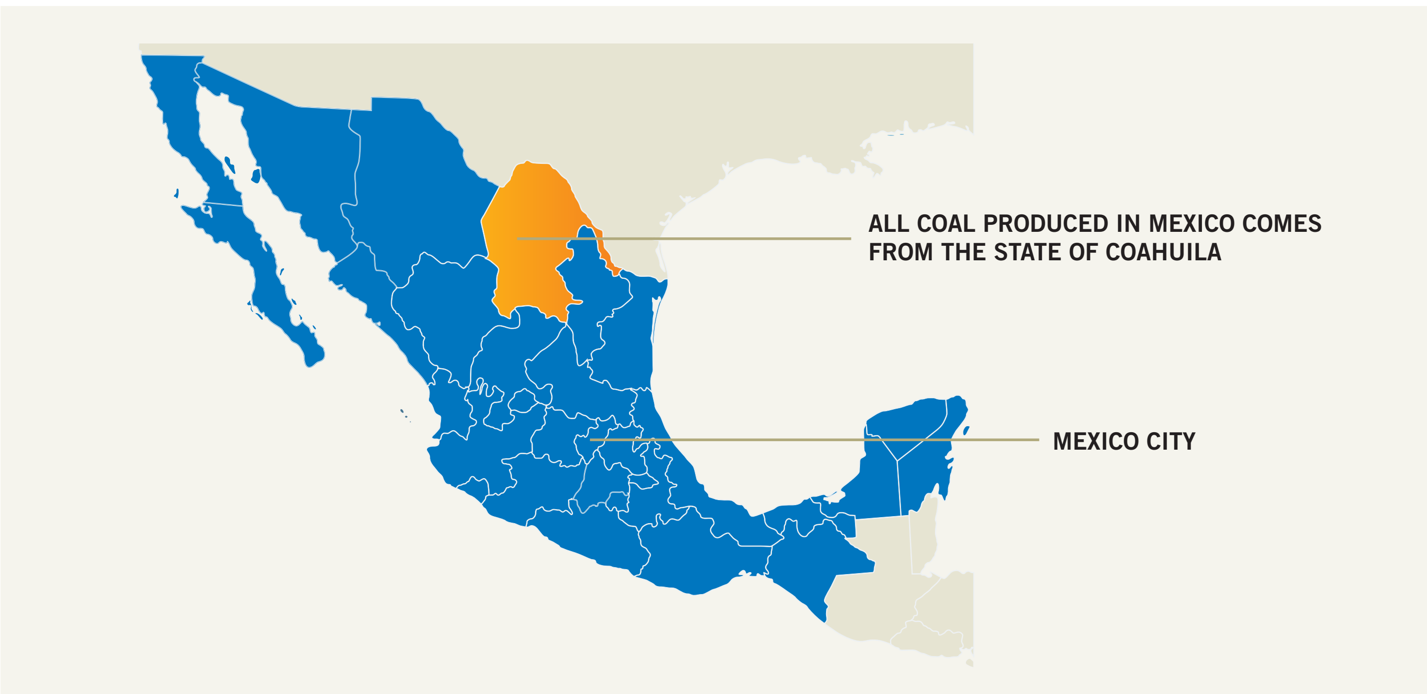
COAL RESOURCES IN MEXICO

Mexican coal production is currently more than ten million short tons per year,[123] out of a total technically recoverable resource base of about 1.3 billion short tons.[124] All coal production in Mexico is in the northern part of the country in the state of **Coahuila**. The largest single source of production was around the municipality of **Nava**, which in 2008 produced nearly seven million short tons of coal. The second largest municipal source of production was **Múzquiz**, with about 3.6 million short tons.[125]

In the past, fuel oil and diesel fuel represented the largest share of Mexico's conventional thermal generation mix. However, both natural gas and coal consumption for electricity generation have risen dramatically in recent years. According to Mexico's Energy Secretariat, Mexico consumed 416 trillion Btu of natural gas, 373 trillion Btu of petroleum products, and 364 trillion Btu of coal for electricity generation in 2010.[126]

COAL IN MEXICO



ENVIRONMENTAL IMPACT

While coal is often maligned as the "dirtiest" hydrocarbon fuel, advances in technologies have dramatically reduced coal's impacts on air, water, and land.

