World and U.S. Fossil Fuel Supplies

Daniel O'Brien and Mike Woolverton, Extension Agricultural Economists

K-State Research and Extension

Supplies of fossil fuel resources used for energy production vary greatly among countries and regions of the world. A country's economic well-being can be greatly affected by the availability and/or cost of obtaining sufficient energy resources to meet its domestic needs. Given the current state of power generation technology in the world economy, it is of critical importance to countries to have access to adequate supplies of fossil fuels, either for domestic use or for revenue generating exports.

This article examines the supplies of fossil fuels in the United States and in other countries. It is based on an October 28, 2009 report by the Congressional Research Service (CRS) (www.crs.gov) titled "U.S. Fossil Fuel Resources; Terminology, Reporting, and Summary," R40872. The original report is available at the following web address: (http://assets.opencrs.com/rpts/R40872_20091028.pdf report key fossil fuel). Much of the information in the CRS report originated from the Energy Information Agency (EIA) (http://www.eia.doe.gov/), the statistical branch of the United States Department of Energy. After examining oil, natural gas, and coal supply inventories in the United States by type and availability, fossil fuel supplies in other countries will be discussed.

Discussions of available fossil fuel supplies depend on careful definition of terms and explanation of what considerations go into the categorization of fossil fuel energy sources. While basic concepts of fossil fuel energy categorization are included here, a full treatment is provided in the CRS paper. All fossil fuel supply inventory information in this paper is basis 2007, the latest year for which summarized U.S. energy data are reported.

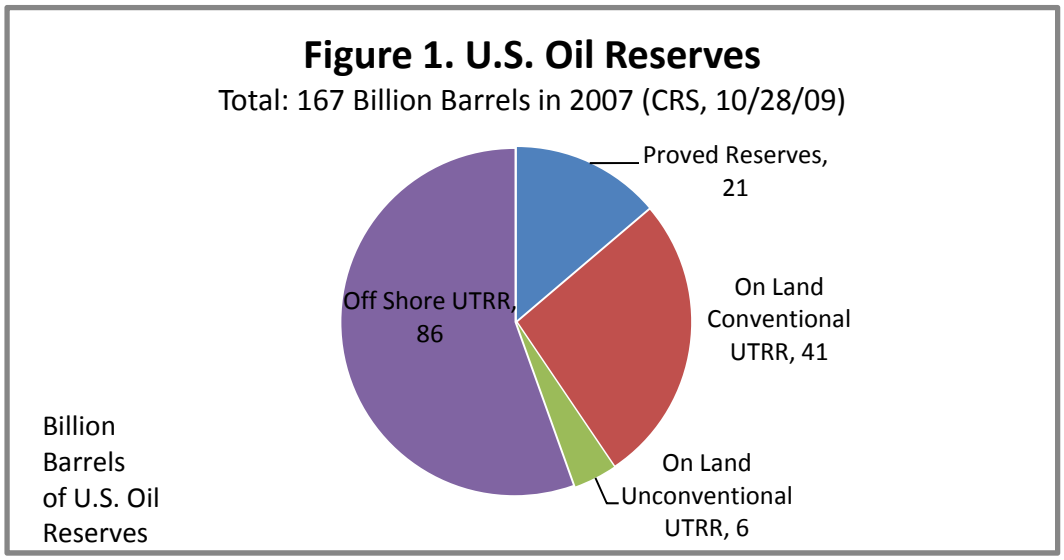
Recoverable Oil Supplies in the United States

Proved reserves of oil in the United States totaled 21.317 billion barrels in 2007 (Figure 1). Undiscovered reserves of oil totaled 145.5 billion barrels. Total proved and undiscovered oil reserves for the U.S. were estimated to be 166.7 billion barrels.

"Proved reserves" are those amounts of fossil fuels that have been "discovered and defined, typically by drilling wells or other exploratory measures, and which can be economically recovered" (page 4, CRS #R40872). Both on-land and off-shore reserves are included in the proved reserves category. The proportion of "economically recoverable" proved oil reserves is affected by variations in market prices for oil, as higher prices make it more feasible to profitably bring higher cost oil supply sources into production. Therefore, as oil prices rise the proportion of oil supplies qualifying as "economically recoverable" increases, and vice verse.

