U.S. Fossil Fuel Resources: Terminology, Reporting, and Summary

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Summary

Discussions of U.S. and global energy supply refer to oil, natural gas, and coal using several terms that may be unfamiliar to some. The terms used to describe different types of fossil fuels have technically precise definitions, and misunderstanding or misuse of these terms may lead to errors and confusion in estimating energy available or making comparisons among fuels, regions, or nations.

Fossil fuels are categorized, classified, and named using a number of variables. Naturally occurring deposits of any material, whether it is fossil fuels, gold, or timber, comprise a broad spectrum of concentration, quality, and accessibility (geologic, technical, and cultural). Terminology is adopted to reflect those characteristics.

For oil and natural gas, a major distinction in measuring quantities of energy commodities is made between proved reserves and undiscovered resources. Proved reserves are those amounts of oil, natural gas, or coal that have been discovered and defined, typically by drilling wells or other exploratory measures, and which can be economically recovered. In the United States, proved reserves are typically measured by private companies, who report their findings to the Securities and Exchange Commission because they are considered capital assets. In addition to the volumes of proved reserves are deposits of oil and gas that have not yet been discovered, which are called undiscovered resources. The term has a specific meaning: undiscovered resources are amounts of oil and gas estimated to exist in unexplored areas. If they are considered to be recoverable using existing production technologies, they are referred to as undiscovered technically recoverable resources (UTRR). In-place resources are intended to represent all of the oil, natural gas, or coal contained in a formation or basin without regard to technical or economic recoverability.

In the United States, certain institutions are designated to determine and report quantities of oil, natural gas, and coal reserves and undiscovered resources. Other institutions also estimate these values, but differences in estimating methodology can produce significantly different values.

U.S. proved reserves of oil total 19.1 billion barrels, reserves of natural gas total 244.7 trillion cubic feet, and natural gas liquids reserves of 9.3 billion barrels. Undiscovered technically recoverable oil in the United States is 145.5 billion barrels, and undiscovered technically recoverable natural gas is 1,162.7 trillion cubic feet. The demonstrated reserve base for coal is 488 billion short tons, of which 261 billion short tons are considered technically recoverable.

Comparisons of different fuel types can be made by converting all of them to a common unit, such as barrels of oil equivalent, based on their heat content. The amounts of fossil fuels found in other nations as reserves and undiscovered resources are much more difficult to determine reliably because data are sometimes lacking or unreliable, but gross comparisons of national endowments can be made using available data.

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Introduction

Current discussions of U.S. and global energy supply refer to oil, natural gas, and coal using several terms that may be unfamiliar to some. The terms used to describe different types of fossil fuels have technically precise definitions, and misunderstanding or misuse of these terms may lead to errors and confusion in estimating energy available or making comparisons among fuels, regions, or nations. This report describes the characteristics of fossil fuels that make it necessary to use precise terminology, summarizes the major terms and their meanings, and provides a brief summary of the United States' endowment of fossil fuels and the relationship between the U.S. fossil fuel energy endowment and those of other nations.

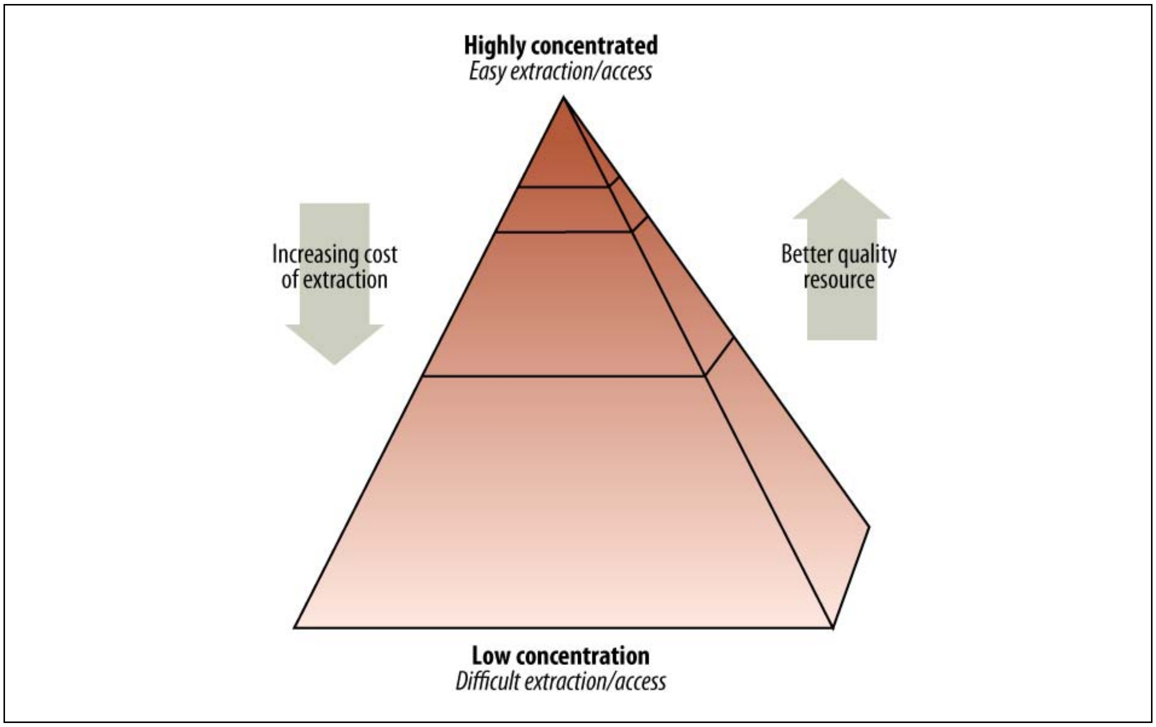
Characteristics of Fossil Fuels

Fossil fuels are categorized, classified, and named using a number of variables. It is important to keep in mind that naturally occurring deposits of any material, whether it is fossil fuels, gold, or timber, comprise a broad spectrum of concentration, quality, and accessibility (geologic, technical, and cultural). These characteristics are graphically portrayed in **Figure 1** as a resource pyramid. At the top of the pyramid are the deposits that are high quality and easy to access. These deposits have been generally discovered and produced first. Examples of the deposits at the top of the resource pyramid are the large oil deposits of Saudi Arabia and the enormous natural gas deposits of Qatar. Moving down the pyramid, the quality and/or accessibility declines, and production becomes more difficult and expensive. A large oil deposit in the deep waters of the Gulf of Mexico would be further down the pyramid than a comparable deposit on land because of the added expense and technology required to produce it.

It is important to note that the deposits at the bottom of the pyramid may be quite extensive. Deposits may be of poor quality or diffuse, but may occur in vast quantities. Examples of fossil fuel deposits that would be found at the bottom of the pyramid are oil shale and methane hydrates (both discussed further below under "Sub-Economic Oil and Natural Gas Resources"). Oil shale and methane hydrate deposits contain massive amounts of oil and natural gas, but their mode of occurrence, poor accessibility, and difficult recovery make them sub-economic. The economic threshold for producing deposits further down the pyramid is partly a function of commodity price. That threshold is also moved by the development of new extraction technologies that make production feasible at lower cost.

