Sierra Club Energy Education – U.S. Oil Supply Issues

- 1. Current oil supply context
  - U.S. oil consumption, production, imports, public lands oil contribution
- 2. Potential U.S. and worldwide oil exhaustion
  - M. King Hubbert-type analyses
- 3. Arctic National Wildlife Refuge (ANWR) facts

Sierra Club Energy Education Program Tom Goerold, Lookout Mountain Analysis

Company Profile

- Founded in 1991, Lookout Mountain Analysis provides consulting and expert services in the analysis of energy, mineral, and other natural resource issues. Investigations involving environmental economics is a specialty of the firm. Some examples of products include expert witness services, project financial modeling, policy analysis, environmental and socioeconomic impact analysis, as well as site-specific and other analytical services.

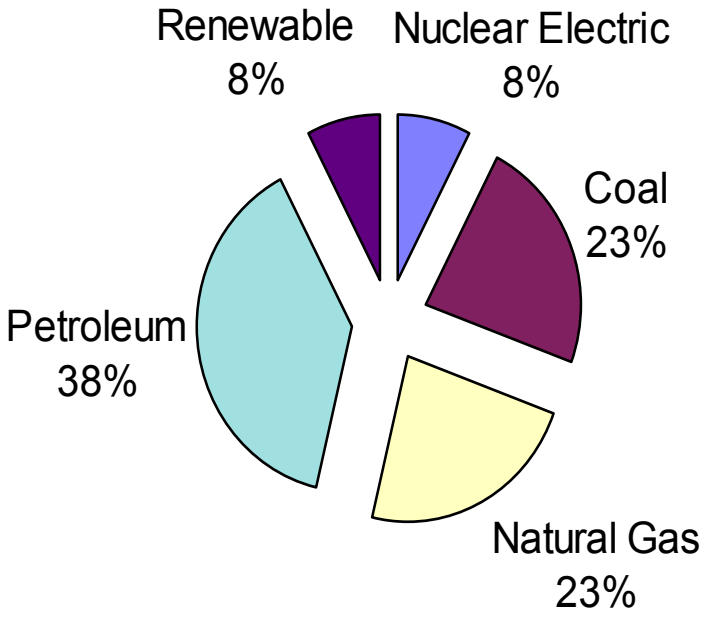
- Dr. Thomas Goerold, owner and chief consulting economist of Lookout Mountain Analysis, is incoming President of the trade group Mineral Economics and Management Society (MEMS). He has worked in and with the private and public sectors, as well as with many Non-governmental organizations (NGOs). He has earned a Ph.D. in Mineral Economics and an M.S. in Geology.

www.lookoutmtn.com --- what's new tab

- Source for many other energy- and mineral-related studies

- Most of the recent studies were funded by The Wilderness Society

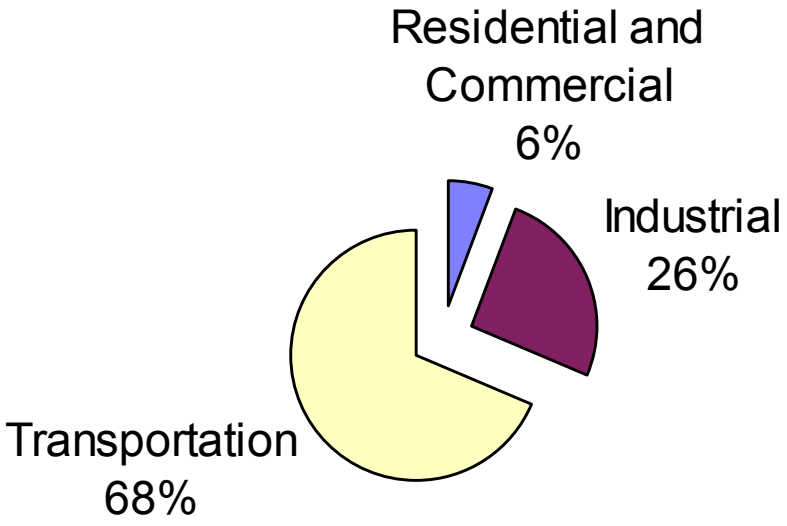
U.S. Energy Consumption by Fuel, 1998



Source: Department of Energy (DOE)/Energy Information Administration (EIA), 1999, *Annual Energy Review*.

Produced by Lookout Mountain Analysis for the World Wildlife Fund, U.K., June 2000.

Petroleum Consumption by Sector, 1998

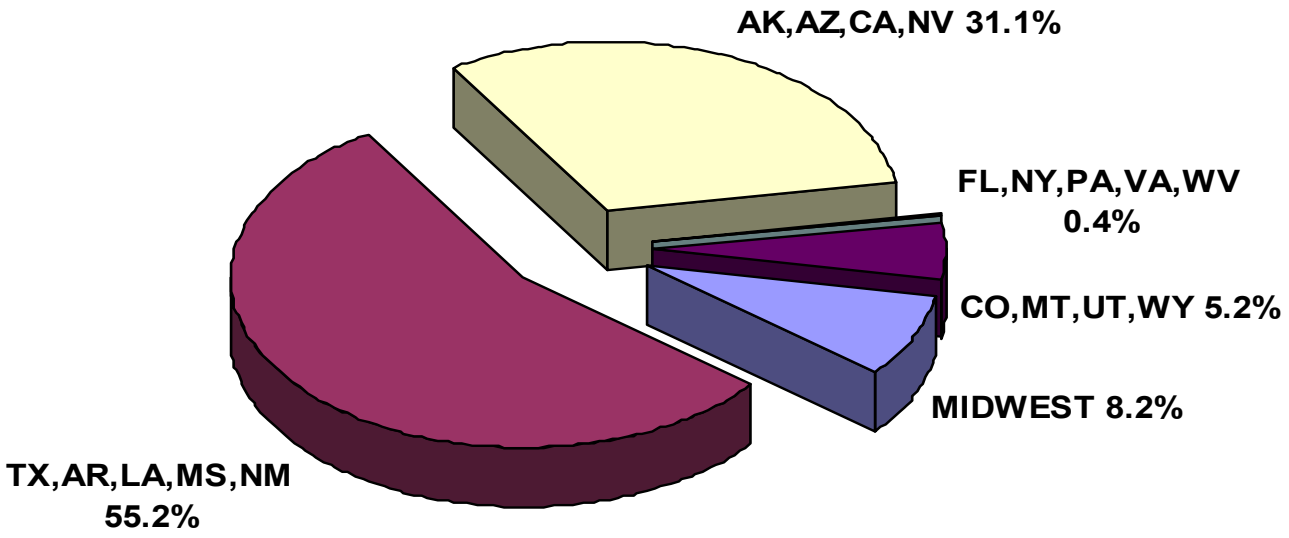


Source: Department of Energy (DOE)/Energy Information Administration (EIA), 1999, *Annual Energy Review*.

