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THE STATE AGENCY FOR GEOLOGIC INFORMATION

MISSION

To inform and advise the public about the geologic character of Arizona in order to foster understanding and prudent development of the State's land, water, mineral, and energy resources.

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Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

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Assist in carrying out the rules, orders, and policies established by the Commission which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

Crude Oil Supply and Demand: Long-Term Trends

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Introduction

The Persian Gulf region contains enormous oil reserves that are of tremendous long-term importance to the global economy. Industrialized democracies of Europe, North America, and the western Pacific Rim consume large quantities of oil for electricity generation, transportation, and heating. Increasing dependence on Middle Eastern oil increases the possibility that political turmoil in the Persian Gulf region could cause major disruption to the global economy.

Future use of Arizona's energy resources will depend in part on the cost of imported oil and the stability of supplies. The long-term trend toward more dependence on imported oil, and eventual depletion of global oil reserves, will lead to increased interest in Arizona's energy resources. Furthermore, the national security implications of dependence on unstable or hostile countries for essential resources require attention by United States citizens and their political leaders.

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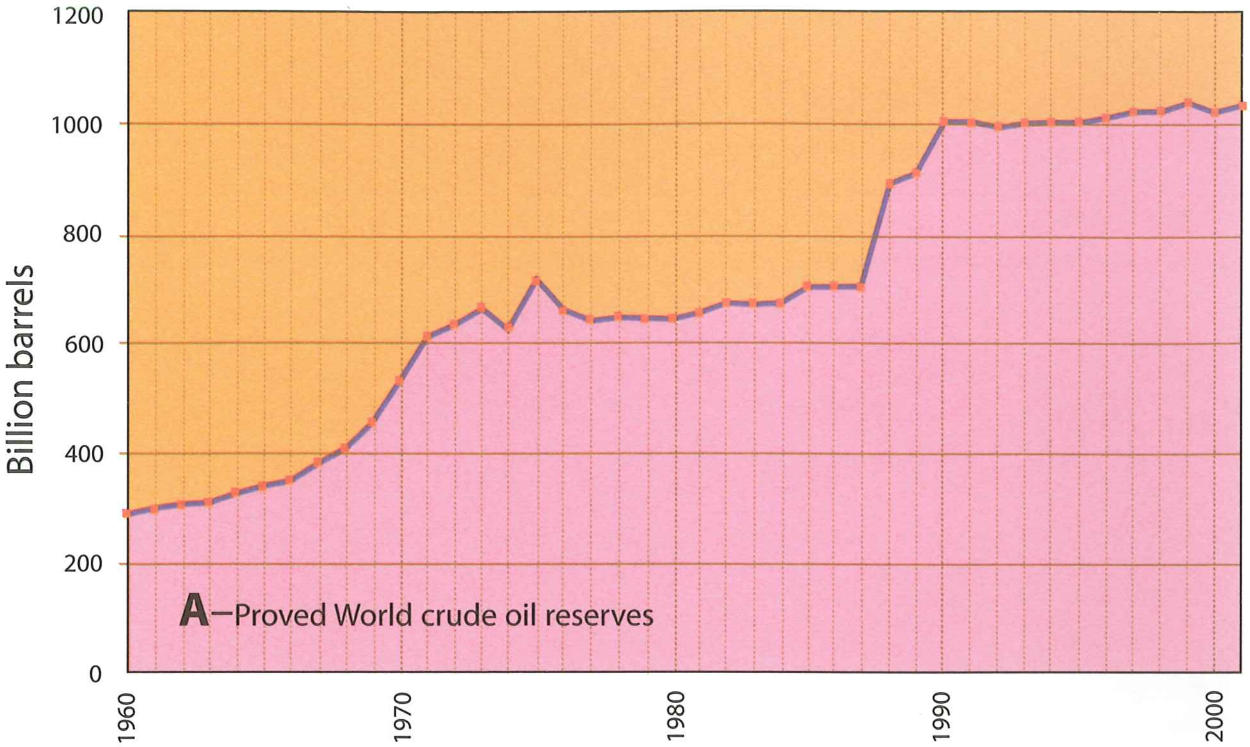
Trans-Alaska pipeline south of Delta Junction. The pipeline extends 800 miles from Prudhoe Bay to Valdez. Alaska Range is in the background.