Figure 1. The Resource Pyramid Concept

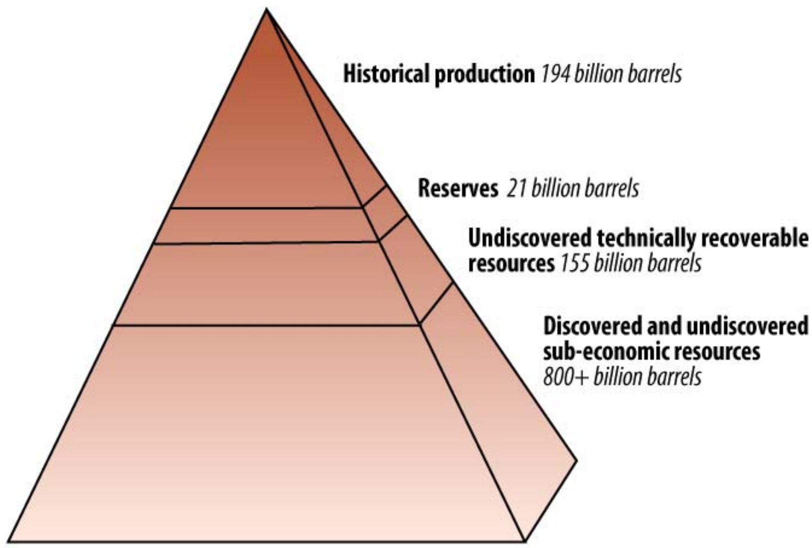
All resources are not equal



Source: Michael Lardelli, "Earth as a Magic Pudding," October 20, 2008, http://www.energybulletin.net/node/46956, modified from Thomas Ahlbrandt and Peter J. McCabe, "Global Petroleum Resources: A View to the Future," Geotimes, November 2002, http://www.geotimes.org/nov02/feature_oil.html

For U.S. oil deposits, the resource pyramid (**Figure 2**) indicates that many of the high-quality, easy-to-find deposits have already been produced. Current proved reserves (see "Terminology" below) include many deposits that are of lower quality or with poorer access than some historical production, but which are still economic under current market conditions. As long as demand for oil continues, the exploration and production process will move down the pyramid under the influences of price (including environmental costs in some cases) and technology. Whether the vast deposits of oil shale that are lower on the pyramid will be produced depends on the price of oil, the cost of production (including environmental cost), and the availability of technology to produce it. Although this example is for oil, similar relationships exist for natural gas and coal.

Figure 2. Resource Pyramid for U.S. Oil



Source: Historical production and proved reserves figures are from Energy Information Administration, undiscovered technically recoverable resource value is from U.S. Geological Survey, and discovered and undiscovered sub-economic resources uses the lower estimate for oil shale resources from RAND as a minimum.

Notes: Discovered and undiscovered sub-economic resources would include poor-quality or small deposits of conventional oil, some deposits of oil sands, and various other forms of oil deposits such as oil shale. Reserves and Undiscovered Technically Recoverable Resource numbers are for 2007 and 2008, respectively.

Terminology

A search for energy statistics in the literature quickly reveals a large number of terms used to describe amounts of fossil fuels. Most of these terms have precise and legitimate definitions, and even a careful comparison of statistics for diverse forms of fossil fuels can become quite difficult to reconcile or understand. Not only do oil, natural gas, and coal occur in many diverse geologic environments, but each commodity may occur in different modes or in different geologic settings that impose vastly different economics on their recovery and delivery to market. A vocabulary of terms has developed over the decades to capture the nature of deposits in terms of their likelihood of being developed and their stage of development.

Examples of terms used for fossil fuel deposits (not an exhaustive list) include:

- Proved reserves
- Probable reserves
- Possible reserves
- Unproved reserves

- Demonstrated reserve base
- Undiscovered resources
- Probable resources
- Possible resources
- Speculative resources
- Potential resources
- Technically recoverable resources
- Economically recoverable resources

Definitions for several of these terms are included in the **Appendix**.

Two particularly important distinctions afford a better understanding of fossil fuel statistics. The first key distinction is between proved reserves and undiscovered resources; the second key distinction is between conventional and unconventional deposits of fossil fuels.

Proved Reserves and Undiscovered Resources

For oil and natural gas, a major distinction in measuring quantities of energy commodities is made between proved reserves and undiscovered resources. Understanding these terms will help avoid confusion about statistical energy data.

Proved reserves are those amounts of oil, natural gas, or coal that have been discovered and defined at a significant level of certainty, typically by drilling wells or other exploratory measures, and which can be economically recovered. In the United States, proved reserves are typically measured by private companies, who report their findings to the Securities and Exchange Commission because those reserves are considered capital assets. Because proved reserves are defined by strict rules, they do not include all of the oil or gas in a region, but only those amounts that have been carefully confirmed.[1] Because proved reserves are, by definition, economically recoverable, the proportion of the oil in the ground that qualifies as proved reserves grows when prices are high, and shrinks when prices are low. That is, even without new discoveries, oil that may be sub-economic at $50 per barrel might become economic at $80 per barrel and so the total proved reserves increase simply because price increases.

In addition to the volumes of proved reserves are deposits of oil and gas that have not yet been discovered, which are called undiscovered resources.[2] The term "resource" has often been used in a generic sense to refer to quantities of energy commodities in general. Observers may refer to resource-rich nations, or speak about a large resource base, for example. But the term "undiscovered resources" has a specific meaning. Undiscovered resources are amounts of oil and

[1] The Securities and Exchange Commission has recently modified their classification of reserves to include proved reserves, probable reserves, and possible reserves, adding precision of language to the degree of certainty associated with a particular volume of oil or gas, but also requiring increased attention to the terms used in energy statistics.

[2] The historic question is "If they are undiscovered, how do we know they exist?" The answer is that there is a probability that such deposits exist based on the geologic characteristics of a region, even if they have not been discovered yet. The exploration process is predicated on the probability that such deposits exist.

gas estimated to exist in unexplored areas. Estimates of undiscovered resources for the United States are made by the U.S. Geological Survey for resources on land, and by the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (formerly the Minerals Management Service) for resources offshore. These assessments are based on observation of geological characteristics similar to producing areas and many other factors. Reported statistics for undiscovered resources may vary greatly in precision and accuracy (determined retrospectively), which are directly dependent upon data availability, and their quality may differ for different fuels and different regions. Because estimates of undiscovered resources are based partly on current production practices, they are generally reported as undiscovered technically recoverable resources.

Another term sometimes used in the fossil fuels literature is "in-place" resources. In-place resources are intended to represent all of the oil, natural gas, or coal contained in a formation or basin without regard to technical or economic recoverability. Because only a small proportion of the total amount of the fossil fuel in a deposit is ever recovered, there are often large discrepancies between volumes of in-place resources and the proportion of those resources that are technically recoverable. In-place resource estimates are sometimes very large numbers, which may be misleading if the reader does not appreciate that usually only a small proportion of the in-place volume of a resource can ever be produced or recovered.

The Importance of Terminology: The Example of the Bakken Formation

Research by a USGS geologist during the 1980s and 1990s revealed that a rock formation in the Williston Basin of North Dakota, South Dakota, Montana, and southern Canada contained an abundance of hydrocarbons dispersed throughout layers of shale and sandstone.[3] Though the author, Dr. Leigh Price, died before publishing his results, the numbers reported were quite impressive; estimates of 271 to 503 billion barrels of oil attracted the attention of the oil industry. However, those estimates, while huge, represented "in-place" oil. That is, the total volume of oil was huge, but it was disseminated throughout thousands of square miles of shale and only a small portion of that total would be recoverable. At that time, production of unconventional (or continuous) oil was not being done at large scales, so the technically recoverable volumes of oil were modest.