Produced by Lookout Mountain Analysis for the World Wildlife Fund, U.K., June 2000.

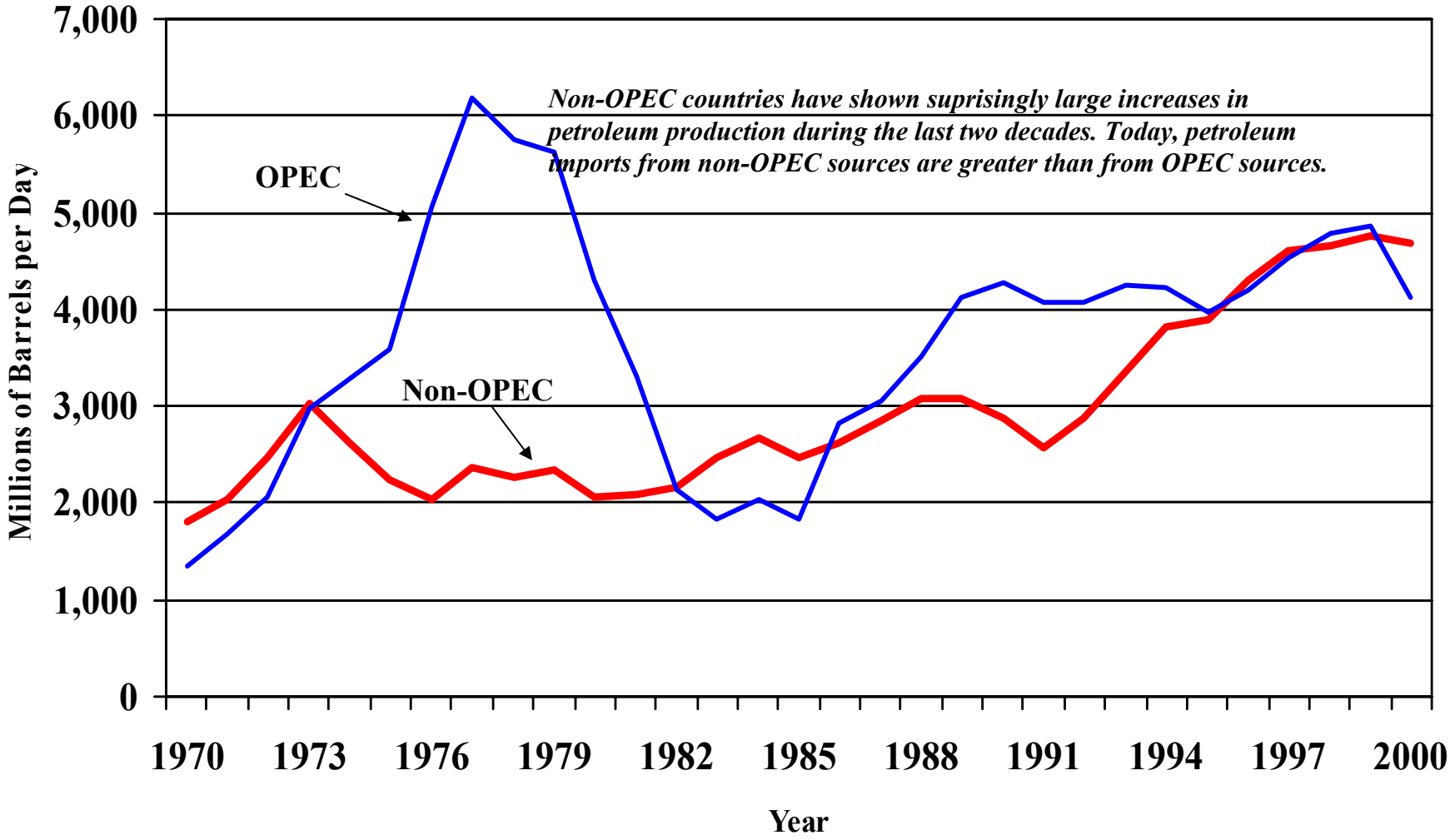
U.S. Oil Production by Region, 2000

More than 85 percent of U.S. oil production came from two EIA regions. The states with the largest oil output in 2000 were Alaska, Texas, California, Louisiana, New Mexico, and Oklahoma.



Source: DOE/EIA, 2001, Petroleum Supply Annual 2000, Volume 1, Table 14.