For example, between 1980 and 2008 emissions of sulfur dioxide (SO2) from coal plants have dropped by 71 percent. Over the same period, ambient nitrogen dioxide levels have decreased by 46 percent and ambient ozone levels have declined 25 percent. This is a big reason why no American city is among the top 50 worst cities worldwide for air pollution, according to the World Bank. Yet since 1980, coal consumption has actually increased in the United States by 60 percent; worldwide it has increased by nearly 80 percent.[127] The development of smokestack scrubbers and the expanded availability and use of low-sulfur coal, combined with cleaner operating systems, mean that a coal plant built today is as much as 99 percent cleaner than one built 40 years ago.[128]

IMPEDIMENTS

As it turns out, many of the problems of energy scarcity and rising costs in the United States have been caused by the government itself. In 2004, the U.S. Department of Energy issued a report that outlined many of the policy and regulatory constraints that impact domestic energy production. While the report focused on natural gas specifically, many of the laws and procedures also represent roadblocks to any form of safe and responsible energy production. The list of energy barriers included the following policies, all of which can limit access to U.S. resources, increase delays related to exploration and production, and/or increase costs of development:

- Acquired Lands Mineral Leasing Act
- Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use
- Advisory Committee Act
- Agriculture and Food Act of 1981
- Alaska National Interest Lands Conservation Act
- Alaska Native Claims Settlement Act (ANCSA)
- American Indian Religious Freedom Act of 1978
- American Recovery and Reinvestment Act
- Antiquities Act of 1906
- Archaeological and Historical Preservation Act
- Archaeological Resource Protection Act of 1979 (ARPA)
- Architectural Barriers Act of 1968
- Bald and Golden Eagle Protection Act
- Bankhead-Jones Farm Tenant Act
- Bans on drilling in the Great Lakes
- BLM Energy and Mineral Policy
- California Desert Conservation Area Plan 1980
- Changes in nationwide permits (NWPs) issued by the U.S. Army Corps of Engineers (COE)
- Clean Air Act
- Clean Water Act
- Coalbed methane (CBM)-produced water and potential regulations to manage such water
- Coastal Zone Management Act
- Commemorative Works Act
- Commodity Credit Corporation Charter Act as amended
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Department of Transportation Act of 1969
- Determination of No Hazard
- DOE 141.1—Department of Energy Management of Cultural Resources
- Drilling permit delays
- Electric Consumer Protection Act of 1986
- Emergency Planning and Community Right-to-Know
- Endangered Species Act of 1973
- Energy Policy Act of 1992
- Energy Policy Act of 2005
- Energy Security and Independence Act
- Environmental Conservation and Occupational Safety
- Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes
- EPA Publication, Federal Guidance Report No. 11
- Essential fish habitat (EFH) regulations
- Farmland Protection Policy Act
- Federal Agriculture Improvement and Reform Act of 1996

- Federal Cave Resources Protection Act of 1988
- Federal Energy Management Program
- Federal Facility Compliance Act
- Federal Insecticide, Fungicide, and Rodenticide Act
- Federal Land Policy and Management Act (FLPMA)
- Federal Lands Recreation Enhancement Act
- Federal Leadership in Environmental, Energy, and Economic Performance
- Federal Onshore Oil and Gas Leasing Reform Act of 1987 FOOGLRA
- Federal Power Act
- Fish and Wildlife Coordination Act
- Food Security Act of 1985 as amended
- Food, Agriculture, Conservation and Trade Act of 1990
- Forest and Rangeland Renewable Resources Planning Act of 1974
- Possible future regulation of hydraulic fracturing
- General Mining Act of 1872
- Geothermal Steam Act of 1970
- Hazardous Materials Transportation Act
- Historic Sites, Buildings and Antiquities Act
- Indian Sacred Sites, Executive Order 13007
- Indian Tribal Energy Development Act
- Land and Water Conservation Fund Act of 1965
- Lease stipulations
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Marine Protection, Research and Sanctuaries Act
- Maximum achievable control technology (MACT) rules
- Mercury discharge regulations
- Migratory Bird Treaty Act
- Mineral Leasing Act
- Mining and Minerals Policy Act of 1970
- Mining in the Parks Act
- Multiple-Use Sustained-Yield Act
- National American Graves Protection and Repatriation Act
- National Cemeteries Act of 1973
- National Environmental Policy Act of 1969 requirements
- National Forest Management Act
- National Historic Preservation Act
- National Park Service Concessions Management Improvement Act of 1998
- National Park System General Authorities Act
- National Park System Resource Protection Act
- National Parks Air Tour Management Act
- National Parks Omnibus Management Act of 1998
- National Trails System Act
- National Wildlife Refuge System Improvement Act
- Native American Graves Protection and Repatriation Acts
- Negotiated Rule making Act
- Nitrogen oxides (NOx) requirements
- Noise Control Act of 1972
- Nonroad diesel regulations
- Noxious Weeds Act
- Occupational Safety and Health Act of 1970
- Ocean discharge criteria
- Oil Pollution Act of 1990
- Omnibus Consolidated Appropriations Act
- Omnibus Public Land Management Act of 2009
- Organic Administration Act
- Outdated BLM land use plans
- Outer Continental Shelf (OCS) moratoria
- Particulate matter (PM) regulations
- Petroleum Act
- Pipeline certification issues
- Pipeline gathering definitions
- Pollution Prevention Act
- Privacy Act of 1974
- Public Rangelands Improvement Act of 1978
- Public Utility Regulatory Policies Act of 1978