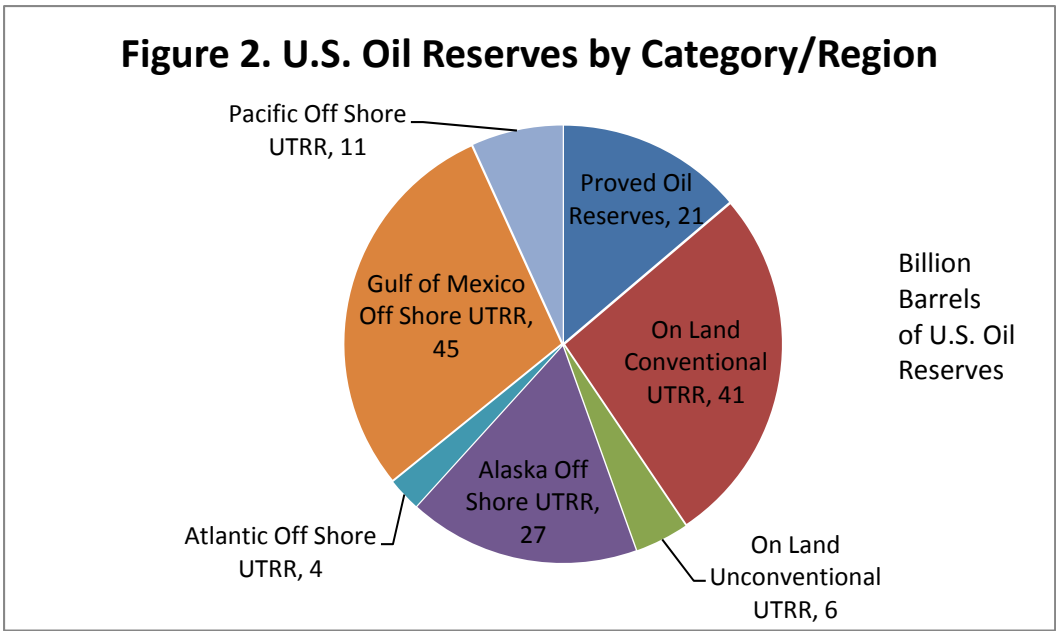
"Undiscovered resources" are the projected quantities of oil and natural gas that are estimated to exist in as yet unexplored areas" (page 4, CRS #R40872). The U.S. Geological Survey (USGS) estimates undiscovered fossil fuel resources on land, while the U.S. Minerals Management Service (MMS) estimates them off shore. The USGS delineates between "conventional" and

"unconventional" oil supplies whereas the MMS does not. "Conventional" oil and natural gas supplies are typically more easily recoverable. These conventional supplies usually are accessible using long-established common oil drilling methods. "Unconventional" oil and natural gas supplies can only be recovered using sometimes difficult and/or expensive extraction processes (beyond traditional lower cost oil drilling and extraction methods). The USGS and MMS estimates of fossil fuel supplies are based on observations of geological characteristics in similar oil and natural gas producing areas as well as other factors. The acronym "UTRR" is used here to refer to "undiscovered technically recoverable resources".