Subsequently, the USGS has conducted a more detailed and thorough estimate of the technically recoverable resources using modern directional drilling techniques and estimates that the Bakken Formation contains 3.65 billion barrels of undiscovered technically recoverable oil and 1.85 trillion cubic feet (tcf) of undiscovered technically recoverable natural gas.[4] These estimates are still substantial in volume, and production in the Bakken Formation is proceeding. But the gap between estimates of in-place oil and technically recoverable oil demonstrates vividly the importance of knowing what the numbers represent.

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[3] Leigh Price, Origins and Characteristics of the Basin-Centered Continuous Reservoir Unconventional Oil-Resource Base of the Bakken Source System, Williston Basin, unpublished but available at http://www.undeerc.org/Price/.

[4] Richard Pollastro, Assessment of Undiscovered Oil Resources in the Devonian-Mississippian Bakken Formation, Williston Basin Province, Montana and North Dakota, 2008, U.S. Geological Survey Fact Sheet 2008-3021, http://pubs.usgs.gov/fs/2008/3021/.

Conventional Versus Unconventional Oil and Natural Gas Deposits

The first oil and gas deposits discovered consisted of porous reservoirs in geologic formations, capped by an impervious rock "trap" within which migrating fluids such as oil, natural gas, and water would accumulate. Within the reservoir, natural gas would be the least dense fluid and would have accumulated at the top of the reservoir. Oil is more dense than gas, but less dense than water and would pool in a layer below the gas cap. Below the oil and gas, water would fill the confined reservoir. This layered arrangement of natural gas, oil, and water within a reservoir is called a conventional deposit and has historically provided most of the oil and natural gas that has been produced.

In recent decades, geologists began to realize that considerable volumes of oil and natural gas exist outside conventional reservoirs in sedimentary rocks situated in geologic basins. The distribution of oil or natural gas throughout a geologic formation over a wide area, but not in a discrete reservoir, is called an unconventional deposit (sometimes called a continuous deposit). The amounts of oil and gas contained in unconventional deposits may be very large, but recovering those deposits is sometimes difficult and expensive. Oil sands provide an example of an unconventional oil deposit in which the oil is distributed widely through the sandstone formation. Recovering the oil from oil sands requires special technologies and treatments such as heating, steam flooding, or even excavation. An example of an unconventional natural gas deposit is coalbed methane. The natural gas (methane) does not exist in a discrete reservoir but is distributed throughout the pore spaces of coal and held in place by water. When the water is removed from the coal, the gas is released and can be produced. Another type of unconventional natural gas deposit is shale gas, which is discussed below (see "Shale Gas").

There is no direct correlation between the economic recoverability of a deposit and whether it is conventional or unconventional. Some conventional deposits are not economically recoverable because they are too small, too deep, or lack surface access. On the other hand, unconventional deposits such as oil sands and coalbed methane are economically recoverable in some locations. For example, coalbed methane production was 2.11 tcf in 2009[5] out of a total U.S. natural gas production of 20.96 tcf (approximately 10%), and is an important component of the U.S. natural gas supply.

Authoritative Data Sources for U.S. Fossil Fuel Reserves and Resources

Many individuals and institutions have attempted to compile and publish estimates of resources. However, the statutory responsibility for collecting and publishing authoritative statistical information on the various types of energy sources in the United States has been given to specific federal agencies. The Energy Information Administration (EIA) was originally created as the Federal Energy Administration (FEA) and is charged with the responsibility of monitoring and reporting U.S. energy reserves and production.

[5] http://www.eia.gov/emeu/aer/pdf/pages/sec6_7.pdf

> The Energy Information Administration (EIA) was created in response to the need for additional Federal initiatives to collect and disseminate energy-related information, and to evaluate and analyze this information. These needs were revealed as the United States sought to respond to the energy crises of the 1970s. The first law to address these needs was the Federal Energy Administration Act of 1974 and, over the years, many subsequent laws have contributed to EIA's evolution and growth.
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> [The law c]reated the FEA and mandated it to collect, assemble, evaluate, and analyze energy information; provide energy information and projections to the Federal Government, State Governments, and the public; and provide Congress with an annual report summarizing these activities. It also provided FEA with data collection enforcement authority for gathering data from energy producing and consuming firms.[6]

Likewise, the responsibility for assessing onshore undiscovered technically recoverable oil and gas resources in the United States resides with the U.S. Geological Survey (USGS), in the Department of the Interior.[7] The USGS has conducted a number of national assessments of undiscovered technically recoverable oil and natural gas resources over several decades. The most recent complete comprehensive national assessment for onshore oil and gas was completed in 1995, but USGS updates that assessment on an ongoing basis as new data become available. Responsibility for assessment of offshore undiscovered technically recoverable oil and natural gas resources belongs to the Bureau of Ocean Energy Management, Regulation and Enforcement, also within the Department of the Interior.[8] EIA and USGS have similar responsibilities for evaluating the nation's endowment of coal.

In addition to purely governmental assessments, several expert groups provide perspectives on individual fuels, geographic areas, or industry sector. Some of these groups are composed of government, industry, and academic experts (e.g., the Potential Gas Committee[9]), expert advisory committees for federal agencies (e.g., National Petroleum Council[10]), independent study groups (e.g., the National Research Council, Committee on Earth Resources[11]), or professional societies (e.g., American Association of Petroleum Geologists[12] or the Society of Petroleum Engineers[13]). Each of these groups provides considerable expertise to the assessment and evaluation of oil and gas reserves and resources, and their reports are considered to be authoritative and serious, but none have the responsibility to provide a consistent, timely statistical review of U.S. oil and natural gas resources. When using estimates generated by these expert groups, it is important to look for clear and transparent explanation of assessment methodology; in the absence of explanation, it will not be clear what is being estimated, and the value and usefulness of the statistics will be diminished.

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[6] Energy Information Administration, "About EIA," http://tonto.eia.doe.gov/abouteia/legislative_timeline.cfm. The Federal Energy Administration Act of 1974 is P.L. 93-275, 15 U.S.C. 761.

[7] http://www.usgs.gov/

[8] http://www.boemre.gov/

[9] http://www.mines.edu/Potential-Gas-Committee-reports-unprecedented-increase-in-magnitude-of-U.S.-natural-gas-resource-base

[10] http://www.npc.org/

[11] http://dels.nas.edu/besr/

[12] http://www.aapg.org/

[13] http://www.spe.org/spe-app/spe/index.jsp

U.S. Oil and Natural Gas Reserves and Resources

Proved Reserves

U.S. proved reserves of crude oil as reported by EIA total 19.121 billion barrels.[14] The data are from the latest full compilation, at the end of calendar year 2008. There is generally a delay of over a year between the end of a reporting year and the compilation of the data because the process is time-consuming and quality control is essential. The EIA value for proved reserves includes both onshore and offshore reserves.

Compiling oil reserves is not a simple arithmetic exercise. Each year, volumes of individual components change significantly. Below is a list of how the reserves changed during 2007 as a function of the normal exploration, production, and business processes conducted by oil companies. A more detailed description of these terms is in the **Appendix**.