- Quiet Communities Act of 1978
- Recreation Enhancement Act
- Regional haze rule
- Regulations for cooling-water intake structures at offshore extraction facilities
- Rehabilitation Act of 1973
- Renewable Resources Extension Act of 1978
- Resource Conservation and Recovery Act (Hazardous and Solid Waste Amendments)
- Rivers and Harbors Appropriation Act of 1899
- Robert T. Stafford Disaster Relief and Emergency Assistance Act
- Safe Drinking Water Act
- Soil and Water Resources Conservation Act of 1977
- Soil Conservation and Domestic Allotment Act,
- Solid Waste Disposal Act
- Spill prevention and control and countermeasures regulations
- State waste disposal regulations
- Stevenson-Wydler Technology Innovation Act of 1980
- Storm water construction permits
- Strengthening Federal Environmental, Energy, and Transportation Management
- Superfund Amendments and Reauthorization Act
- Surface Mining Control and Reclamation Act of 1977
- Surface Resources Act of 1955
- Taylor Grazing Act of 1934
- Telecommunication Act of 1996
- Tennessee Valley Authority Act
- The Farm Security and Rural Investment Act of 2002
- The "Roadless Rule"
- Total maximum daily load (TMDL) regulations
- Toxic Substance Control Act
- U.S. Department of Agriculture (USDA) Forest Service (FS) restrictions
- Volunteers in the Parks Act of 1969
- Water Mitigation Agreement
- Wet lands mitigation issues
- Wild and Scenic Rivers Act
- Wild Free Roaming Horse and Burro Act of 1971
- Wilderness Act
- Wind Energy Protocol Between the Department of Defense and the BLM

Drilling permit delays from the Gulf of Mexico to Alaska have contributed to a significant decline in America's capacity to produce its own oil and gas. The ban on drilling in the federal OCS has been lifted and re-imposed in just the past three years. Oil producers in the fields of west Texas—which for a century have been one of the largest sources of domestically produced oil in the United States—are worried that the application of the Endangered Species Act could shut down a significant portion of the region's production. The EPA and the Department of Interior are constantly being pressured by anti-energy activists to regulate directly or even ban hydraulic fracturing. An EPA-issued Clean Water Act permit for a coal company in West Virginia was retroactively vetoed by the EPA last year, sacrificing hundreds of jobs and casting significant investor doubt on the entire permit approval process.

CONCLUSION

North America is blessed with enough energy supplies to promote and sustain economic growth for many generations. The government's own reports detail this, and Congress was advised of our energy wealth when the Congressional Research Service of the Library of Congress released a report showing that the United States' combined recoverable oil, natural gas, and coal endowment is the largest on Earth.

Despite this overwhelming evidence of energy abundance, many continue to proclaim that an energy problem or "crisis" exists that justifies increased central planning, increased expenditures of public money, increased energy taxes and increased diktats on American citizens in order to solve "the problem."

For forty years, politicians and special interests have argued successfully that energy production requires more regulations, more taxes, and more restrictions and the result has been less domestically produced energy, less economic growth, and fewer jobs. Nowhere is this more evident than the recent steep decline of production of energy from federal lands and waters, where production of oil and gas has fallen more than 40 percent over the last ten years. The effect of bad federal policies is seen most clearly on those lands owned by the federal government.

Ironically, many of the policies that serve to hamstring energy production were abetted by the same premise: since America does not have enough oil, natural gas, and coal to continue to build its economy and improve the standards of living for all, the impact of proposed policies would negligibly affect energy production and security. The truth that is finally becoming clear is that North America is not only blessed with huge quantities of energy, but also could become the single largest producer in the world, with all of the attendant manufacturing, technological innovation and re-industrialization that would provide generations with good jobs and sustainable futures.

The question Americans therefore need to ask is whether government officials throughout North America will embrace this enormous opportunity or scorn it. Armed only with pessimistic assumptions about technology and an incomplete and misleading understanding of our energy wealth here at home, we should not be surprised that our energy situation has gotten worse the more they intervened.

This is precisely where this assessment can play a vital role in educating the public. The era of perceived energy shortages must end, and informed judgments about North America's energy potential must finally be made. Millions of new jobs, untold economic growth, and unprecedented wealth creation for North America and the world await a productive and conducive environment for energy production.

Facing a future of plentiful and affordable energy supplies, Americans can once again reclaim the optimism that has characterized our history, replacing the pessimism of scarcity and government rationing that has placed limits on the growth of our economy and perhaps more importantly, our way of looking at the world. The America President Ronald Reagan described as the "Shining City on the Hill" can keep its lights shining as an example to the rest of the world if we choose to avail ourselves of our energy wealth. The question remaining is whether we have the will to do so.