Net Petroleum Imports by Source



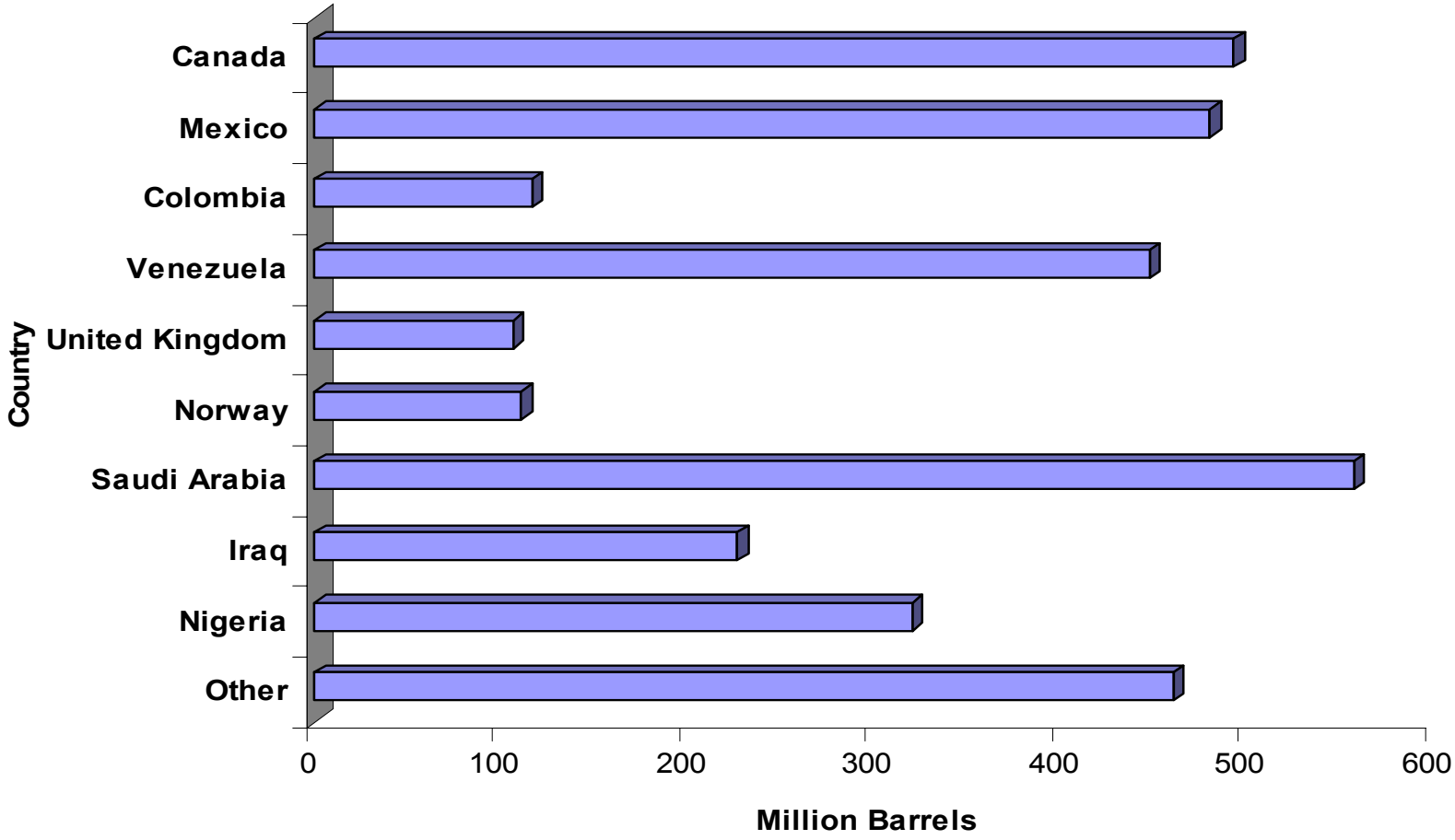
Source: Energy Information Administration, 2000, Online Energy Statistics.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000.

U.S. Crude Oil Imports by Country, 2000

In 2000, Canada and Mexico each supplied almost supplied as much crude oil imports as Saudi Arabia.

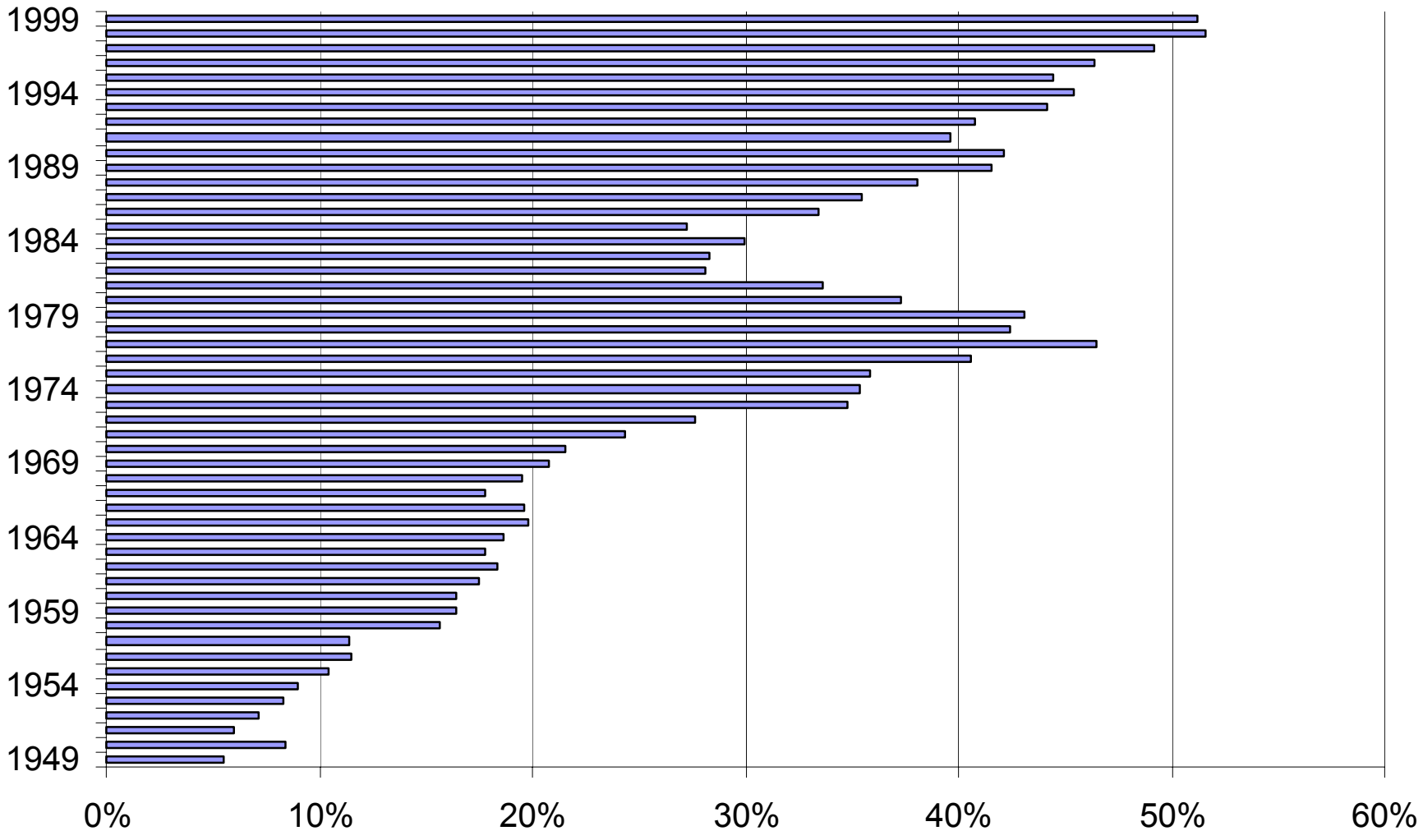
North and South American countries supplied much more crude oil to the U.S. than Arab OPEC countries.



