
GLOBAL ENERGY SUPPLIES AND THE U.S. MARKET

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The U.S. energy market will continue to rely heavily on fossil fuels for the foreseeable future, and net imports of oil and gas will continue to rise, with most of the increased foreign supplies coming from OPEC, Caruso and Doman say.

Overall, the world's energy resources are sufficient to meet projected global demand for the next two decades, but supplies will remain unevenly distributed among regions and countries. This article provides an overview of oil and gas resources worldwide; takes a look at U.S. energy demand, supply, and production potential; and reviews possible changes in the future U.S. energy mix.

The United States is projected to become increasingly dependent on foreign sources of oil and natural gas to meet growing domestic demand, with most of the increased imports coming from the Organization of Petroleum Exporting Countries (OPEC). In 2002, the United States imported 53 percent of its oil and 16 percent of its natural gas. In 2025, net petroleum imports are projected to reach 70 percent of total petroleum demand and natural gas imports 23 percent of total natural gas demand. In the Energy Information Administration's (EIA) *Annual Energy Outlook 2004*, OPEC accounts for nearly 60 percent of the projected growth in U.S. petroleum imports between 2002 and 2025. Although the United States is expected to produce around three-quarters of the gas it is projected to consume in 2025, net imports do grow over the projection period, mostly in the form of liquefied natural gas (LNG).

Petroleum products accounted for 40 percent of the total energy consumed in the United States in 2002 and natural gas for another 24 percent, with coal, nuclear power generation, and renewable and other energy sources (including methanol, liquid hydrogen, and net electricity imports) making up the remainder. While the United States must import oil and natural gas to meet domestic supply, it is self-sufficient in terms of coal, nuclear power, and renewable energy sources.

GLOBAL OIL RESOURCES

The world's oil resource base is defined by three categories:

proved reserves (that is, those quantities that have been discovered already and that can be recovered under present technologies and prices); reserve growth (increases in reserves resulting mainly from technological factors that enhance a field's recovery rate); and undiscovered reserves (oil that remains to be found through exploration). Data on proved reserves are updated and published annually in the *Oil & Gas Journal*, a weekly publication that covers developments affecting the world petroleum industry. Undiscovered oil resources estimates were derived by the U.S. Geological Survey (USGS) as part of its *World Petroleum Assessment 2000* and regional reserve growth was estimated by EIA. Accordingly, the world's total oil resources are estimated to be 2,935 billion barrels between 1995 and 2025, which includes estimates for natural gas liquids and reflects the removal of cumulative production (oil that has already been produced from the beginning of time).

According to EIA's *International Energy Outlook 2004*, world oil consumption is expected to grow from 28 billion barrels per year in 2001 to 44 billion barrels per year by 2025. Under these growth assumptions, less than half of the world's total oil resources would be exhausted by 2025. The estimate of the world's total oil resources involves only conventional sources of oil.

Nonconventional oil resources are defined as resources that cannot be produced economically with today's technology and include oil sands, ultra-heavy oils, gas-to-liquids technologies, coal-to-liquids technologies, biofuel technologies, and shale oil. In the case of heavy oil and tar sands, for instance, more than 3,300 billion barrels are estimated worldwide, with Canada and Venezuela having the most significant deposits. If world oil prices were to rise to \$35 per barrel (in constant 2002 dollars) by 2025, nonconventional oil could be expected to provide as much as 8 million barrels per day.

There are sufficient resources to meet the world's growing demand for oil through 2025. However, the distribution of these oil resources is not uniform around the world. The member countries of OPEC, a cartel of eleven oil-producing countries (Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United

Arab Emirates, and Venezuela) hold most of the world's proved oil reserves. According to *Oil & Gas Journal*, in January 2004, OPEC accounted for 69 percent of the world's proved oil reserves, 870 billion barrels of 1,265 billion barrels. Six of the seven countries with the largest proved reserves are all OPEC members, and alone account for 61 percent of the world's oil reserves. Moreover, oil reserves among the OPEC nations are dominated by the Gulf states — Saudi Arabia, Iran, Iraq, Kuwait, and the United Arab Emirates — which account for about 80 percent of OPEC's proved oil reserves.

Although OPEC member countries account for much of the world's proved reserves, there are substantial reserves outside the cartel. The regions of Central and South America, Africa, and Eastern Europe and the former Soviet Union (FSU) each hold between 6 and 8 percent of the world's proved oil reserves. There are substantial opportunities in all of these regions to increase reserves over the next two decades. Estimates for undiscovered reserves and increases in reserves have the potential to be twice as large as current proved reserves and, in the case of the FSU, quadruple that level.