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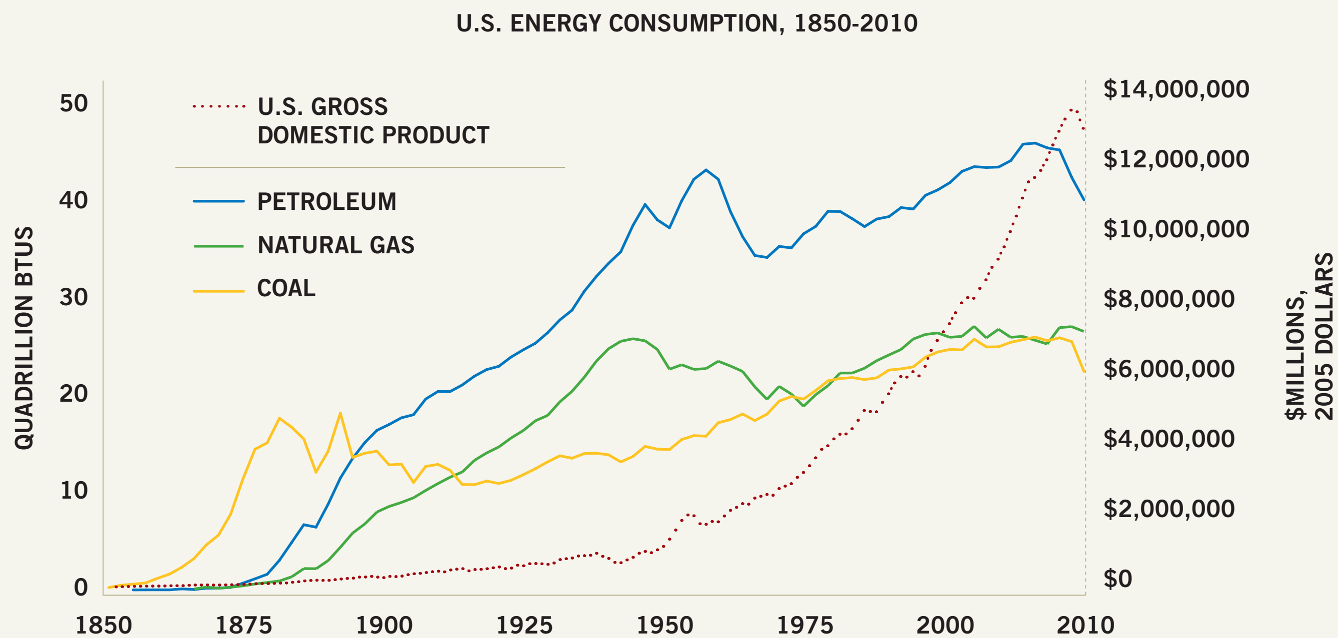
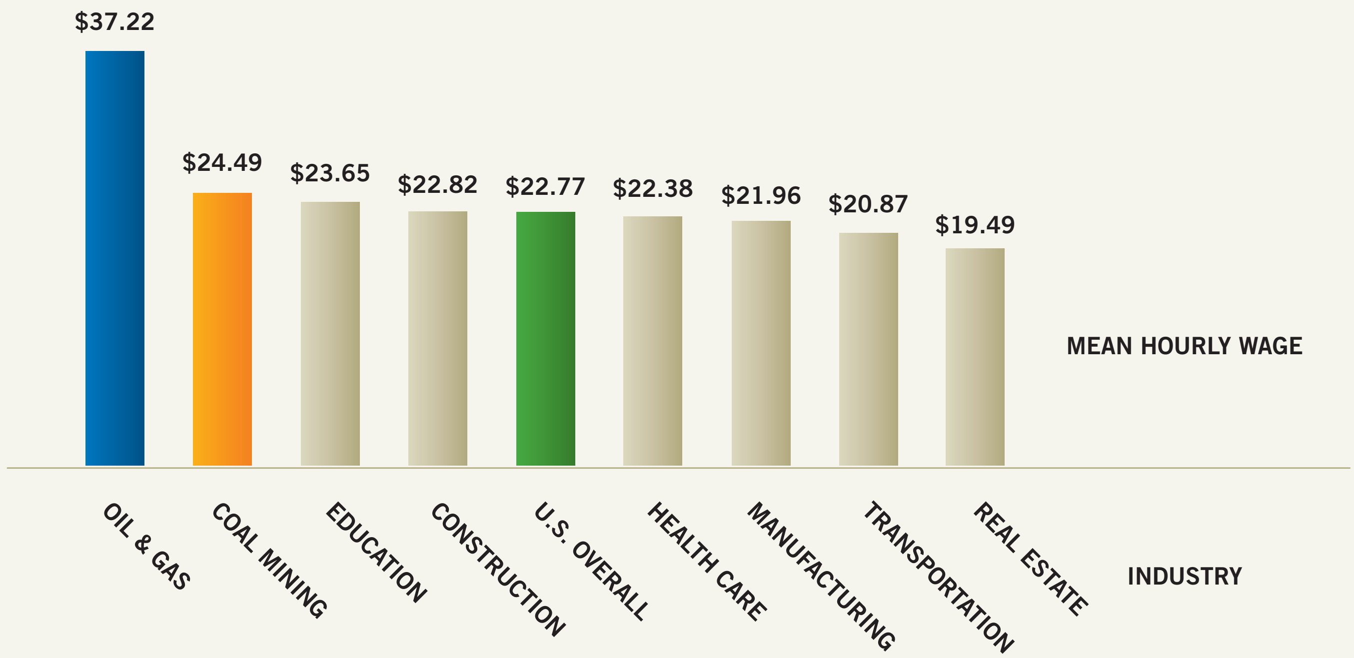
APPENDIX