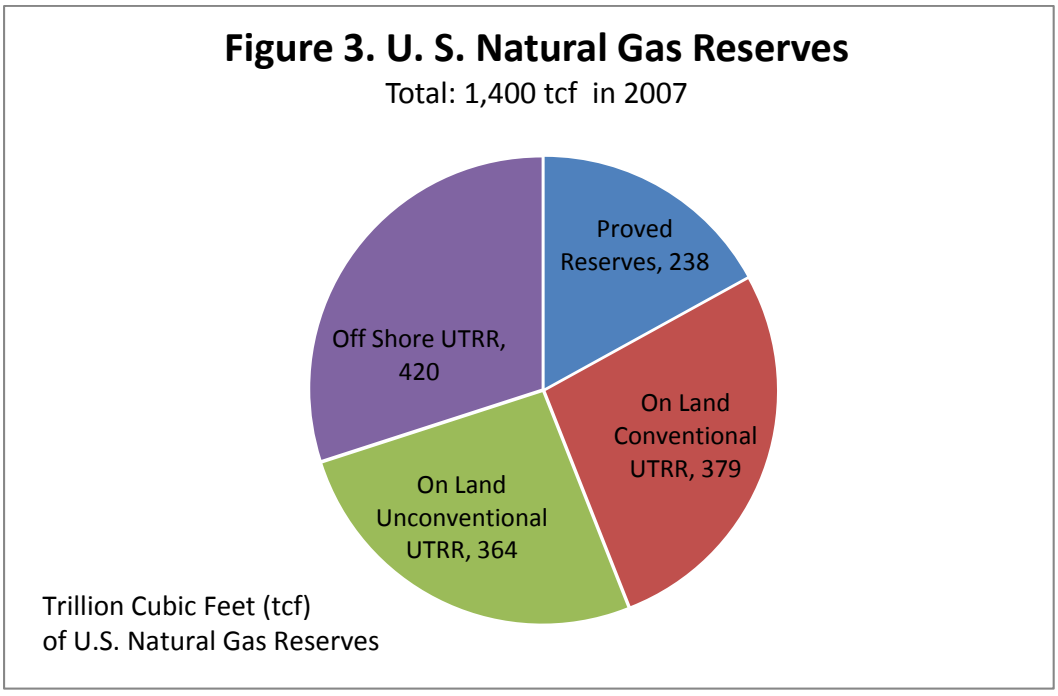
Undiscovered (i.e., "UTRR") "on-land" oil supplies were projected to be 47 bb, of which 41 bb are available via conventional extraction methods, and 6 from unconventional methods. The MMS does not delineate between conventional and unconventional in defining off-shore supplies. An estimate of 86 bb of undiscovered or UTRR oil was projected to be located off-shore in the coastal waters of the United States.

A closer examination of the off-shore UTRR oil reserves shows that 45 bb are projected to be available in the Gulf of Mexico, 27 bb near Alaska, 11 bb off of the Pacific Coast, and 4 bb off of the Atlantic coast (Figure 2).



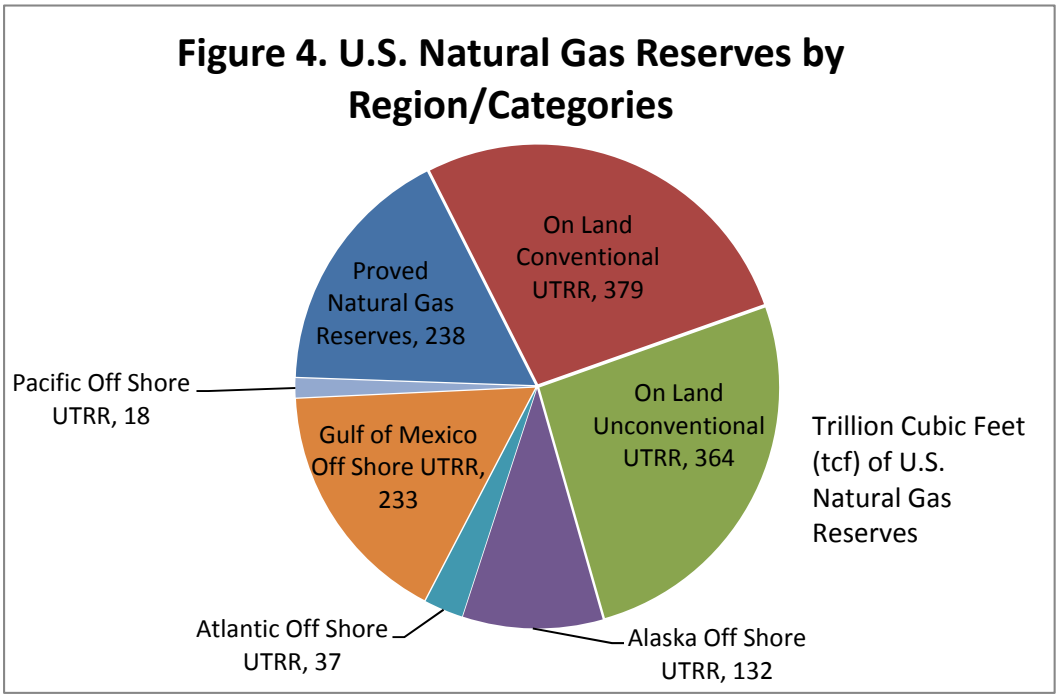
Recoverable Natural Gas Supplies in the United States