- Adjustments (+,-)
- Revision Increases (+)
- Revision Decreases (-)
- Sales (-)
- Acquisitions (+)
- Extensions (+)
- New Field Discoveries (+)
- New Reservoir Discoveries in Old Fields (+)
- Estimated Production (-)

U.S. proved reserves of natural gas, also reported by EIA for 2008, total 244.656 tcf.[15] Like oil, the compilation of proved reserves of natural gas involved keeping track of several kinds of production and adjustments. The liquid components (natural gas liquids) are reported with oil production.[16] Total proved reserves are reported as dry natural gas and include both onshore and offshore reserves. The following list shows a breakdown of how natural gas production is reported prior to separation into its gas and liquid components.

- Natural Gas, Wet After Lease Separation
- Natural Gas Nonassociated, Wet After Lease Separation
- Natural Gas Associated-Dissolved, Wet After Lease Separation
- Natural Gas Liquids

[14] Energy Information Administration, Data as of 12/31/2008, Release Date:10/29/2009, http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html.

[15] Energy Information Administration, Data as of 12/31/2008, Release Date: 10/29/2009, http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html.

[16] http://tonto.eia.doe.gov/cfapps/ipdbproject/docs/IPMNotes.html#p1

The last item listed, natural gas liquids (NGL), are hydrocarbons (including propane, butane, and other compounds) that condense and are separated at the earth's surface after production of natural gas. For 2008, U.S. proved reserves of natural gas liquids were 9.275 billion barrels. In subsequent statistical discussions, natural gas liquids will be added to crude oil production to represent total U.S. liquids production. Specifically, total U.S. petroleum liquid reserves as of year-end 2008 is 19.1 billion barrels of crude, plus 9.3 billion barrels of NGL for a total of 28.4 billion barrels of liquids.

Undiscovered Oil and Natural Gas Resources

As mentioned previously, the responsibility for assessing the undiscovered technically recoverable resources of oil and natural gas is split between the USGS for onshore resources, and the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) (formerly the Minerals Management Service(MMS)) for offshore resources. USGS and BOEMRE use somewhat different assessment methodologies. The combined results of the onshore and offshore assessments are based on the availability of geologic data, which may be quite limited, especially for certain offshore areas. Nevertheless, the estimates are complementary and are tabulated in **Tables 1 and 2**. The USGS distinguishes between conventional and unconventional undiscovered resources, and they are reported separately for oil, natural gas, and natural gas liquids. BOEMRE reports its estimates for each offshore planning region but does not distinguish between conventional and unconventional deposits.

Table 1.Onshore U.S. Oil, Natural Gas, and Natural Gas Liquids

Undiscovered Technically Recoverable Resources (UTRR)

	Oil (Bbo)	Natural Gas (Tcf)	Natural Gas Liquids (BOE)
Conventional	31.69	356.92	5.89
Unconventional (continuous)	6.16	399.40	4.92
TOTAL U.S. ONSHORE UTRR	37.84	756.31	10.77

Source: U.S. Geological Survey, Department of the Interior, 2010: http://certmapper.cr.usgs.gov/data/noga00/natl/tabular/2010/summary_10.pdf.

Notes: Unconventional natural gas includes coalbed methane; Bbo = billion barrels of oil, Tcf = trillion cubic feet, BOE = billion barrels of oil equivalent.

Table 2.Offshore U.S. Oil and Natural Gas

Undiscovered Technically Recoverable Resources (UTRR), mean values

U.S. OCS Region	Oil (Bbo)	Natural Gas (Tcf)
Alaska	26.6	132.0
Atlantic	3.8	36.9
Gulf of Mexico	44.9	232.5
Pacific	10.5	18.2
TOTAL U.S. OFFSHORE UTRR	85.8	419.8

Source: BOEMRE, Department of the Interior, 2006: http://www.mms.gov/revaldiv/PDFs/2006NationalAssessmentBrochure.pdf.

Notes: Bbo = billion barrels of oil; Tcf = trillion cubic feet; BOE = billion barrels of oil equivalent

The total endowment of technically recoverable oil and natural gas for the United States is obtained by summing proved reserves from EIA with the onshore and offshore undiscovered technically recoverable resources from USGS and MMS, as shown in **Table 3**.

Although values for proved reserves reported by EIA include proved reserves of shale gas, the value for total technically recoverable natural gas (1,176.21 tcf) does not include much of the newly prospective shale gas being explored in the United States. According to a 2009 report by the Potential Gas Committee, a consortium of industry, academic, and government experts, the total "future supply" of natural gas is 2,074 tcf, which includes substantial volumes of shale gas (see "Shale Gas" below).

Table 3. Total U.S. Endowment of Technically Recoverable Oil and Natural Gas

(sum of EIA reserves, USGS, and MMS UTRR values)

	Oil (Bbo)	Natural Gas (Tcf)
Total U.S. UTRR	134.5[a]	1,176.2
Proved reserves	28.4[b]	244.7
Total U.S. endowment	162.9	1420.9

Source: USGS, http://certmapper.cr.usgs.gov/data/noga00/natl/graphic/2010/summary_10_final.pdf; BOEMRE, http://www.boemre.gov/revaldiv/ResourceAssessment.htm; and EIA, http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html.

Note: Bbo = billion barrels of oil, Tcf = trillion cubic feet.

a. Represents the total of technically recoverable oil plus natural gas liquids from Tables1 and 2.

b. Includes proved reserves of crude oil and natural gas liquids.

Sub-Economic[17] Oil and Natural Gas Resources

Shale Oil

After coal, shale oil represents the most abundant fossil fuel in the United States. However, despite government programs in the 1970s and early 1980s to stimulate development of the resource, production of shale oil is not yet commercially viable. The need for massive capital investment and the cost of production itself have been the major barriers. A further economic factor lies in the fact that shale oil has a unique chemical composition and, unlike conventional crude oil, cannot be distilled to produce gasoline, but would be primarily a source of other liquid middle distillate fuels such as jet fuel or diesel oil, fuels for which there is significant national demand.

[17] The amount of resources considered "sub-economic" changes with economic conditions and extraction technologies.

In addition, production of shale oil requires large amounts of water, an important factor since most of the resource is located in water-scarce regions of western Colorado, Utah, and Wyoming. Other environmental problems include the difficulty in disposing of tailings if excavation is used as the extraction process, and the production of greenhouse gases.

In light of these difficulties, efforts to aid in the development of shale oil are focused on pilot projects to test alternative technologies of production.[18]

Estimates of the amount of hydrocarbon fuel in U.S. shale oil resources are highly speculative, given the small amount of development that has taken place. The Department of Energy (DOE) Office of Naval Petroleum and Oil Shale estimates that approximately 1.38 trillion barrels of shale oil are potentially recoverable from the roughly 7.8 million acres of federal oil shale.[19] A more conservative estimate by the RAND Corporation is that 800 billion barrels may be recoverable.[20]

Shale Gas

Shale gas is an emerging type of natural gas deposit, and exploration for and production of shale gas is increasing. Shale gas is currently marginally economic, and production is therefore sensitive to the price of natural gas; if natural gas prices increase, production of shale gas would likely increase. Shale gas is a classical unconventional type of deposit; the gas is distributed throughout the low-permeability shale formations rather than accumulating in a more permeable reservoir. The occurrence of gas in this manner requires special production techniques that often involve horizontal drilling into the gas-bearing formation, followed by hydrofracturing of the rock (exerting pressure in the gas well so high that it causes brittle rock to fracture) to release the gas from the rock. The use of hydrofracturing has caused some environmental concerns arising from the injection of large amounts of water into the well, concerns about the chemical composition of the injected fluids, fears that the fractured rock will expose local water wells to non-potable waters, and the observation that some hydrofracturing jobs have apparently created small earthquakes. However, industry officials insist that any environmental concerns could be mitigated through careful production practices. Of the current total natural gas proved reserves of 244.7 tcf, EIA includes 32.8 tcf of proved reserves as shale gas.