FIG. 1 | GDP AND ENERGY USE



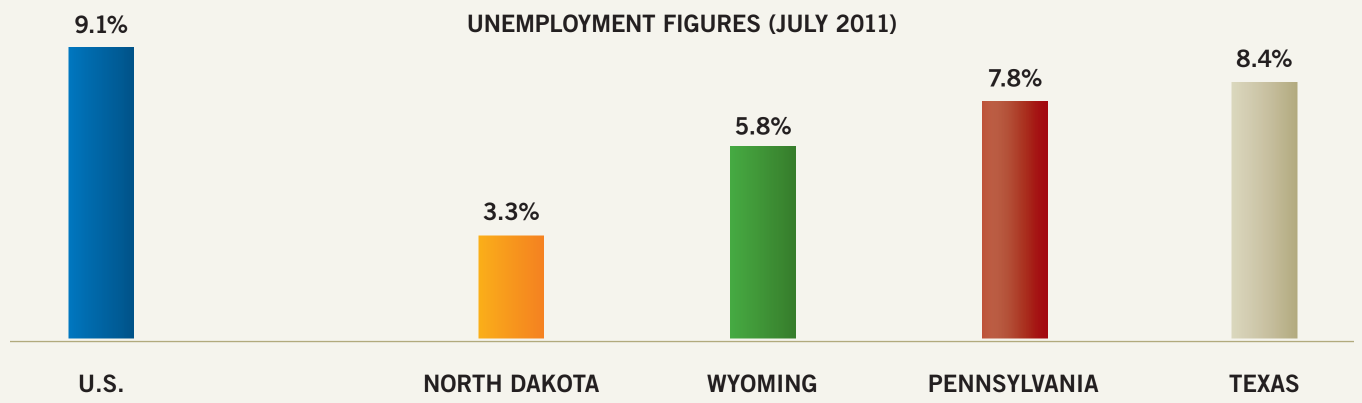
SOURCE: Energy data: U.S. Energy Information Administration, Annual Energy Review; GDP: U.S. Bureau of Economic Analysis

FIG. 2 | ENERGY AND JOBS: SELECTED INDUSTRIES



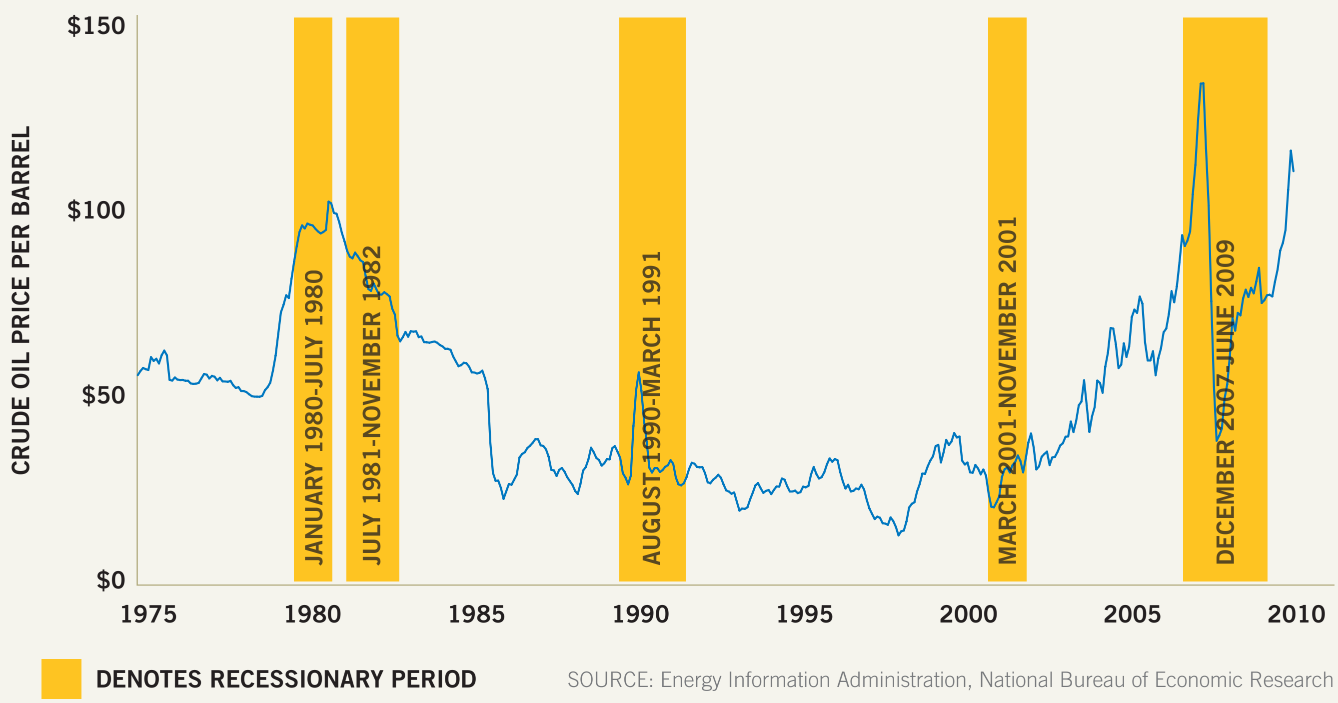
Source: BLS, May 2010 National Industry-Specific Occupational Employment and Wage Estimates