Proved reserves of natural gas in the United States totaled 237.726 trillion cubic feet (tcf) in 2007 (Figure 3). Undiscovered reserves of natural gas totaled 1,162.7 trillion cubic feet. Total proved and undiscovered natural gas reserves for the U.S. in 2007 were 1,400.4 trillion cubic feet. Both on-land and off-shore natural gas resources are included in proved reserves. Liquid natural gas is reported as part of U.S. oil production, separately from "dry" form natural gas.



An estimate of 743 tcf of undiscovered or UTRR natural gas supplies were located “on-land”, with 379 tcf available via conventional extraction methods, and 364 tcf from unconventional methods. Off-shore supply estimates of 420 tcf were not delineated between conventional and unconventional.

Off-shore UTRR natural gas reserves are projected to be 233 tcf in the Gulf of Mexico, 132 tcf near Alaska, 37 tcf off of the Atlantic Coast, and 18 tcf off of the Pacific coast (Figure 4).



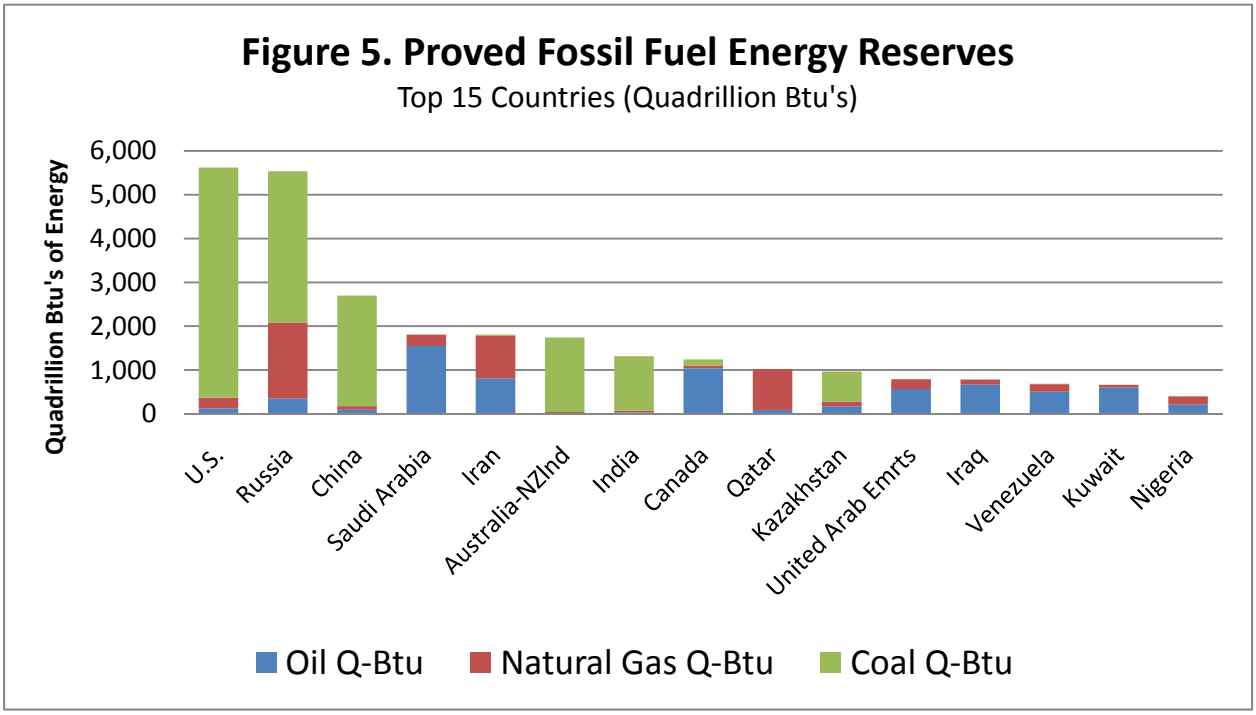
Coal Supplies in the United States

The U.S. is projected by the EIA to have 489 billion short tons of reserve coal supplies, of which 262 billion tons are projected to be actually available for mining. In some cases factors such as technical coal extraction constraints, societal and/or environmental restrictions may limit the actual amount of coal even more in the United States. The U.S. actually consumes approximately 1.2 billion tons of coal per year for energy / power generation.