Source: DOE/EIA, 2001, Petroleum Supply Annual, 2000, Volume 1, Table 21.

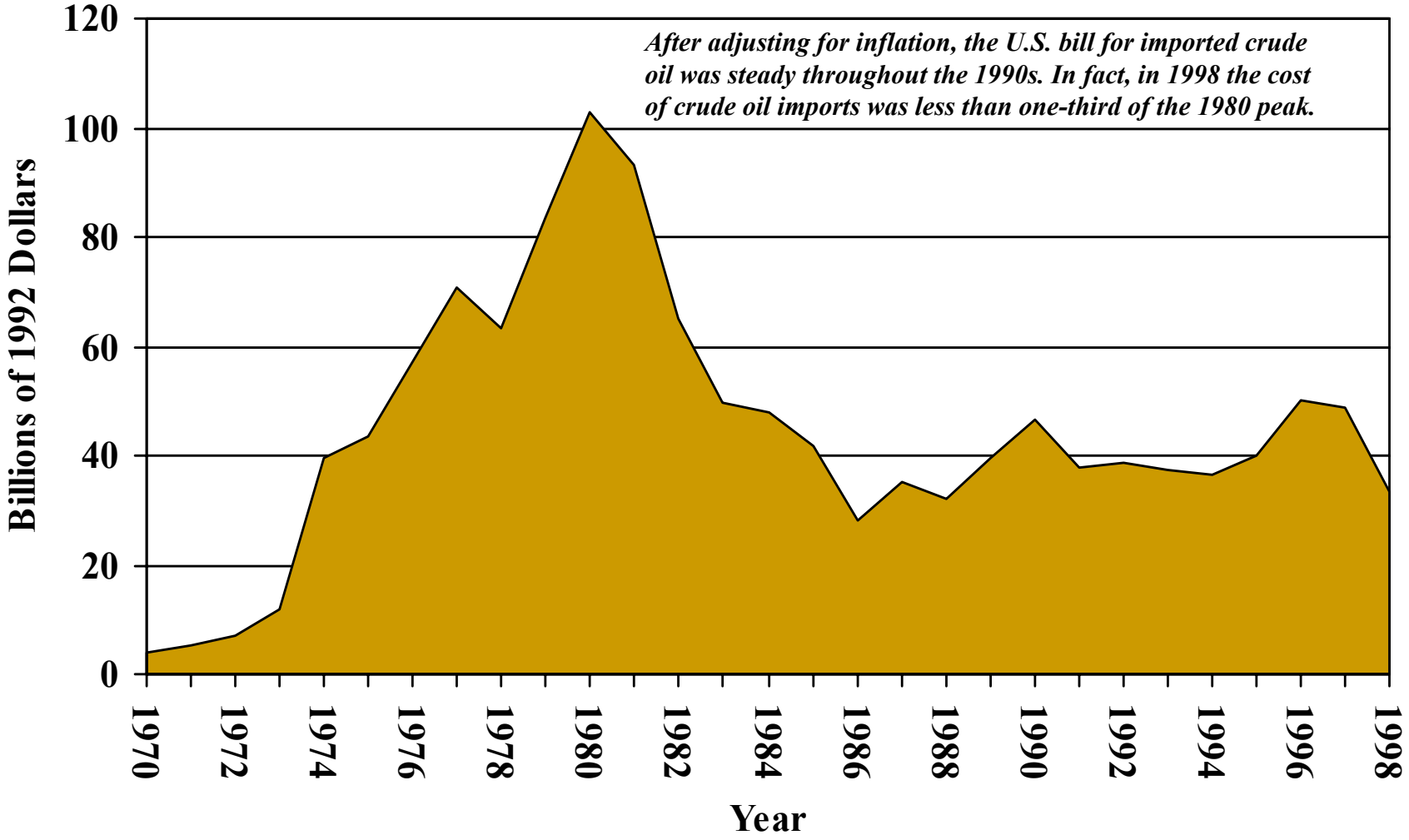
Prepared by Lookout Mountain Analysis for Alaska Wilderness Coalition