FIG. 3 | UNEMPLOYMENT IN MAJOR ENERGY PRODUCING STATES



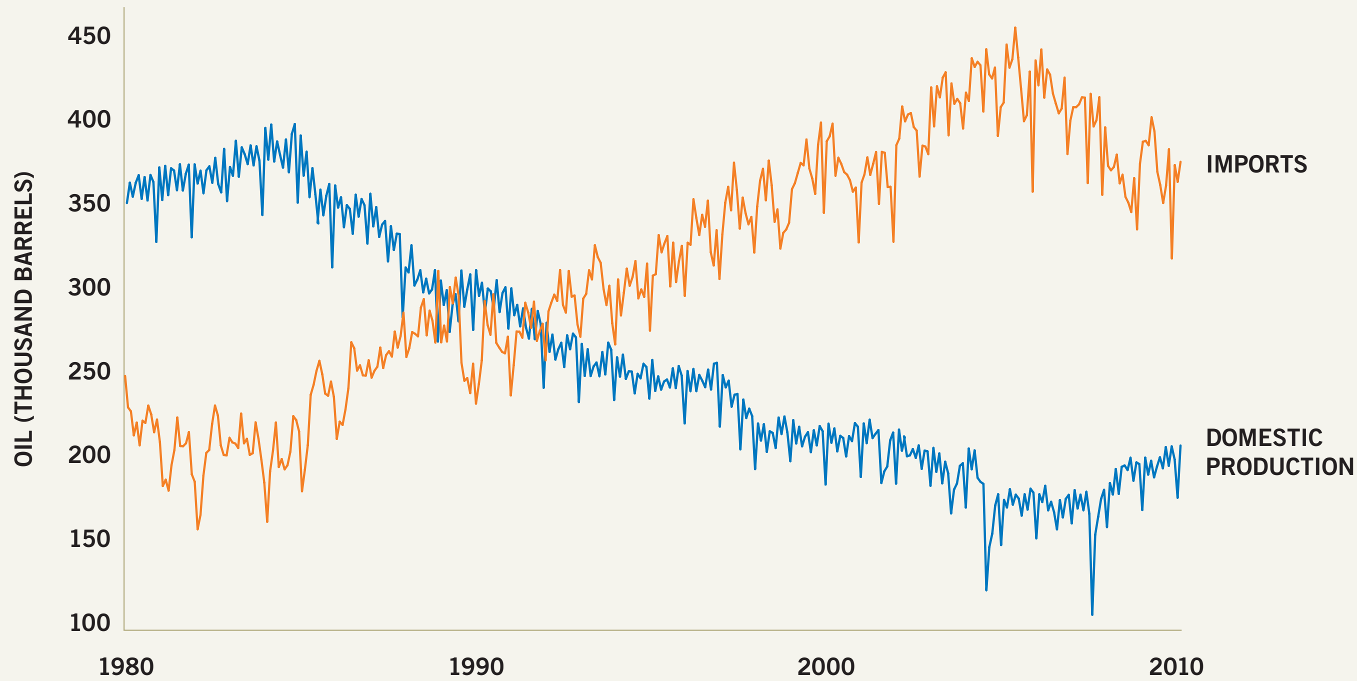
SOURCE: Bureau of Labor Statistics (BLS), July 2011