World Fossil Fuel Supplies

The United States and Russia have the largest proved supplies of fossil fuels in the world, but their respective portfolios of oil, natural gas, and coal supplies vary considerably in composition. To sum and compare fossil fuels supplies on an energy-production basis, it was assumed that 1 short ton of coal produces 19,988,000 Btu, 1 cubic foot of natural gas produces 1,028 Btu, and that 1 barrel of oil producers 5,800,000 Btu of energy. The energy-production value of fossil fuel supplies are compared on the basis of total quadrillion Btu (i.e., “q-Btu”) of energy production capacity per country. The top 6 countries in terms of their projected total proved and undiscovered fossil fuel-based energy supplies are discussed below.

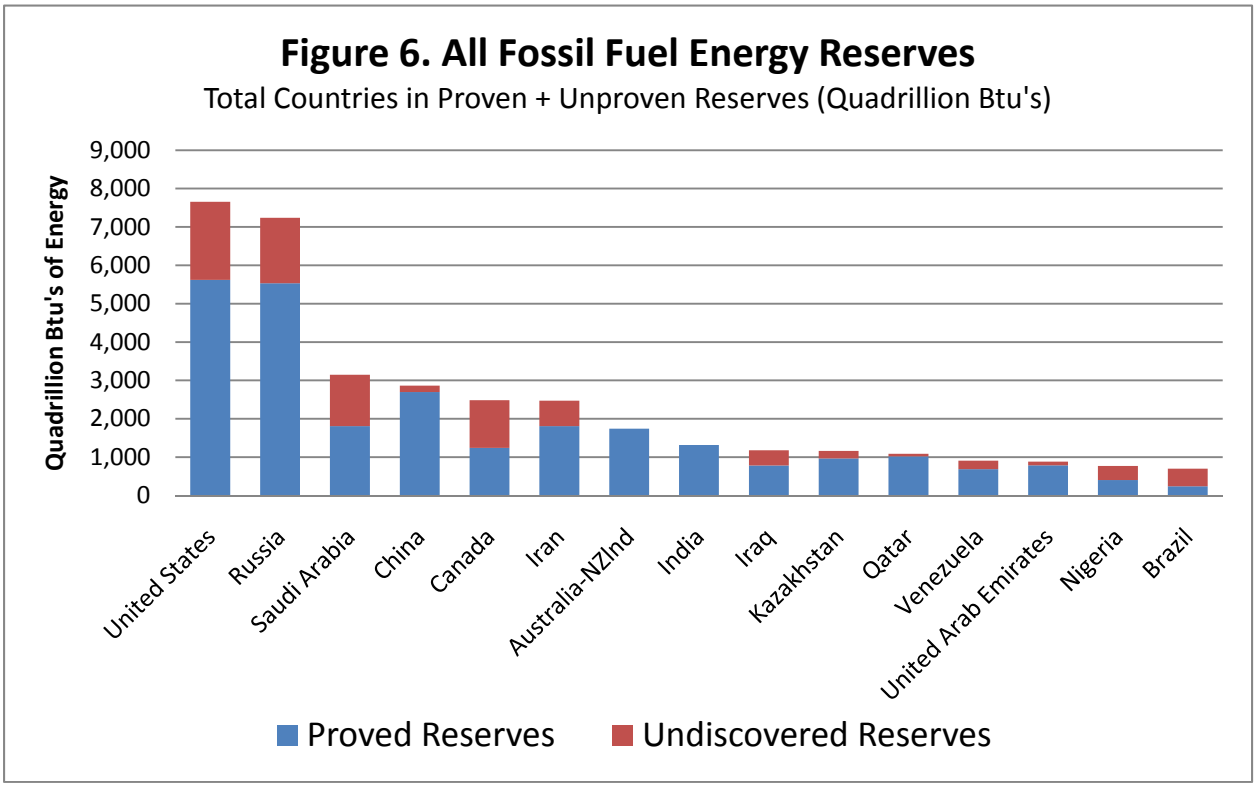
1) United States: The U.S. has the largest amount of proved fossil fuel energy supplies in the world with 5,619 quadrillion Btu equivalents, or 17.2% of world supplies (Figure 5). Coal comprises 5,251 q-Btu of energy supplies – making up 93% of the proved U.S. fossil fuel energy supply, and 28% of the proved world coal supply. Natural gas accounts for 244 q-Btu, or 4% of U.S. fossil fuel proved energy supplies. Oil provides 124 q-Btu or 3% of U.S. energy equivalent proved fossil fuel supplies. When an additional 2,039 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, the U.S. is projected to have 7,657 q-Btu of fossil fuel energy supplies – the most of any nation (Figure 6).