Import Share of Total U.S. Oil Consumption



Source: DOE/EIA, 2000, Annual Energy Review

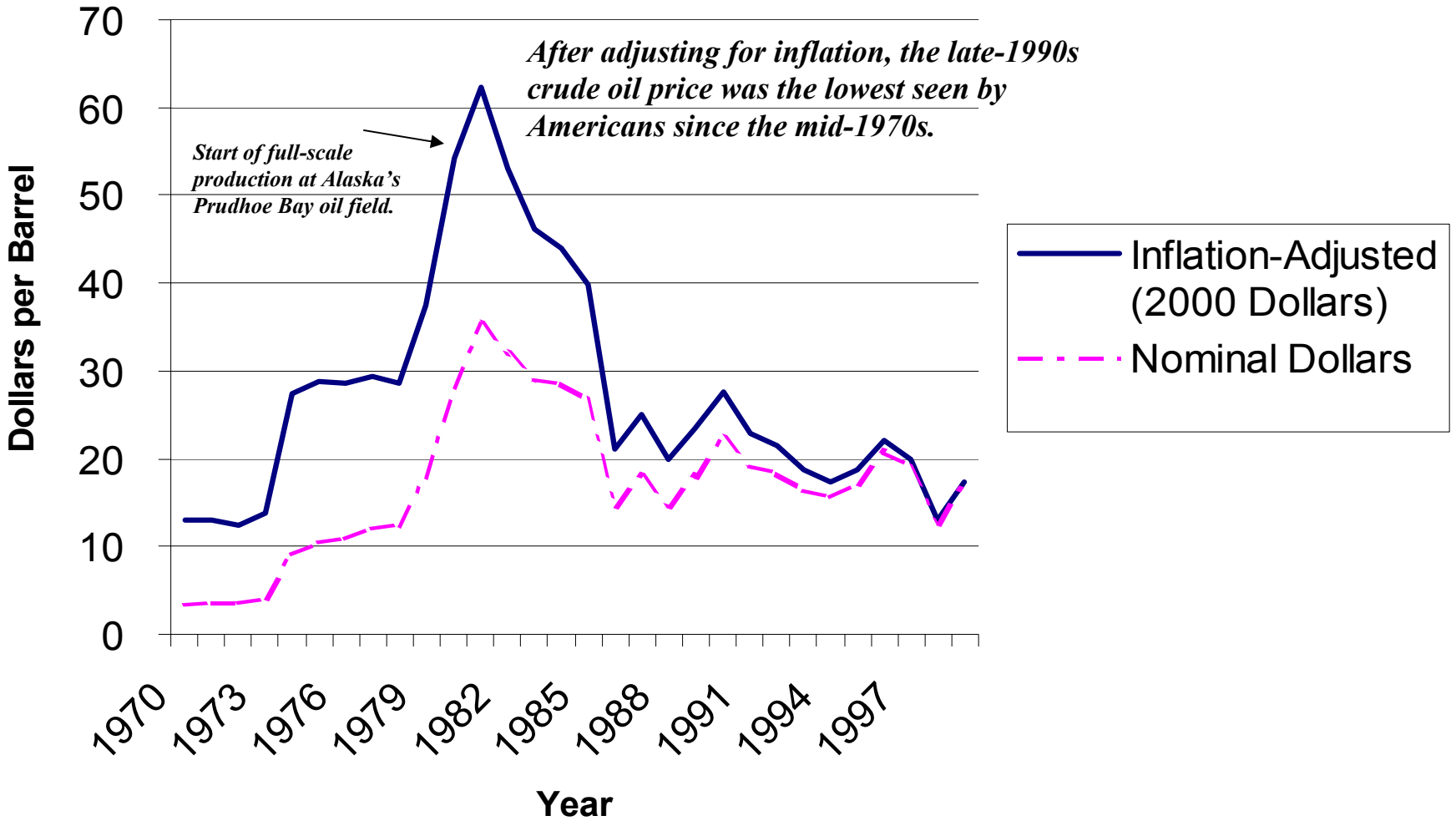
Value of Crude Oil Imports



Source: Energy Information Administration, 2000, Online Energy Statistics.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000

Refiner's Acquisition Cost of Crude Oil (Composite)



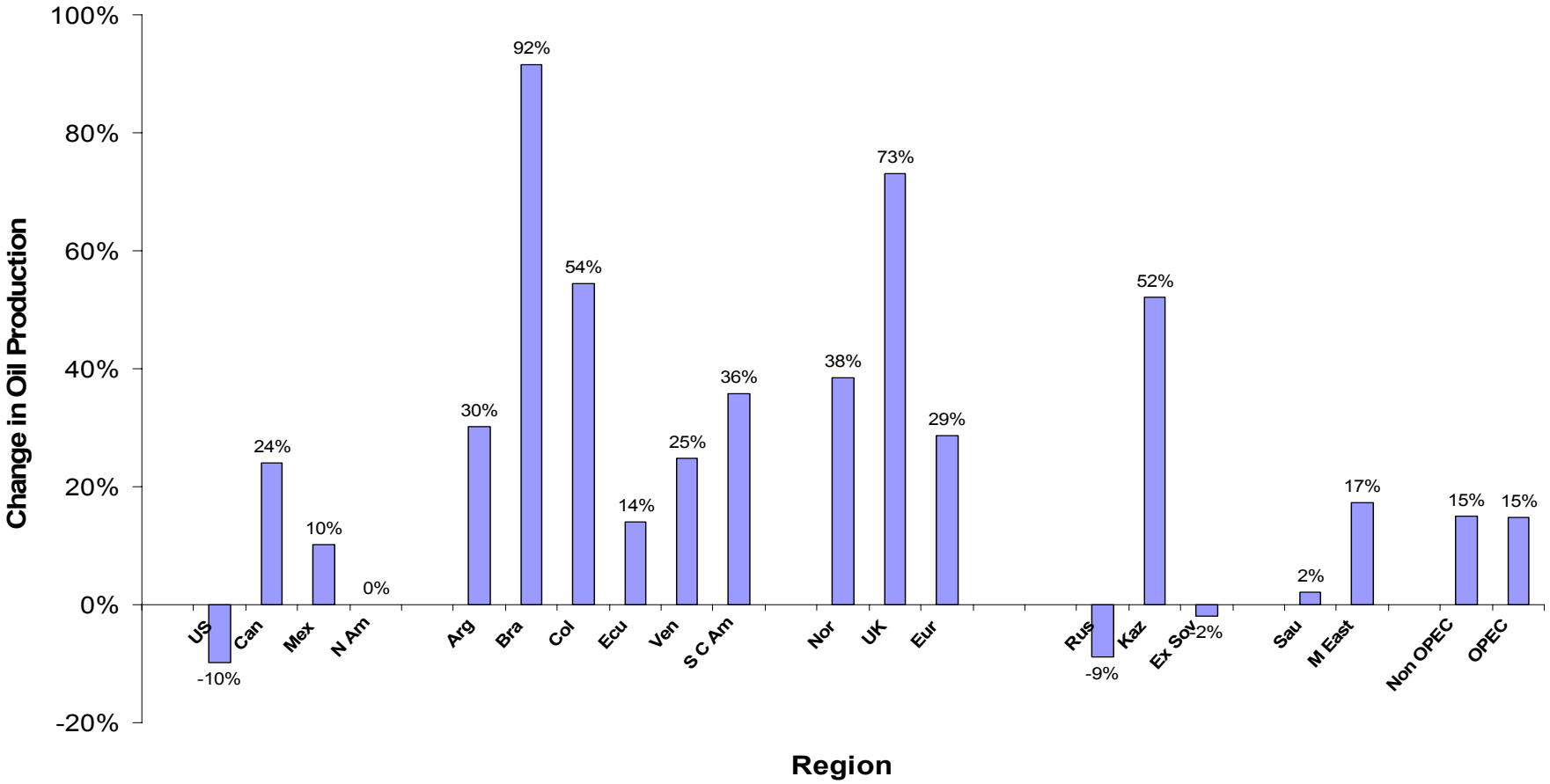
Source, Energy Information Administration, 2000, Online Energy Statistics.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000.