FIG. 4 | OIL PRICES AND RECESSIONS



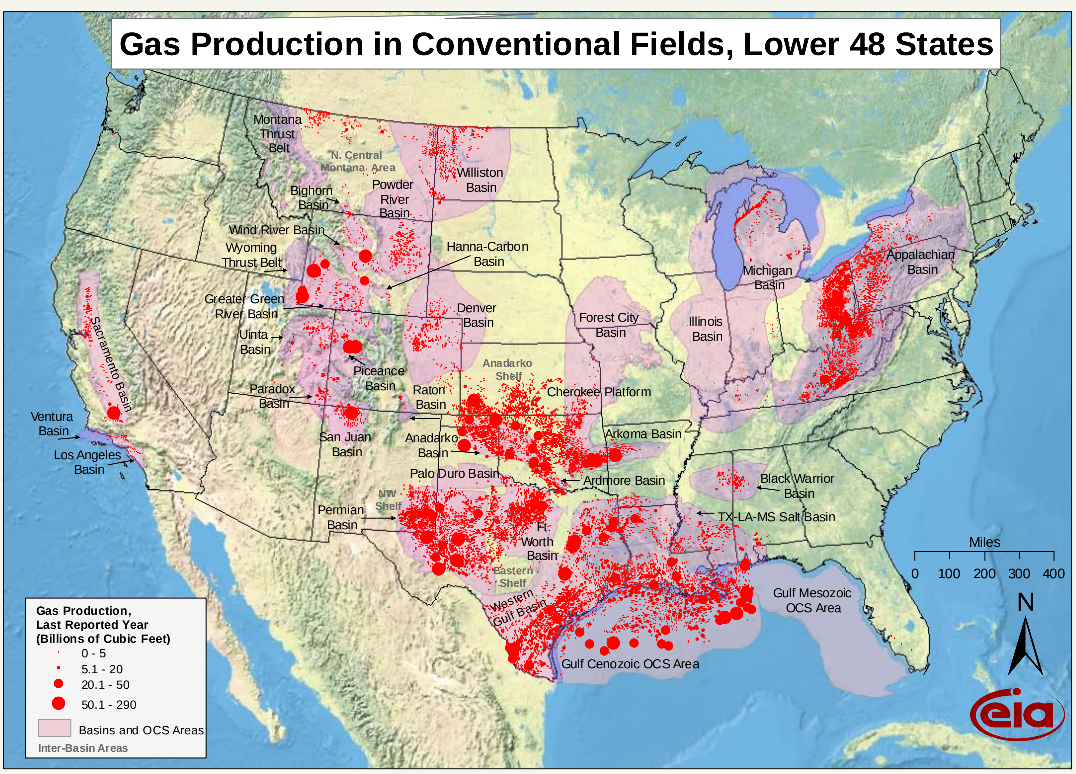
SOURCE: Energy Information Administration, National Bureau of Economic Research