North America (United States, Canada, and Mexico) accounts for 17 percent of the world's proved reserves. One of the more dramatic changes to the published proved reserves reported by the *Oil & Gas Journal* was the addition of Alberta's oil sands to Canada's total reserves in 2003. Until this point, oil sands were largely considered to be an unconventional form of oil, one that could not be produced economically relative to conventional forms of petroleum. Large reductions in development and production costs are making oil sands economically viable. The 2003 revision to Canadian proved reserve estimates added 174 billion barrels of reserves (bitumen contained in oil sands) to the Canadian conventional crude oil and condensate reserves as reported by the Canadian Association of Petroleum Producers. Canadian conventional crude oil and condensate are estimated to be 4.5 billion barrels.

NATURAL GAS RESOURCES

Similarly to petroleum reserves, natural gas resources have in general increased every year since the 1970s. As of January 1, 2004, proved natural gas reserves were estimated by the *Oil & Gas Journal* at 6,076 trillion cubic feet. Most of the increases in natural gas reserves in recent years have been in the developing world, and about three-quarters of the world's natural gas reserves are

found in the Middle East and in the former Soviet Union — with Russia, Iran, and Qatar together accounting for about 58 percent of those reserves. The remaining reserves are spread fairly evenly among other regions of the world.

Reserves-to-production (r/p) ratios provide a rough measure of the number of years one could expect a region's supply of natural gas might last, assuming current production levels. R/p ratios are computed by dividing the proved reserves in a given region by current annual production in that region. Despite the high rates of increase in the use of natural gas worldwide, most regional r/p ratios have remained high. Worldwide, the reserves-to-production ratio is estimated at 61 years, but the FSU has an r/p ratio estimated at 76 years, Africa nearly 90 years, and the Middle East more than 100 years.

According to the USGS's most recent assessment of world natural gas resources, there is a significant amount of natural gas that remains to be discovered. The USGS publishes three versions of assessments of natural gas resources over the 1995 to 2025 period. The lowest estimate is an estimate based on a 95 percent chance or better that the undiscovered resources will be found and the highest estimate is that there is a 5 percent chance or better that the resources will be discovered. If we consider the expected value or mean assessment, the estimate for worldwide undiscovered natural gas is 4,258 trillion cubic feet. Of the natural gas resources that are expected to be added over the next twenty-five years, reserve growth accounts for 2,347 trillion cubic feet. As is true for oil, natural gas resources can and do increase over time, owing to technological advancements and economic circumstances.

It is estimated that one-fourth of the undiscovered natural gas is located in undiscovered oil reserves. As a result, more than one-half of the mean undiscovered natural gas is expected to come from the Middle East, former Soviet Union, and North Africa. Although the United States has produced more than 40 percent of its total estimated natural gas resources and holds only 10 percent of its remaining proved reserves, in the rest of the world reserves have been largely unexploited. Outside the United States, the world has so far produced less than 10 percent of its total estimated natural gas endowment and carries more than 30 percent as remaining reserves.

U.S. OIL AND NATURAL GAS SUPPLIERS

Since the early 1960s, the United States has been steadily increasing its reliance on imported supplies of both petroleum and natural gas. Whereas in 1960 the country imported about 17 percent of its oil, by 2002 imports accounted for nearly 53 percent of total oil use. The largest suppliers of U.S. imports have changed somewhat over this period, along with their relative importance. In 1960, Venezuela, Canada, Saudi Arabia, Colombia, and Iraq were the largest suppliers of foreign oil to the United States. In 2002, Canada provided the largest share of U.S. imports, followed by Saudi Arabia, Mexico, Venezuela, and Nigeria. In addition, the number of oil exporters to the United States has increased, with supplies coming from Angola, Argentina, Ecuador, Norway, and the United Kingdom, among others.

In the future, U.S. dependence on OPEC for oil supplies is expected to grow, from about 40 percent in 2002 to around 50 percent in 2025, according to the reference case projection from the EIA's *Annual Energy Outlook 2004*. Gross imports are projected to increase from nearly 12 million barrels per day in 2002 to 21 million barrels per day in 2025 (with the United States expected to consume a total of 28 million barrels per day in 2025). U.S. petroleum production is projected to decline somewhat over the next two decades, falling from 9.16 million barrels per day in 2002 to 8.60 million barrels per day in 2025. Crude oil imports from the North Sea are expected to decline gradually as North Sea production declines. Oil imports from Canada and Mexico decline over the forecast period, with much of the Canadian contribution coming from the development of its enormous oil sands resource base.