Changes in Worldwide Oil Production 1993 - 2000

From 1993 to 2000, U.S. oil production decreased by 10 percent. But, North American output was constant during the period due to increases in Canadian and Mexican oil output.

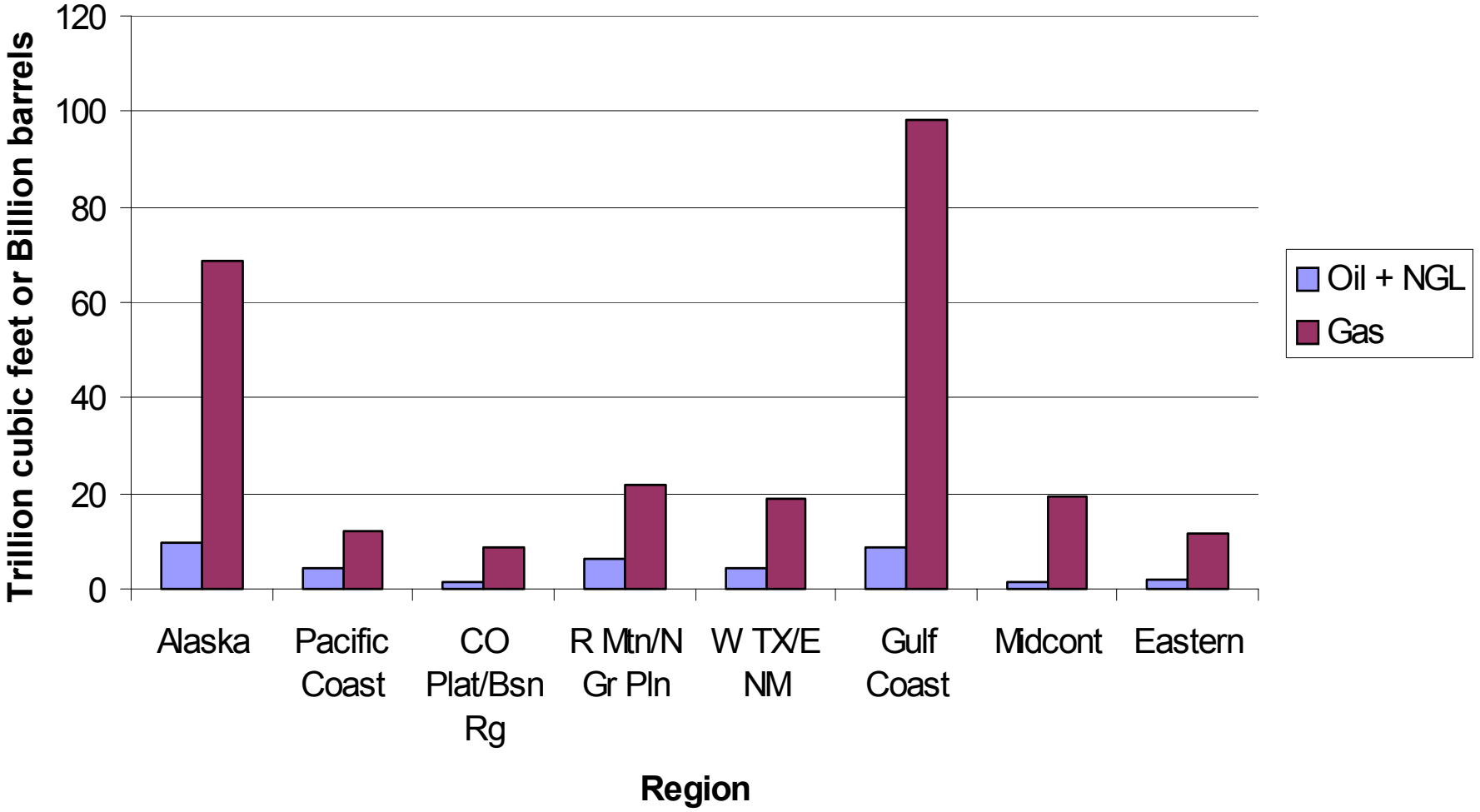
Both Non-OPEC and OPEC oil production increased by 15 percent during the period. Total South and Central American oil output grew by 36 percent, and European by 29 percent, even as petroleum from the former Soviet countries shrank by 2 percent.



Source: BP, June 2001, BP Statistical Review of World Energy.