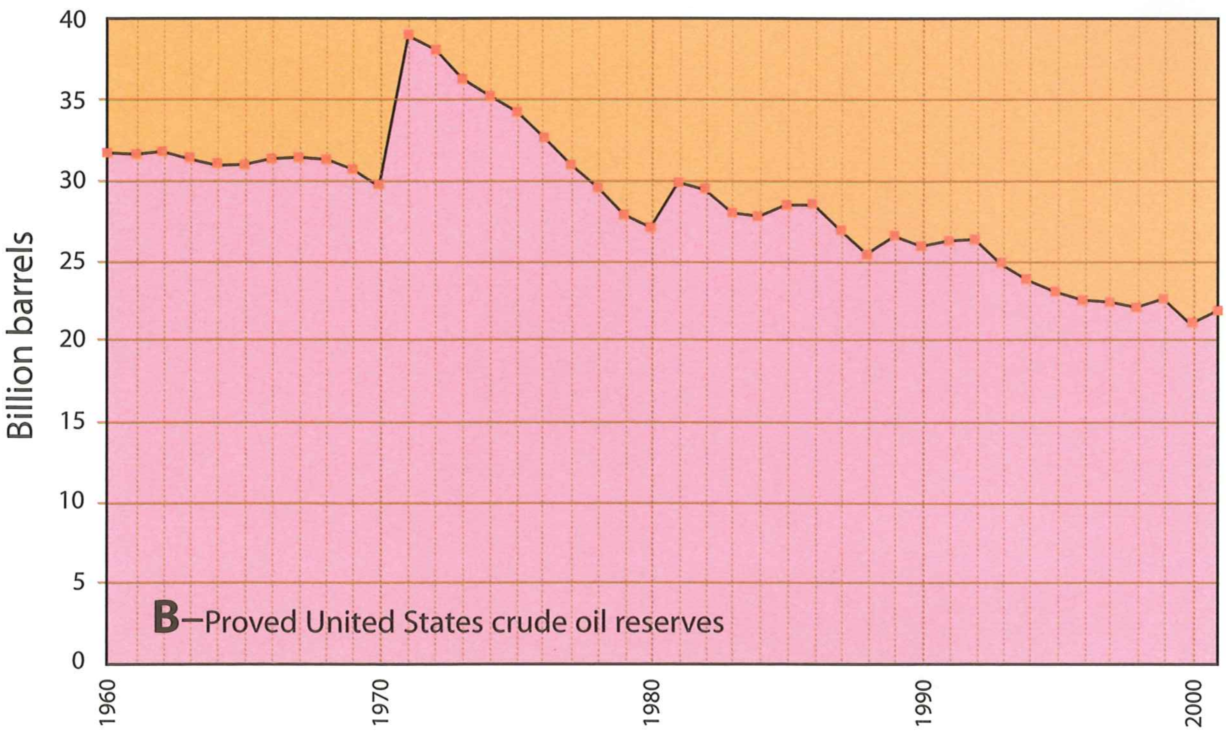


Figure 1. Estimated proved crude oil reserves in the world (A) and the United States (B) over the past 41 years. The large increases in world reserves in 1988 and 1990 were due to new estimates from the Persian Gulf region. The large increase in United States reserves in 1971 was due to identification of reserves in Prudhoe Bay, Alaska. Drilling and well testing in the Arctic National Wildlife Refuge could result in a similar increase in proved reserves in the United States. Data from API (1982), AAC (1988), and for data since 1988, annual summaries in Oil & Gas Journal.