No systematic assessment of undiscovered technically recoverable shale gas resources has been conducted for the United States, though industry and academic experts estimate that the technically recoverable volumes of natural gas from these shale deposits are very large. Recently, the Potential Gas Committee estimated that the United States has 616 tcf of "potential natural gas resources" occurring as shale gas.[21] The proportion of that resource that will actually be produced will depend on further development of exploration and production technology, the price of natural gas, and the ways in which states deal with potential environmental issues.

[18] For more details about shale oil development, see CRS Report RL34748, *Developments in Oil Shale*, by Anthony Andrews1.

[19] U.S. DOE, Office of Petroleum and Oil Shale Reserves, *National Strategic Unconventional Resource Model*, April 2006.

[20] J. T. Bartis, T. LaTourrette, L. Dixon, D.J. Peterson, and G. Cecchine, *Oil Shale Development in the United States Prospects and Policy Issues* (MG-414-NETL), RAND Corporation, 2005.

[21] http://geology.mines.edu/pgc/index.html

Methane Hydrates

Another form of fossil fuel with potentially vast resources is natural gas in the form of methane hydrate. Methane hydrate (sometimes called natural gas hydrate, or just gas hydrates) is being investigated as an energy source by both DOE[22] and USGS.[23] Methane hydrate is a crystalline solid composed of methane and water that forms in porous rocks under very specific conditions of temperature and pressure. Deposits occur most commonly offshore in the sediments or rocks of the continental shelf and slope, or in cold climates such as northern Alaska and Canada. Although considered a scientific oddity until the 1990s, methane hydrates are now known to exist in hundreds of locations around the world, often in small, isolated deposits, but sometimes in massive quantities. Total worldwide in-place resources of methane hydrates are probably huge, perhaps thousands of trillion cubic feet, but hydrates have never been produced commercially. Current efforts by the United States, Canada, Japan, India, and several other nations are aimed at developing technologies to exploit this large and widespread form of natural gas.

The mean in-place gas hydrate resource for the entire United States is estimated to be 320,000 tcf of gas, with approximately half of this resource occurring offshore of Alaska and most of the remainder occurring beneath the continental margins of the lower 48 states.[24] The USGS estimates that there are about 85 tcf of undiscovered, technically recoverable gas resources within gas hydrates in northern Alaska, and recent studies have shown that methane hydrates are more abundant in the sediments of the Gulf of Mexico than previously believed.[25] Improved understanding of the occurrence and behavior of these important natural gas deposits, and improved technology for producing them, may make methane hydrates a viable source of natural gas in the future.

Heavy Oil

Heavy oil, so-named because its specific gravity and viscosity are higher than those of light crude oil, constitutes substantial deposits of oil in Canada, Venezuela, and other parts of the world. Canada's Athabasca oil sands and Venezuela's Orinoco oil sands are the largest deposits of this type. Canada's oil sands contain an estimated 173 billion barrels of technically recoverable oil and account for more than half of Canada's oil production. The Orinoco oil sands are estimated to contain 1.36 trillion barrels of extra heavy oil in-place, of which approximately 270 billion barrels are technically recoverable.[26] Oil sands generally require special production techniques such as excavation or steam flooding, and the oil produced is often limited to certain refineries equipped to handle the heavy oil. U.S. heavy oil is found in California, Alaska, and Wyoming, and is estimated to constitute in-place resources of up to 100 billion barrels of oil, though production of heavy oil in the United States is declining because of the depth of the resource and the cost of production.[27]

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[22] http://www.fossil.energy.gov/programs/oilgas/hydrates/

[23] http://energy.usgs.gov/other/gashydrates/

[24] Statement of Dr. Timothy S. Collett, Research Geologist, U.S. Geological Survey, U.S. Department of the Interior, Before the House Committee on Resources Subcommittee on Energy and Mineral Resources: On Unconventional Fuels II: The Promise of Methane Hydrates, July 30, 2009.

[25] http://www.usgs.gov/newsroom/article.asp?ID=2227

[26] http://www.eia.doe.gov/oiaf/aeo/otheranalysis/aeo_2006analysispapers/nlf.html

[27] http://fossil.energy.gov/programs/reserves/npr/Heavy_Oil_Fact_Sheet.pdf

U.S. Coal Reserves and Resources

EIA is the authoritative source for coal reserves and resource estimates for the United States. EIA compiles data on coal reserves and resources from state sources and federal sources, including from work done by the USGS.[28] The terminology used for coal is slightly different than for oil and natural gas. The primary statistic reported by EIA is the demonstrated reserve base (DRB), which is comprised of coal resources that have been identified to specified levels of accuracy and may support economic mining under current technologies.[29] For the latest reporting period, calendar year 2007, the U.S. demonstrated reserve base was 488 billion short tons.[30] Because the United States produces and consumes about 1.0 billion short tons of coal per year, the demonstrated reserve base would appear to provide hundreds of years' supply of coal, if U.S. users continue to consume it at the same rate. However, because coal production often requires ground disturbance, especially for open-pit mining, the amount that is technically recoverable is not always available. EIA has applied an availability factor that reduces the technically recoverable amount to 261 billion short tons that would actually be available for mining.[31] Detailed availability studies by the USGS have indicated that, at least in some cases, the available and economically recoverable coal might be substantially less than the technically recoverable amount for a variety of reasons:[32]

> a significant portion of the coal resources less than 4,000 ft (1,219.2 m) in depth are also typically subeconomic due to a number of restrictions that further limit their availability and recoverability. Some of these restrictions are technical constraints (using existing technology) such as coal beds too thin to recover or dipping too steeply. Many societal or environmental restrictions such as the presence of towns, wetlands, or other environmentally sensitive areas may also preclude coal recovery. Both regional mine planning and economic studies are necessary to derive estimates of the coal reserves for any given area.

For example, in one specific case in Wyoming, 47% of the in-place coal is technically recoverable, but the available, economically recoverable coal is only about 6% of the in-place coal.[33] While these proportions may vary between 5% and 20%, depending upon the specific conditions for each coal-mining area, very large coal numbers are viewed with some caution because in-place numbers, or even recoverable numbers, may not provide a realistic assessment of the coal that could actually be produced.

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[28] http://energy.cr.usgs.gov/coal/coal_assessments/summary.html

[29] http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html

[30] A short ton is 2,000 pounds. A metric tonne is 2,204 pounds.

[31] http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html

[32] James A. Luppens, Timothy J. Rohrbacher, Lee M. Osmonson, and M. Devereux Carter, Coal Resource Availability, Recoverability, and Economic Evaluations in the United States—A Summary, U.S. Geological Survey Professional Paper 1625-F, Chapter D, 2009.