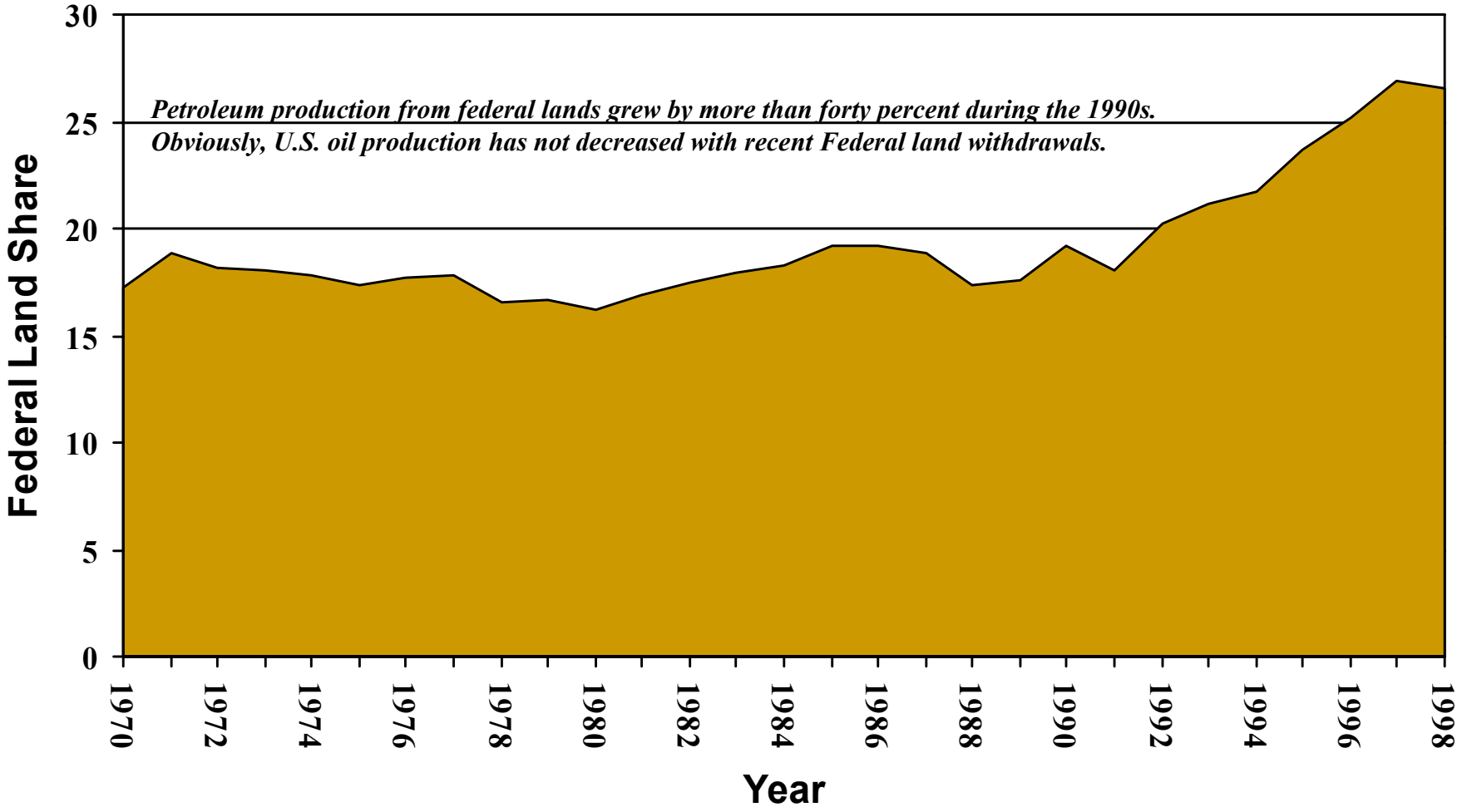
Prepared by Lookout Mountain Analysis for Alaska Wilderness Coalition

Conventional Undiscovered Technically Recoverable Oil and Gas Resources in the U.S. by Region



Source: U.S. Geological Survey, 1996, *1995 National Assessment of United States Oil and Gas Resources—Results, Methodology, and Supporting Data.*

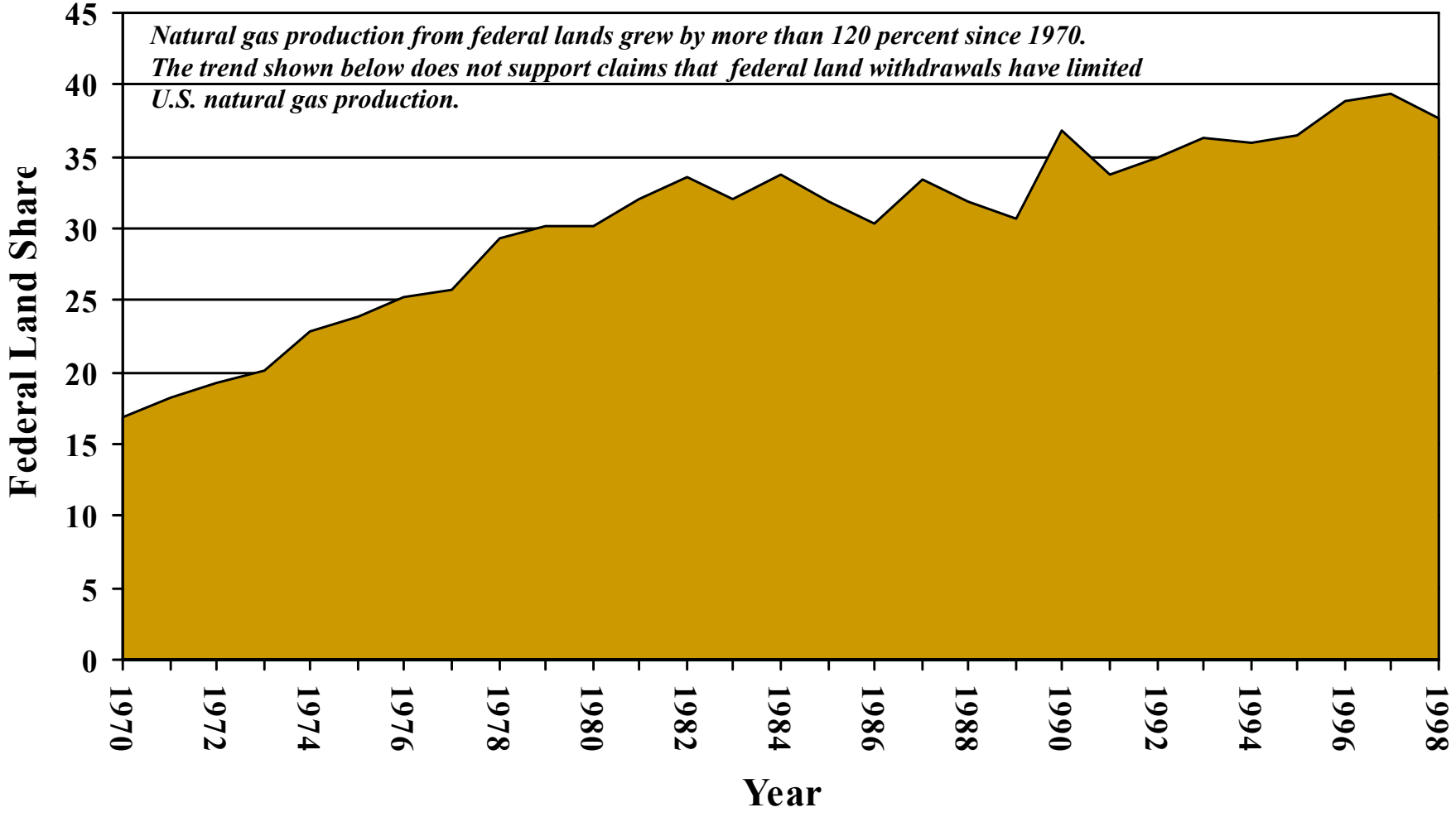
Federal Land Share of U.S. Oil Production