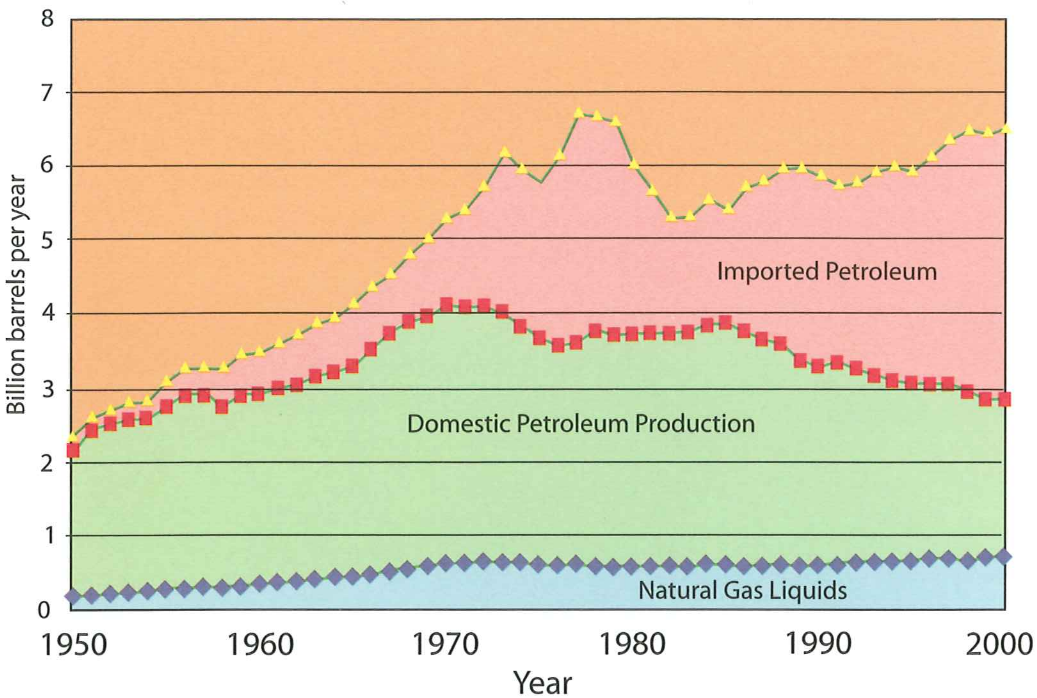


Figure 2. Liquid petroleum consumed in the United States during the past 50 years came from three sources, as shown. Note the gradual decline in domestic oil production during the past thirty years, the gradual increase in production of natural gas liquids over the past 50 years, and the large increase in oil imports over the past 15 years. Data from EIA (2001).

Global Reserves

Estimating the amount of oil in an oilfield is a difficult, uncertain task that must be done by industry to make basic business decisions. As a result, estimating oil reserves has become something of a science. One basic type of estimated oil reserves is "proved reserves." Proved reserves are defined as those quantities of petroleum thought to be commercially recoverable based on all factors affecting oil-field production, including economic conditions (SPE, 1997). Proved reserves are supported by oil-well tests or actual production.

Global proved reserves are estimated at 1028 billion barrels as of January 1, 2001 (Radler, 2000). Changes over time in estimated global proved reserves reflect decreases due to production and increases due to new discoveries. Although annual global production was 24.5 billion barrels in 2000, and a similar amount for each of several previous years, estimated global reserves have increased rather than decreased. This is because many new discoveries were made and the estimated size of many known fields increased (Figure 1).

Approximately two-thirds of proved global oil reserves are located in just five countries. Saudi Arabia contains an estimated 260 billion barrels of oil, or about one-fourth of proved global reserves (Radler, 2000). Iran, Iraq, Kuwait, and the United Arab Emirates each contain about 100 billion barrels of proved reserves (Table 1). About 72 percent of the world's proved oil reserves are located in dominantly Islamic nations, including the five nations mentioned above, plus Libya, Qatar, Algeria, Oman, Indonesia, Kazakhstan, and several others (Table 1). Members of the Organization of Petroleum Exporting Countries (OPEC), which controls production to elevate profit margins, account for 79 percent of global proved reserves.

United States

Annual domestic oil production in the United States declined from a maximum of 4.1 billion barrels in 1970 to 2.8 billion barrels in 2000 (EIA, 2001; Figure 2). This production, derived from many areas in the U.S., includes petroleum pumped from the ground as crude oil and liquids derived from natural gas. Approximately 82 percent of crude oil production in 2000 was from just four states (Louisiana, Texas, Alaska, and California; Table 2); 26 percent was from offshore wells in federally controlled waters adjacent to Louisiana, Texas, and California (included with those states' production in Table 2). Of the 530,000 operating oil wells in the U.S., 78 percent were "stripper wells," each of which produced less than 10 barrels per day (IOGCC, 2001). These wells accounted for 0.3 billion barrels of production in 2000, or about 15 percent of U.S. crude oil production.