[33] http://pubs.usgs.gov/of/2008/1202/pdf/ofr2008-1202.pdf

Expressing Fossil Fuels as Barrels of Oil Equivalent (BOE)

It is sometimes useful to equate the different types of fossil fuels in order to compare the energy content or to gauge the magnitude of one type of fossil fuel in terms of another. Fossil fuels may be liquid, gas, and solid; oil is a liquid measured in barrels, natural gas is a gas measured in cubic feet, coal is a solid measured in pounds or short tons, and all three types of fossil fuels vary in composition, quality, and heat content. Therefore, converting one type of fossil fuel to an equivalent amount of another is a slightly problematic calculation. For example, the energy content of coal varies by at least a factor of three depending on grade.[34] However, government and industry sources commonly use rule-of-thumb measures to make these conversions. For example, EIA provides a conversion tool on its website[35] that assumes the following heat contents (based on U.S. consumption, 2008):

Coal	1 Short Ton = 19,988,000 Btu[36]
Natural gas	1 Cubic Foot = 1,028 Btu
Oil	1 Barrel = 42 U.S. gallons = 5,800,000 Btu

Using these rule-of-thumb heat values, we can express natural gas and coal units in terms of barrels of oil equivalent (BOE):

Coal	1 Short Ton = 3.45 BOE
Natural gas	1 million cubic feet = 1,028,000,000 Btu = 177.2 BOE = 5,643 cubic feet/barrel

Using these conversion factors, we present a crude comparison of U.S. energy reserves plus resources in **Table 4**.

Table 4.U.S. Fossil Fuel Reserves and Resources Expressed as BOE

BOE = Barrels of oil equivalent

Fossil Fuel	Native units	BOE
Technically recoverable oil[0]	162.9 billion barrels	162.9 billion BOE
Technically recoverable natural gas	1420.9 trillion cubic feet	251.8 billion BOE
Recoverable reserve base of coal	261 billion short tons	900.5 billion BOE
TOTAL U.S. fossil fuel endowment		1,315.2 billion BOE

[34] http://www.aps.org/policy/reports/popa-reports/energy/units.cfm

[35] http://tonto.eia.doe.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

[36] Btu is the abbreviation for British thermal units, a common measure of heat content. One Btu is the amount of energy in the form of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Source: USGS, http://certmapper.cr.usgs.gov/data/noga00/natl/graphic/2010/summary_10_final.pdf; BOEMRE, http://www.boemre.gov/revaldiv/ResourceAssessment.htm; and EIA, http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html.

a. Technically recoverable oil and natural gas includes proved reserves plus undiscovered technically recoverable resources.

A Brief Overview of Global Fossil Fuel Resources

Reliable values for proved reserves and undiscovered resources outside the United States are less available than for the United States. The only source of data for some countries is one of the nation's ministries (energy, resource, interior, commerce, etc.), and those data may not be completely accurate because of the lack of good geologic data and assessment methodology, or because the information is purposely withheld. In fact, even if all nations wished to report their resource estimates reliably, it would not be possible to collect uniform data because different methods, accounting rules, and terminology are used in each country. Therefore, some reserve statistics reported outside the United States are not consistent with the U.S. data. Furthermore, only reserves and production statistics are reported for most nations. There has been no reliable source for estimates of undiscovered oil and natural gas resources internationally since the U.S. Geological Survey completed its World Petroleum Assessment in 2000.[37]

Data for proved reserves and production in all countries are most reliable. Production statistics can be obtained for the Organization of the Petroleum Exporting Countries (OPEC)[38] and for the Organization for Economic Cooperation and Development (OECD) countries from the International Energy Agency,[39] an arm of OECD. For international statistics, the EIA relies on the Oil & Gas Journal (a publication of PennWell Corporation) or World Oil (a publication of Gulf Publishing Company) for foreign oil and natural gas reserves. These energy industry trade publications monitor individual national sources for information, as described by the Oil & Gas Journal:

> OGJ does not make its own estimates of a country's reserves but rather compiles the estimates of proved reserves from an annual survey of official sources, including government agencies and ministries. Since most countries do not assess their reserves annually, many of the figures in this report are unchanged from a year ago.[40]

World Oil summarizes their data sources this way:

> World Oil's tables are produced with data from a variety of sources, including governmental agencies. Operating companies with drilling programs also contributed to this year's survey. Our survey is not scientifically randomized, and new environmental and political challenges may emerge at any time. In some cases, a country may not have responded to our surveys, in which case we might use proxies such as rig counts and third-party sources, both public and private.[41]

[37] U.S. Geological Survey, World Petroleum Assessment, 2000, http://certmapper.cr.usgs.gov/rooms/we/index.jsp.

[38] http://www.opec.org/home/.

[39] http://www.iea.org/index.asp.

[40] Marilyn Radler, *Oil & Gas Journal*, "New estimates boost worldwide oil, gas reserves," December 22, 2008.

[41] World Oil, Production and reserves lag as world drilling grows, September, 2008.

A source of global oil and gas information commonly used by a number of analysts is the BP Statistical Review of World Energy.[42] Some of BP's data also come from Oil & Gas Journal and World Oil, but are supplemented with additional data:

> The reserve numbers published in the BP Statistical Review of World Energy are an estimate of proved reserves, drawn from a variety of official primary sources and data provided by the OPEC Secretariat, Cedigaz, World Oil and the Oil & Gas Journal and an independent estimate of Russian oil reserves based on information in the public domain. Oil reserves include field condensate and natural gas liquids as well as crude oil. They also include an estimate of Canadian oil sands 'under active development' as a proxy for proved reserves. This inclusive approach helps to develop consistency with the oil production numbers published in the Review, which also include these categories of oil.

The BP Statistical Review of World Energy uses data from the World Energy Council (WEC)[43] for coal reserves. The WEC is a global consortium of national committees that compile energy statistics for their own countries. WEC estimates for oil and natural gas reserves differ somewhat from the Oil & Gas Journal and World Oil values, but not dramatically. For the United States, the U.S. Energy Association (USEA)[44] is the WEC national committee, and USEA cites EIA sources for its estimates for the United States. When using any international fossil fuel statistics, users should be cognizant of ultimate sources of data among these energy data organizations.

Using the best-available data, it is possible to draw a comparison of the total endowment of fossil fuels for nations. **Table 5** includes the basic data for oil, natural gas, and coal for selected nations, with calculations of the total fossil fuels in each nation, expressed in billions of barrels of oil equivalent (billion BOE).

Table 5. Total Fossil Fuel Reserves of Selected Nations

(expressed in native units and as billions of barrels of oil equivalent (BOE))

	Oil Reserves[a] (billions of barrels)	Natural Gas Reserves (trillion cubic feet)	Natural Gas As BOE	Coal (billion short tons)	Coal As BOE	Total Fossil Fuels in BOE (billions of barrels)
World	1,354.2	6,609.3	1,171.2	930.4	3,209.9	5,735.2
Saudi Arabia	262.4	263.5	46.7	0.0	0.0	309.1
Canada	175.2	62.0	11.0	7.3	25.2	211.4
Iran	137.6	1045.7	185.3	1.5	5.2	328.1
Iraq	115.0	111.9	19.8	0.0	0.0	134.8
Kuwait	104.0	63.5	11.3	0.0	0.0	115.3
Venezuela	99.4	176.0	31.2	0.5	1.8	132.4

[42] http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622.