2) Russia: In terms of total fossil fuel energy supplies, Russia has the second largest amount of proved fossil fuel energy supplies in the world with 5,535 quadrillion Btu equivalents, or 16.9% of world supplies. Coal accounts for 3,460 q-Btu or 63% of Russian fossil fuel proved energy supplies, and 19% of the proved world coal supply. Natural gas accounts for 1,727 q-Btu, or 31% of Russian proved fossil fuel energy supplies, and 27% of proved world natural gas supplies. Oil provides 348 q-Btu or 6% of Russian proved energy equivalent fossil fuel supplies. When an additional 1,703 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, Russia is projected to have 7,238 q-Btu of fossil fuel energy supplies – 2nd only to and just slightly behind the United States.

3) Saudi Arabia: The proved total fossil fuel energy supplies of Saudi Arabia are estimated to be 1,808 quadrillion Btu equivalents, or 5.5% of world supplies. This is the 4th largest amount of proved fossil fuel energy supplies in the world. Oil provides 1,547 q-Btu or

86% of Saudi Arabian energy equivalent proved fossil fuel supplies, and 20% of proved world oil supplies. Natural gas accounts for 260 q-Btu, or the remaining 14% of Saudi Arabian proved fossil fuel energy supplies, and 4% of proved world natural gas supplies. Saudi Arabia has no appreciable supply of coal. When an additional 1,342 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, Saudi Arabia is projected to have 3,149 q-Btu of fossil fuel energy supplies – 3rd only to the United States and Russia.



4) China: Chinese proved fossil fuel energy supplies are estimated to be 2,698 quadrillion Btu equivalents, or 8.3% of world supplies. Coal comprises 2,522 q-Btu of fossil fuel energy equivalents – making up 93% of the Chinese proved fossil fuel energy supply, and 14% of the proved world coal supply. Oil provides 93 q-Btu or 4% of China's proved energy equivalent fossil fuel supplies. Natural gas accounts for 82 q-Btu, or 3% of Chinese proved fossil fuel energy supplies. When an additional 165 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, China is projected to have 2,862 q-Btu of fossil fuel energy supplies – the 4th most of any nation.

5) Canada: The proved total fossil fuel energy supplies of Canada are estimated to be 1,242 quadrillion Btu equivalents, or 3.8% of world supplies. Oil provides 1,036 q-Btu or 83% of Canadian energy equivalent proved fossil fuel supplies, and 13% of world proved oil supplies. Coal comprises 146 q-Btu of fossil fuel energy equivalents – making up 12% of the proved Canadian fossil fuel energy supply. Natural gas accounts for 60 q-Btu, or the

remaining 5% of Canadian proved fossil fuel energy supplies. When an additional 1,242 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, Canada is projected to have 2,483 q-Btu of fossil fuel energy supplies – the 5th most of any nation.