About 25 percent of the 2.8 billion barrels of U.S. oil produced in 2000 was from gas wells (IPAA, 2001).

Global proved reserves, 2000

Country	Proved reserves (billion barrels)	Percent of total world
Saudi Arabia*	262	25.5
Iraq*	112	10.9
United Arab Emirates*	98	9.5
Kuwait*	96	9.3
Iran*	90	8.8
Venezuela	77	7.5
Russia	49	4.8
Libya*	29	2.8
Mexico	28	2.7
China	24	2.3
Nigeria	22	2.1
United States	22	2.1
Qatar*	13	1.3
Norway	9	0.9
Algeria*	9	0.9
Brazil	8	0.8
Oman*	6	0.6
India	5	0.5
Indonesia*	5	0.5
United Kingdom	5	0.5
Kazakhstan*	5	0.5
Angola	5	0.5
Malaysia*	4	0.4
Yemen*	4	0.4
Canada	4	0.4
Rest of world	37	3.6
Total World	1028	100.0
Total OPEC	814	79.2
Total for dominantly Islamic nations	742	72.2

*Dominantly Islamic nation

Table 1

2000 U.S. oil production*

State	thousand barrels/day	million barrels/yr	percent
Louisana	1513	552	25.7
Texas	1400	511	23.8
Alaska	1050	383	17.9
California	857	313	14.6
Oklahoma	193	70	3.3
New Mexico	176	64	3.0
Wyoming	167	61	2.8
North Dakota	90	33	1.5
Kansas	80	29	1.4
Other	355	130	6.0
Total	5881	2147	100.0
LA, TX, AK, CA	4820	1759	82.0
Gulf of Mexico OCS	1420	518	24.1

*Not including natural gas liquids

Table 2

The pressure and temperature of natural gas in underground reservoirs is much greater than at the Earth's surface. Natural gas from such reservoirs may contain hydrocarbons that are gaseous underground but condense into liquid at surface temperature and pressure. These "condensates" typically resemble oil and are sent promptly to oil refineries. Natural gas is further processed at gas refining facilities where more liquid is derived from the gas. Most of these refinery-derived liquids are propane and butane, which are known as "natural gas liquids." Unlike domestic oil production, which declined by about 32 percent during the past 20 years, production of natural gas liquids increased by 20 percent over the same period.

Fifty-six percent (3.7 billion barrels) of the 6.5 billion barrels of crude oil and natural gas liquids consumed in the U.S. in 2000 was imported (Figure 2). Of the 2.8 billion barrels (44 percent) produced domestically, 2.1 billion barrels were crude oil and 0.7 billion barrels were natural gas liquids. At the beginning of 2001, the United States had an estimated 21.8 billion barrels of proved reserves (only 2 percent of the total global proved reserves). At current rates of production, these reserves would last just 9.5 years. Because production rates will decline gradually and new reserves will be discovered, an abrupt end of domestic oil production will not occur. Domestic production will almost certainly continue the long decline that began in 1970.

Arctic National Wildlife Refuge

Northeastern Alaska includes the approximately 30,000-square-mile Arctic National Wildlife Refuge (ANWR). The "1002 area," an approximately 2300-square-mile area on the northern coastal plain of the ANWR, probably contains a large amount of oil but is not accessible for exploration because it is a federal wildlife refuge. The U.S. Geological Survey, in a recently completed study of the 1002 area and the adjacent area that extends 3 miles offshore, estimated that there is a 90 percent chance that the total amount of technically recoverable oil in this area is 5.7 to 16.0 billion barrels, with a mean estimate of 10.4 billion barrels (U.S. Geological Survey, 2001). The amount of oil that could be recovered profitably, known as "economically recoverable oil," is dependent on the price of oil. Economically recoverable oil could not be produced at a market price of $13 per barrel. At a market price of $30 per barrel, however, 70 to 90% of the technically recoverable oil probably would be recovered. Eighty percent recovery from the 10.4 billion-barrel mean estimate of technically recoverable oil amounts to a total production of 8.3 billion barrels. For comparison, U.S. oil consumption in 2000 was about 7 billion barrels, 4 billion barrels of which were imported. At 2000 oil consumption and import rates, therefore, 8 billion barrels of crude oil from the ANWR, produced over an 8-year period, would reduce U.S. imports by 25 percent (4 billion barrels of imported oil annually reduced to 3 billion barrels). If steps are taken to reduce domestic consumption, further reduction

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of imports will be achieved. Even if ANWR oil is produced and domestic energy consumption is reduced, the U.S. probably will require substantial quantities of imported oil.