[43] http://www.worldenergy.org/

[44] http://www.usea.org/

	Oil Reserves[a] (billions of barrels)	**Natural Gas Reserves** (trillion cubic feet)	**Natural Gas As BOE**	**Coal** (billion short tons)	**Coal As BOE**	**Total Fossil Fuels in BOE** (billions of barrels)
United Arab Emirates	97.8	214.4	38.0	0.0	0.0	135.8
Russia	60.0	1680.0	297.7	173.1	597.2	954.9
Libya	44.3	54.4	9.6	0.0	0.0	53.9
Nigeria	37.2	185.3	32.8	0.2	0.7	70.8
Kazakhstan	30.0	85.0	15.1	34.5	119.0	164.1
Qatar	25.4	899.3	159.4	0.0	0.0	184.8
China	20.4	107.0	19.0	126.2	435.4	474.8
United States	19.1	244.7	43.4	263.8	910.1	972.6
Brazil	12.8	12.9	2.3	7.8	26.9	42.0
Algeria	12.2	159.0	28.2	0.1	0.2	40.6
Mexico	10.4	12.7	2.3	1.3	4.5	17.1
Angola	9.5	9.6	1.7	0.0	0.0	11.2
Azerbaijan	7.0	30.0	5.3	0.0	0.0	12.3
Norway	6.7	81.7	14.5	0.0	0.0	21.2
India	5.6	38.0	6.7	62.3	214.9	227.3
Indonesia	4.0	106.0	18.8	4.8	16.5	39.2
Malaysia	4.0	83.0	14.7	0.0	0.0	18.7
Egypt	3.7	58.5	10.4	0.0	0.1	14.1
Australia and New Zealand	3.4	111.2	19.7	84.5	291.5	314.6
Turkmenistan	0.6	265.0	47.0	0.0	0.0	47.6
Uzbekistan	0.6	65.0	11.5	3.3	11.4	23.5

Source: Energy Information Administration,
http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6,
http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=3&aid=6,
http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=6.

Note: All values are for 2009 or latest available data. Countries are listed in order of oil reserve ranking.

a. Oil and natural gas reserve numbers are from the EIA tables, using only the Oil & Gas Journal values.

Using only proved reserve numbers for the United States and other nations shows that the United States remains among the top nations in proved reserves of all fossil fuels taken together.

Values for technically recoverable oil and natural gas resources estimated by the USGS contain greater uncertainty than the statistics for proved reserves. Nevertheless, adding the estimates for undiscovered technically recoverable oil and natural gas provides a more inclusive estimate of total endowment of technically recoverable fossil fuels. **Table 6** adds technically recoverable oil and natural gas resources to the proved reserve figures of **Table 5** to provide a more complete tabulation of technically recoverable fossil fuels. Values for total fossil fuels in **Table 6** include the estimates for coal reserves in the first column but do not include any estimates for undiscovered coal resources; those data simply do not exist in any consistent form for various nations.

As an example of how such undiscovered coal resources might affect the ultimate total endowment of fossil fuels, the U.S. coal resource estimates do not include some potentially massive deposits of coal that exist in northwestern Alaska. These currently inaccessible coal deposits have been estimated to be more than 3,200 billion short tons of coal.[45] Only a portion of that coal would likely be technically recoverable even if development were pursued but, nevertheless, it suggests other fossil fuel deposits in many parts of the world that have not been estimated or are not available for extraction.

Table 6. Reserves of Fossil Fuels Plus Technically Recoverable Undiscovered Oil and Natural Gas

	Total Fossil Fuel Proved Reserves (from **Table 5**)	**Estimated Undiscovered Oil and Gas** (Billion BOE, USGS[a])	**Total Fossil Fuels**[b] (Billion BOE)
Saudi Arabia	309.1	231.3	540.4
Canada	211.4	7.2	218.6
Iran	328.1	114.3	442.4
Iraq	134.8	68.4	203.3
Kuwait	115.3	4.7	119.9
United Arab Emirates	135.8	16.2	152.0
Venezuela	132.4	38.1	170.5
Russia	954.9	293.7	1,248.6
Libya	53.9	10.8	64.7
Nigeria	70.8	63.4	134.2
Kazakhstan	164.1	33.7	197.8
United States	972.6	351.5	1,324.1
China	474.8	28.4	503.2
Qatar	184.8	12.1	196.9
Brazil	42.0	79.4	121.4

a. U.S. Geological Survey, World Petroleum Assessment, 2000, http://energy.cr.usgs.gov/WEcont/WEMap.pdf; mean values of estimates are used for foreign countries. U.S. number is taken from values in **Table 3**.

b. Total Fossil Fuels in this table include the technically recoverable reserves of oil, natural gas, and coal from **Table 5**, plus estimates of undiscovered oil and natural gas from the USGS World Petroleum Assessment. No global estimates of undiscovered coal exist.

A meaningful comparison of the ultimate endowments of fossil fuels among nations would include the important deposits of oil, natural gas, and coal that are lower on the resource pyramid in **Figure 1**, and that might be exploited in the future given the appropriate technology, economic

[45] Romeo M. Flores, Gary D. Stricker, and Scott A. Kinney, "Alaska Coal Resources and Coalbed Methane Potential," U.S. Geological Survey Bulletin 2198, 2003.

viability, and environmental acceptability. However, the uncertainty associated with estimates of those deposits is too great to produce meaningful comparisons. For example, the values in **Table 6** could be amended further by including estimates of oil shale or methane hydrate resources, but the final tally would have very little meaning considering the difficulties in estimating those resources. The United States has considerable amounts of fossil fuels, both conventional and unconventional, both discovered and undiscovered, that are not currently economically viable. However, it is likely that other nations contain similar deposits but lack any comprehensive assessment of those resources.

U.S. Production and Consumption of Oil, Natural Gas, and Coal

To provide some scale for the reserves and undiscovered resource values reported above, **Table 7** lists production and consumption of oil, natural gas, and coal by the United States. For a more complete summary of U.S. energy supply and demand, see CRS Report R40187, *U.S. Energy: Overview and Key Statistics*, by Carl E. Behrens and Carol Glover.

Table 7.United States Annual Consumption of Oil, Natural Gas, and Coal

Values are for year-end, 2009

	Production	Consumption
Oil	2.63 billion barrels/year (2.63 billion BOE)	6.85 billion barrels/year (6.85 billion BOE)
Natural Gas	20.95 trillion cubic feet/year (3.71 billion BOE)	22.74 trillion cubic feet/year (4.03 billion BOE)
Coal	1.07 billion short tons/year (3.7 billion BOE)	1.00 billion short tons/year (3.45 billon BOE)

Source: Energy Information Administration, http://www.eia.gov/dnav/pet/pet_crd_pres_dcu_NUS_a.htm, http://www.eia.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm, http://www.eia.doe.gov/cneaf/coal/page/acr/table1.html.

Notes: Natural gas is reported on a dry basis, BOE = barrels of oil equivalent.

Appendix. Definition of Terms

Reserves and Resources Terms

Definitions of terms taken from U.S. Department of the Interior, Survey of Available Data on OCS Resources and Identification of Data Gaps, Report to the Secretary, OCS Report MMS 2009-015, Appendix A, List of Terms Used, http://www.doi.gov/ocs/report.pdf.

Proved reserves. The quantities of hydrocarbons estimated with reasonable certainty to be commercially recoverable from known accumulations under current economic conditions, operating methods, and government regulations. Current economic conditions include prices and costs prevailing at the time of the estimate. Estimates of proved reserves do not include reserves appreciation.

Reserves. The quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

Reserves appreciation. The observed incremental increase through time in the estimates of reserves (proved and unproved) of an oil and/or natural gas field as a consequence of extension, revision, improved recovery, and the additions of new reservoirs.

Resources. Concentrations in the earth's crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered.

Undiscovered resources. Resources postulated, on the basis of the geologic knowledge and theory, to exist outside of known fields or accumulations.

Undiscovered technically recoverable resources (UTRR). Oil and gas that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance, or other secondary recovery methods, but without any consideration of economic viability. They are primarily located outside of known fields.