6) Iran: The proved total fossil fuel energy supplies of Iran are estimated to be 1,807 quadrillion Btu equivalents, or 5.5% of world supplies. Natural gas accounts for 975 q-Btu, or 54% of Iranian proved fossil fuel energy supplies, and 15% of proved world natural gas supplies. Oil provides 803 q-Btu or 44% of Iranian proved energy equivalent fossil fuel supplies, and 10% of proved world oil supplies. Coal accounts for 30 q-Btu or 2% of Iranian fossil fuel proved energy supplies. When an additional 663 q-Btu of undiscovered or UTRR oil and natural gas supplies are added, Iran is projected to have 2,470 q-Btu of fossil fuel energy supplies – the 6th most of any nation.

Other nations of note include Qatar with its sizable natural gas reserves. Qatar has 905 tcf of proved natural gas supplies, equaling 931 q-Btu of energy equivalents, or 15% of world natural gas supplies. Iraq has sizable reserves of oil, with 115 billion barrels of proven oil reserves, accounting for 9% of proven world oil supplies. With 397 q-Btu of undiscovered or UTRR oil and gas, Iraq's total fossil fuel energy supplies are projected at 1,179 q-Btu. Australia – New Zealand and India both have sizable proved coal resources, accounting for 1,701 q-Btu and 1,245 q-Btu of equivalent energy, respectively. Australia-New Zealand possesses 9.2% and India controls 6.7% of the world's coal supplies, respectively. Brazil's fossil fuel supplies increase from 240 q-Btu to 700 q-Btu of energy (i.e., an increase of 192%) when unexplored oil and gas supplies are added for consideration, likely reflecting recent off-shore energy finds.

Annual U.S. Fossil Fuel Energy Consumption

To keep perspective on the adequacy or inadequacy of these U.S. fossil fuel energy supplies, it is useful to compare them to annual fossil fuel consumption and imports. In 2008, the United States consumed 22.4 q-Btu of energy from coal, 23.8 q-Btu of energy from natural gas, and 37.1 q-Btu of energy from petroleum (source: Energy Information Administration, an agency of the U.S. Department of Energy, http://www.eia.doe.gov/). These rates of energy use in 2008 equal 0.3% of proved U.S. coal supplies, 9.7% of proved U.S. natural gas supplies, and 29.9% of U.S. proved oil supplies as identified earlier in this report.

These results are consistent with the current dependence of the U.S. on oil imports. Recent technological developments in oil and natural gas extraction technologies and processes that help to tap unconventional on-land and off-shore as well as exploration in areas of the Gulf of Mexico; the Bakken formation in North Dakota, South Dakota, Montana and Canada; and elsewhere in the United States. These technological developments have the potential to increase supplies of U.S. fossil fuels in the next few years, and improve the narrow energy use-to-supply relationships for U.S. oil and natural gas.

Conclusions

The Congressional Research Service (www.crs.gov) report on "U.S. Fossil Fuel Resources: Terminology, Reporting, and Summary" (document #R4082, October 28, 2009) provides

definitions for various categories of U.S. fossil fuel energy use. An explanation is provided in the "Resource Pyramid Concept" for how differences in extraction methods and physical access to fossil fuel energy sources largely determine whether a particular coal, natural gas or oil resource is ultimately used or not in U.S. and world energy markets. Potential oil and natural gas energy resources in the U.S. such as shale oil, shale gas, methane hydrates, and heavy oil are discussed the CRS paper, but are not included in the above fossil fuel energy equivalent calculations because they are considered to be "sub-economic" given current energy market conditions. Their potential inclusion of these fossil fuel-based energy resources at some future time for the U.S. as well as other countries would likely cause major changes to the final country-by-country tally of available fossil fuel resources.

Fossil Fuel-based energy supplies in the U.S. are largely made up of coal (93%), with natural gas (4%) and oil (3%) also included. Substantial supplies of oil and gas are projected to be available in the coastal waters of the U.S., especially in the Gulf of Mexico and in the region of Alaska, as well as on the Atlantic and Pacific coasts. Possible access to these off-shore fossil fuel resources in the future will involve a number of technical, economic and environment issues.

Russia is the only nation with comparable quantities of fossil fuel-based energy resources to those of the United States. However, Russian energy supplies have a higher proportion of natural gas and a lower proportion of coal than do those of the United States. Saudi Arabia, China, Canada, and Iran each have sizable supplies of fossil fuel energy resources that impact both their economies and the broader world energy market supply- consumption balance.