FIG. 5 | PRODUCTION VS. IMPORTS



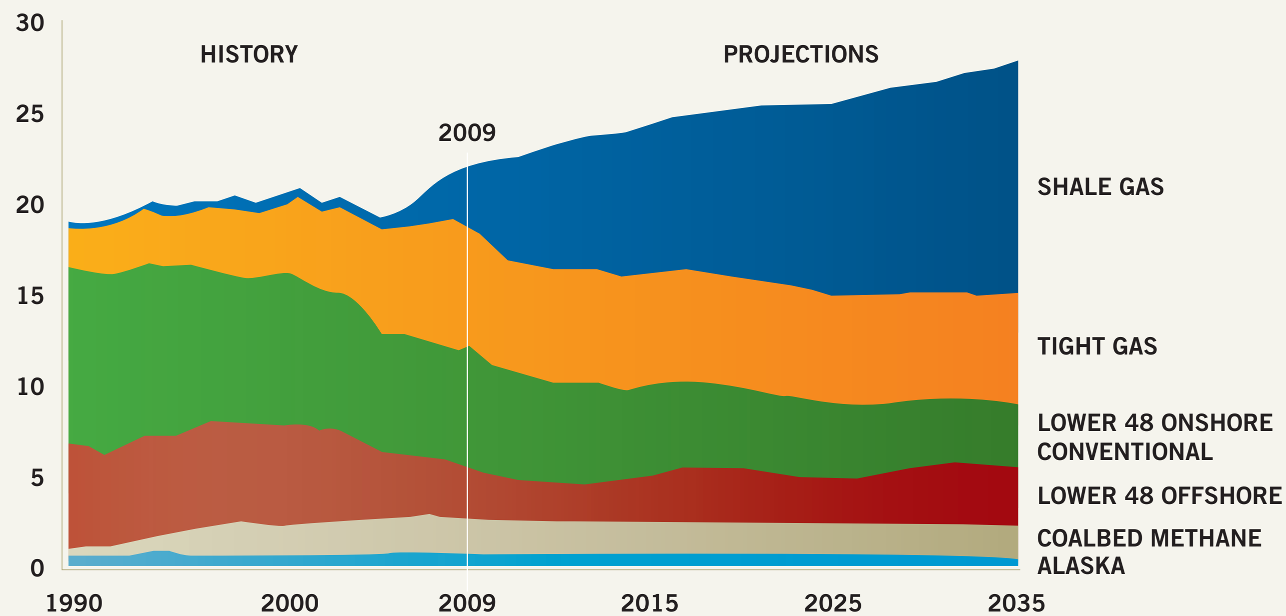
SOURCE: EIA

FIG. 7 | U.S. NATURAL GAS PRODUCTION



SOURCE: Energy Information Administration

FIG. 8 | THE REBIRTH OF NATURAL GAS



SOURCE: EIA

FIG. 9 | NATURAL GAS PRODUCTION—FUTURE PROJECTIONS

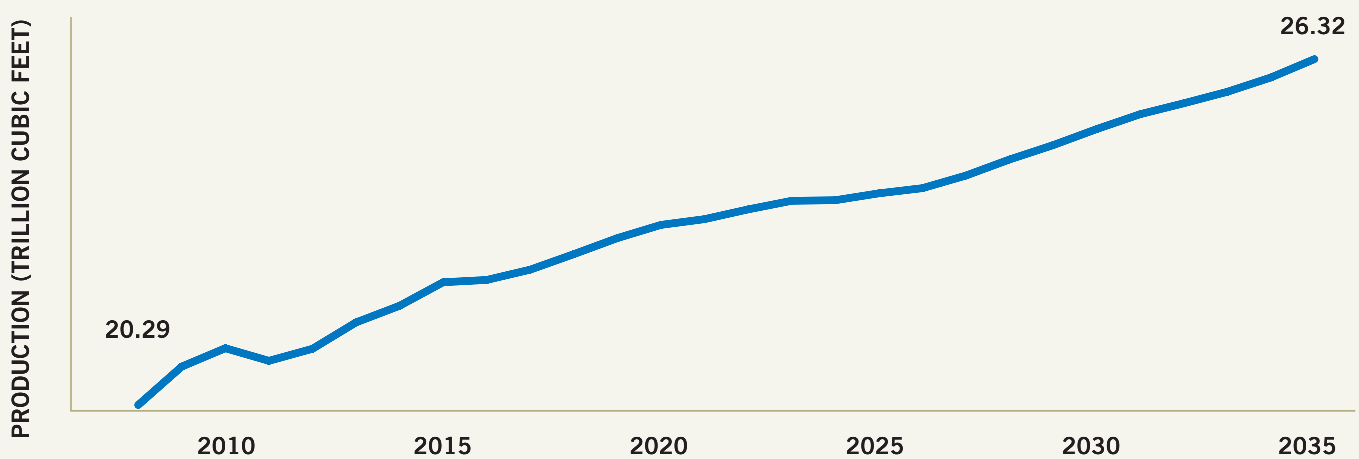


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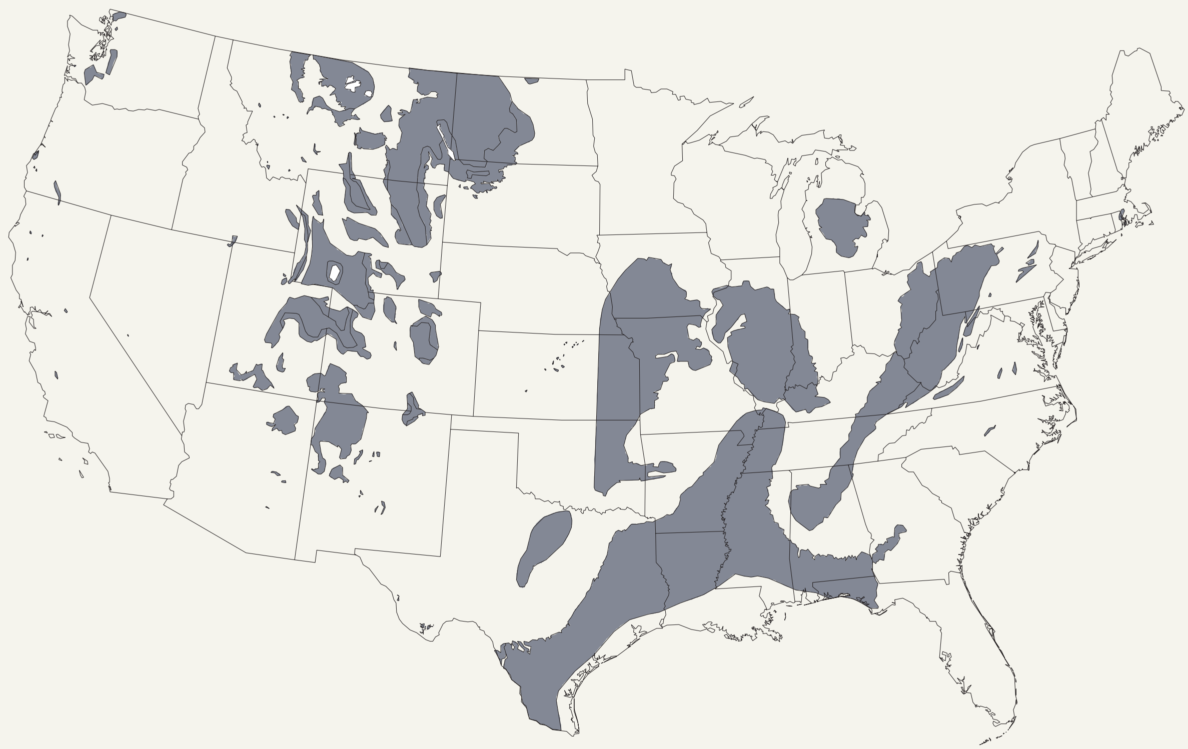
FIG. 10 | COAL IN THE U.S.A.



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