Undiscovered economically recoverable resources (UERR). The portion of the undiscovered technically recoverable resources that is economically recoverable under imposed economic and technologic conditions.

Unproved reserves. Quantities of hydrocarbon resources that are assessed based on geologic and engineering information similar to that used in developing estimates of proved reserves, but technical, contractual, economic, or regulatory uncertainty precludes such reserves from being classified as proved.

Key Terms Used in Oil Statistics

Acquisitions	The volume of proved reserves gained by the purchase of existing fields or properties, from the date of purchase or transfer.
Adjustments	The quantity which preserves an exact annual reserves balance within each State or State subdivision of the following form: Adjustments + Revision Increases - Revision Decreases - Sales + Acquisitions + Extensions + New Field Discoveries + New Reservoir Discoveries in Old Fields - Report Year Production = Published Proved Reserves at End of Report Year These adjustments are the yearly changes in the published reserve estimates that cannot be attributed to the estimates for other reserve change categories because of the survey and statistical estimation methods employed. For example, variations as a result of changes in the operator frame, different random samples or imputations for missing or unreported reserve changes, could contribute to adjustments.
Crude Oil	A mixture of hydrocarbons that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Crude oil may also include: Small amounts of hydrocarbons that exist in the gaseous phase in natural underground reservoirs but are liquid at atmospheric pressure after being recovered from oil well (casinghead) gas in lease separators, and that subsequently are comingled with the crude stream without being separately measured. Small amounts of non-hydrocarbons produced with the oil. When a State regulatory agency specifies a definition of crude oil which differs from that set forth above, the State definition is to be followed.
Extensions	The reserves credited to a reservoir because of enlargement of its proved area. Normally the ultimate size of newly discovered fields, or newly discovered reservoirs in old fields, is determined by wells drilled in years subsequent to discovery. When such wells add to the proved area of a previously discovered reservoir, the increase in proved reserves is classified as an extension.
New Field Discoveries	The volumes of proved reserves of crude oil, natural gas and/or natural gas liquids discovered in new fields during the report year.
New Reservoir Discoveries in Old Fields	The volumes of proved reserves of crude oil, natural gas, and/or natural gas liquids discovered during the report year in new reservoir(s) located in old fields.
Production, Crude Oil	The volumes of crude oil which are extracted from oil reservoirs during the report year. These volumes are determined through measurement of the volumes delivered from lease storage tanks, (i.e., at the point of custody transfer) with adjustment for (1) net differences between opening and closing lease inventories, and for (2) basic sediment and water. Oil used on the lease is considered production.

Proved Reserves of Crude Oil	Proved reserves of crude oil as of December 31 of the report year are the estimated quantities of all liquids defined as crude oil, which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Reservoirs are considered proved if economic producibility is supported by actual production or conclusive formation test (drill stem or wire line), or if economic producibility is supported by core analyses and/or electric or other log interpretations. The area of an oil reservoir considered proved includes: (1) that portion delineated by drilling and defined by gas—oil and/or gas—water contacts, if any; and (2) the immediately adjoining portions not yet drilled, but which can be reasonably judged as economically productive on the basis of available geological and engineering data. In the absence of information on fluid contacts, the lowest known structural occurrence of hydrocarbons is considered to be the lower proved limit of the reservoir. Volumes of crude oil placed in underground storage are not to be considered proved reserves. Reserves of crude oil which can be produced economically through application of improved recovery techniques (such as fluid injection) are included in the "proved" classification when successful testing by a pilot project, or the operation of an installed program in the reservoir, provides support for the engineering analysis on which the project or program was based. Estimates of proved crude oil reserves do not include the following: (1) oil that may become available from known reservoirs but is reported separately as "indicated additional reserves"; (2) natural gas liquids (including lease condensate); (3) oil, the recovery of which is subject to reasonable doubt because of uncertainty as to geology, reservoir characteristics, or economic factors; (4) oil that may occur in undrilled prospects; and (5) oil that may be recovered from oil shales, coal, gilsonite, and other such sources. It is necessary that production, gathering or transportation facilities be installed or operative for a reservoir to be considered proved.
Revisions	Changes to prior year-end proved reserves estimates, either positive or negative, resulting from new information other than an increase in proved acreage (extension). Revisions include increases of proved reserves associated with the installation of improved recovery techniques or equipment. They also include correction of prior report year arithmetical or clerical errors and adjustments to prior year-end production volumes to the extent that these alter reported prior year reserves estimates.
Sales	The volume of proved reserves deducted from an operator's total reserves when selling an existing field or property, during the calendar year.

Source: EIA, http://tonto.eia.doe.gov/dnav/pet/TblDefs/pet_crd_pres_tbldef2.asp.

Key Terms Used in Natural Gas Statistics

Dry Natural Gas	Natural gas which remains after: (1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation); and (2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. (Note: Dry natural gas is also known as consumer-grade natural gas. The parameters for measurement are cubic feet at 60 degrees Fahrenheit and 14.73 pounds per square inch absolute.)
Natural Gas Associated-Dissolved	The combined volume of natural gas which occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved).
Natural Gas Liquids	Those hydrocarbons in natural gas which are separated from the gas through the processes of absorption, condensation, adsorption, or other methods in gas processing or cycling plants. Generally such liquids consist of propane and heavier hydrocarbons and are commonly referred to as condensate, natural gasoline, or liquefied petroleum gases. Where hydrocarbon components lighter than propane are recovered as liquids, these components are included with natural gas liquids.
Natural Gas Non-associated	Natural gas not in contact with significant quantities of crude oil in a reservoir.
Natural Gas, Wet After Lease Separation	The volume of natural gas remaining after removal of lease condensate in lease and/or field separation facilities, if any, and after exclusion of non-hydrocarbon gases where they occur in sufficient quantity to render the gas unmarketable. Natural gas liquids may be recovered from volume of natural gas, wet after lease separation, at natural gas processing plants.
Proved Reserves of Natural Gas	Proved reserves of natural gas as of December 31 of the report year are the estimated quantities which analysis of geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. Reservoirs are considered proved if economic producibility is supported by actual production or conclusive formation test (drill stem or wire line), or if economic producibility is supported by core analyses and/or electric or other log interpretations. The area of a gas reservoir considered proved includes: (1) that portion delineated by drilling and defined by gas—oil and/or gas—water contacts, if any; and (2) the immediately adjoining portions not yet drilled, but which can be reasonably judged as economically productive on the basis of available geological and engineering data. In the absence of information on fluid contacts, the lowest known structural occurrence of hydrocarbons is considered to be the lower proved limit of the reservoir. Volumes of natural gas placed in underground storage are not to be considered proved reserves. For natural gas, wet after lease separation, an appropriate reduction in the reservoir gas volume has been made to cover the removal of the liquefiable portions of the gas in lease and/or field separation facilities and the exclusion of non-hydrocarbon gases where they occur in sufficient quantity to render the gas unmarketable. For dry natural gas, an appropriate reduction in the gas volume has been made to cover the removal of the liquefiable portions of the gas in lease and/or field separation facilities, and in natural gas processing plants, and the exclusion of non-hydrocarbon gases where they occur in sufficient quantity to render the gas unmarketable. It is not necessary that production, gathering, or transportation facilities be installed or operative for a reservoir to be considered proved. It is to be assumed that compression will be initiated if and when economically justified.

Source: EIA, http://tonto.eia.doe.gov/dnav/ng/TblDefs/ng_enr_sum_tbldef2.asp.

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