In contrast to oil, the United States still produces most of the natural gas the country needs. In 2002, net imports of natural gas accounted for 16 percent of total gas consumption in the United States. Canada remains the country's most important natural gas supplier, as it has been since the 1960s. There is, however, some modest diversification in U.S. natural gas imports, as the number of LNG suppliers have increased over the past several years. Trinidad and Tobago, Qatar, Algeria, Nigeria, Oman, Brunei, and Malaysia all exported LNG to the United States in 2002.

While U.S. natural gas production is expected to grow in the future, demand for natural gas is expected to grow faster than domestic supply. The United States consumed

22.8 trillion cubic feet of natural gas in 2002 and this is expected to increase to 31.2 trillion cubic feet in 2025. By 2025, dependence on gas imports is projected to increase to 23 percent. U.S. gas production is forecast to expand to 24.1 trillion cubic feet, much of which will come from unconventional sources — tight sands, shale, and coalbed methane — as a result of technological improvements and rising natural gas prices. Canada's importance as a gas supplier to the United States is expected to decline in the future. Canadian gas exports will begin to decline after 2010, a result of the depletion of conventional resources in the Western Sedimentary Basin. LNG imports are projected to become increasingly more important to U.S. gas supplies, rising from 0.2 trillion cubic feet in 2002 to 4.8 trillion cubic feet in 2025.

ALTERNATIVE ENERGY SOURCES

There are opportunities for fuel-switching to allow alternative fuels to displace oil and natural gas, in the same way other fuels have been replaced in the past. Fuelwood was the dominant form of energy from the time of the founding of the first American colonies in the 1600s until late in the 19th century. The 20th century saw a number of new energy sources penetrate the U.S. energy market, expand quickly, and replace fuelwood almost entirely. Coal surpassed fuelwood in the United States by about 1895, but was itself surpassed in 1951 by petroleum and then by natural gas a few years later. In addition, hydroelectric power appeared in about 1890 and nuclear generation in 1957, diversifying the electric power sector. Other alternative energy sources, such as solar photovoltaic, advanced solar thermal, and geothermal technologies represent the most recent developments in energy sources. There is also the possibility that new technologies, such as hydrogen fuel cells, might affect the fuel mix in the future.

At present, and notwithstanding new technological advancements, oil and natural gas are not expected to be substantially displaced in the U.S. fuel mix over the next two decades. Oil, in particular, is expected to remain dominant in the transportation sector where there are presently no economically competitive alternative fuels. In contrast, oil has been displaced to a large extent in the U.S. electric power sector. Oil use for electricity generation has fallen since the late 1970s. In 2002, oil-fueled generation provided about 2 percent of total U.S. electricity generation, and it is expected to have a relatively small role in the future.

There has been strong growth in natural gas use for electric power generation, especially over the past 10 years. Natural gas consumption for generation increased by 4.8 percent per year between 1992 and 2002, compared to increases of about 2 percent per year for coal and nuclear power and 0.4 percent per year for hydroelectricity and other renewable energy sources. Economics play a large role in fuel-switching, given that sustained high energy prices can result in weakening demand when there is an opportunity to use alternative fuels. In the case of natural gas, demand in the power sector is likely to slow in the future, particularly after 2020 when natural gas prices are expected to rise and adding new coal-fired electric power capacity would become economically competitive.

In addition to economic forces influencing the U.S. energy mix, government policies can affect diversification of the fuel mix away from oil and natural gas. Many state governments have enacted renewable portfolio standards, for example, to increase the proportion of electric power from renewable energy sources. Upgrades and improved efficiencies at existing plants can also influence the energy supply mix. The average capacity factor of nuclear power plants in the United States has increased from 71 percent in 1992 to 91 percent in 2002,

allowing nuclear power generation to increase by 26 percent, despite a 300-megawatt contraction in installed capacity over this period.

CONCLUSION

The United States will likely continue to rely upon fossil fuels to meet much of its energy needs over the foreseeable future. With demand for oil and natural gas expected to rise steadily over the next two decades and limited new domestic resources available for development, dependence on foreign suppliers will also rise. U.S. reliance on OPEC is poised to increase, but supplies from non-OPEC producers will also grow, ensuring some diversity in supply. The United States will continue to produce much of its natural gas domestically in the future, but LNG from a diverse set of suppliers is expected to become increasingly important to meeting demand. Resources do not pose a key constraint to world demand through 2025. Instead, political, economic, and environmental circumstances are likely to influence the world energy markets of the future. □