Conclusion

The Persian Gulf region contains approximately two thirds of the world's proved oil reserves. Because exploration for new oil and drilling in existing fields has kept pace with or exceeded the pace of consumption, proved global oil reserves have increased. The rate of increase is slowing, however, and reversal is possible in the near future. Oil reserves in the Persian Gulf region are adequate to support global demand in the near future. Political instability, however, raises concern about dependence on this region for an essential resource. Furthermore, at some future time, probably in this century, Middle Eastern oil reserves will be depleted.

Oil production in the United States has declined for thirty years, while demand has increased. The United States now imports 56 percent of its oil, and this number seems likely to increase. Opening the 1002 area of the Arctic National Wildlife Refuge to oil exploration and production could significantly reduce U.S. imports, and would provide partial and temporary relief from growing dependence on imported oil. An inevitable transition to different types of transportation and energy fuels will be difficult, but not overly disruptive if it occurs gradually. If this transition occurs abruptly due to political forces, it could have a major adverse impact on the global economy. Either case will result in renewed focus on Arizona's various energy resources.

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EIA, 2001, Petroleum overview, 1949-2000 (Table 5.1): Energy Information Administration, U.S. Department of Energy, http://www.eia.doe.gov/emeu/aer/txt/tab0501.htm.

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GEOLOGIC MAPPING

The Arizona Geologic Mapping Advisory Committee, which met in early October, recommended that the following areas be given highest priority for new geologic mapping: 1) the San Pedro River Valley from Benson to Sierra Vista and 2) the Colorado River corridor from Yuma to Bullhead City. The Arizona Geological Survey followed this recommendation in its proposal for funding from the STATEMAP component of the National Cooperative Geologic Mapping Program, administered by the U.S. Geological Survey. Funding awards will be announced in early 2002.

INTERNET ADDRESS CHANGE FOR AZGS

On December 3, 2001 the AZGS will be making some changes on the Internet. Our website will have a new address: **http://www.azgs.az.gov**
Our employee email addresses will also change to the following format: **firstname.lastname@azgs.az.gov**
You can visit our website to get email addresses for our employees. We will also have a general email address for communicating with the AZGS: **azgs@azgs.az.gov**
Sorry for any inconvenience. These changes are required due to computer equipment replacements in Phoenix.

JUST RELEASED

Compilation geologic map of the Galleta Flat West 7.5' quadrangle, Pima and Cochise Counties, Arizona: Skotnicki, S.J. and Siddoway, C.H., 2001, Arizona Geological Survey Digital Geologic Map 08 (DGM 08), 1 CD ROM. $15.00 plus shipping and handling.

Geologic map of the Mescal 7.5' quadrangle, Pima and Cochise Counties, Arizona: Skotnicki, S.J., 2001, Arizona Geological Survey Digital Geologic Map 09 (DGM 09), 1 CD ROM. $15.00 plus shipping and handling.

Surficial geology and geologic hazards of the Amado-Tubac area, Santa Cruz and Pima Counties, Arizona: Youberg, Ann, and Helmick, W.R., 2001, Arizona Geological Survey Digital Geologic Map 13 (DGM 13), 1 CD ROM, scale 1:24,000. $15.00 plus shipping and handling.

Field guide to "A" Mountain and description of surrounding region, Pima County, Arizona: McGarvin, T.G., 2001, Arizona Geological Survey Open-File Report 01-07 (OFR 01-07), 9 p. $2.00 plus shipping and handling.

Geologic field guide to the Copper Butte area, eastern Pinal County, Arizona: Dickinson, W.R., 2001, Arizona Geological Survey Contributed Report 01-C (CR 01-C), 16 p. $3.25 plus shipping and handling.

Geologic map of Tertiary volcanic rocks in the southern King Canyon and east central Chino Valley North 7.5' quadrangles, Yavapai County, Arizona: Cunningham, Heather, 2001, Arizona Geological Survey Contributed Map 01-A (CM 01-A), two sheets, scale 1:12,000. $2.50 plus shipping and handling.

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