Source: Energy Information Administration, 2001, Online Energy Statistics.

Produced by Lookout Mountain Analysis for the The Wilderness Society, July 2001.

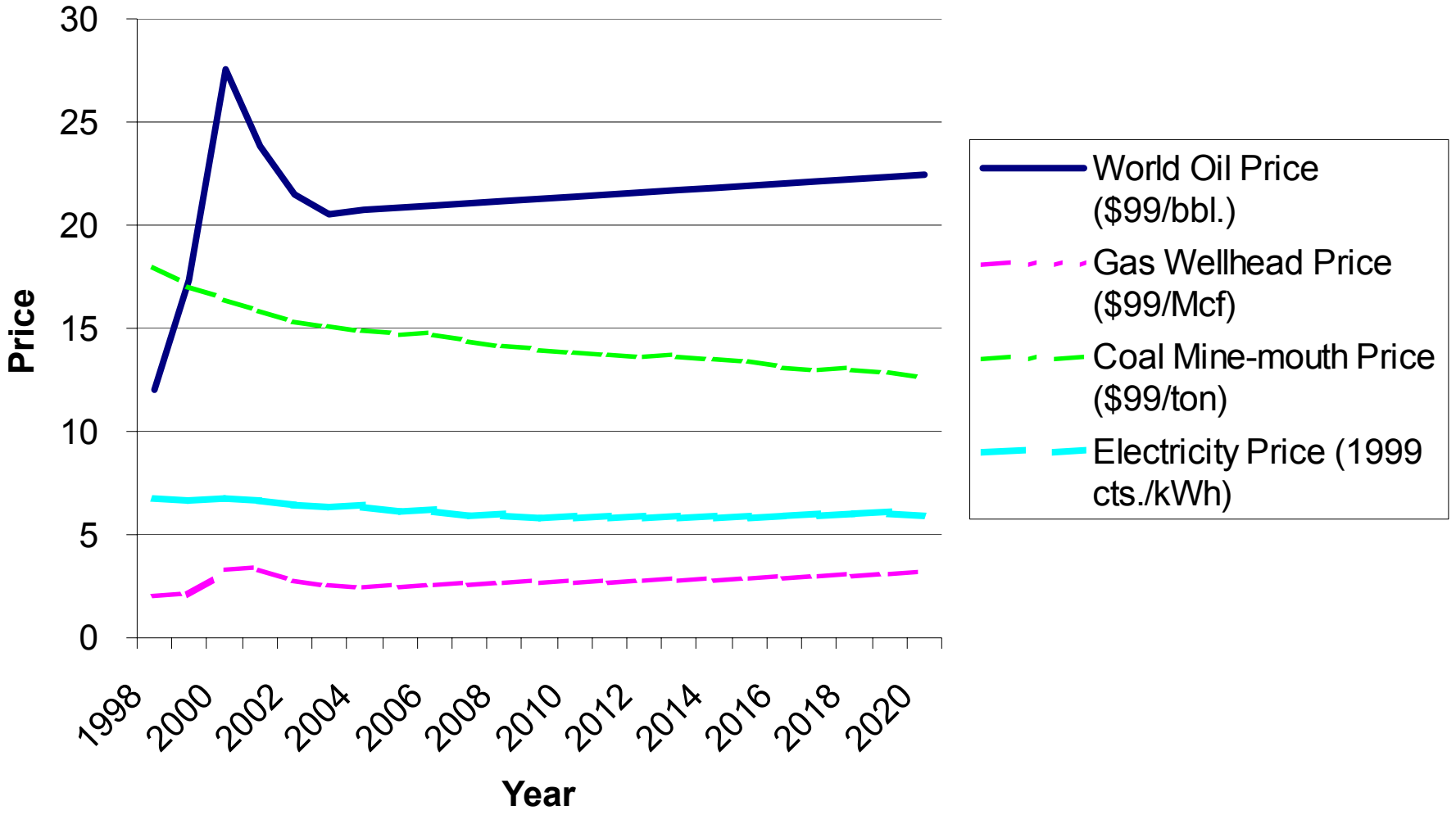
Federal Land Share of U.S. Natural Gas Production



Source: Energy Information Administration, 2001, Online Energy Statistics.

Produced by Lookout Mountain Analysis for the The Wilderness Society, July 2001.

EIA-Projected Energy Prices

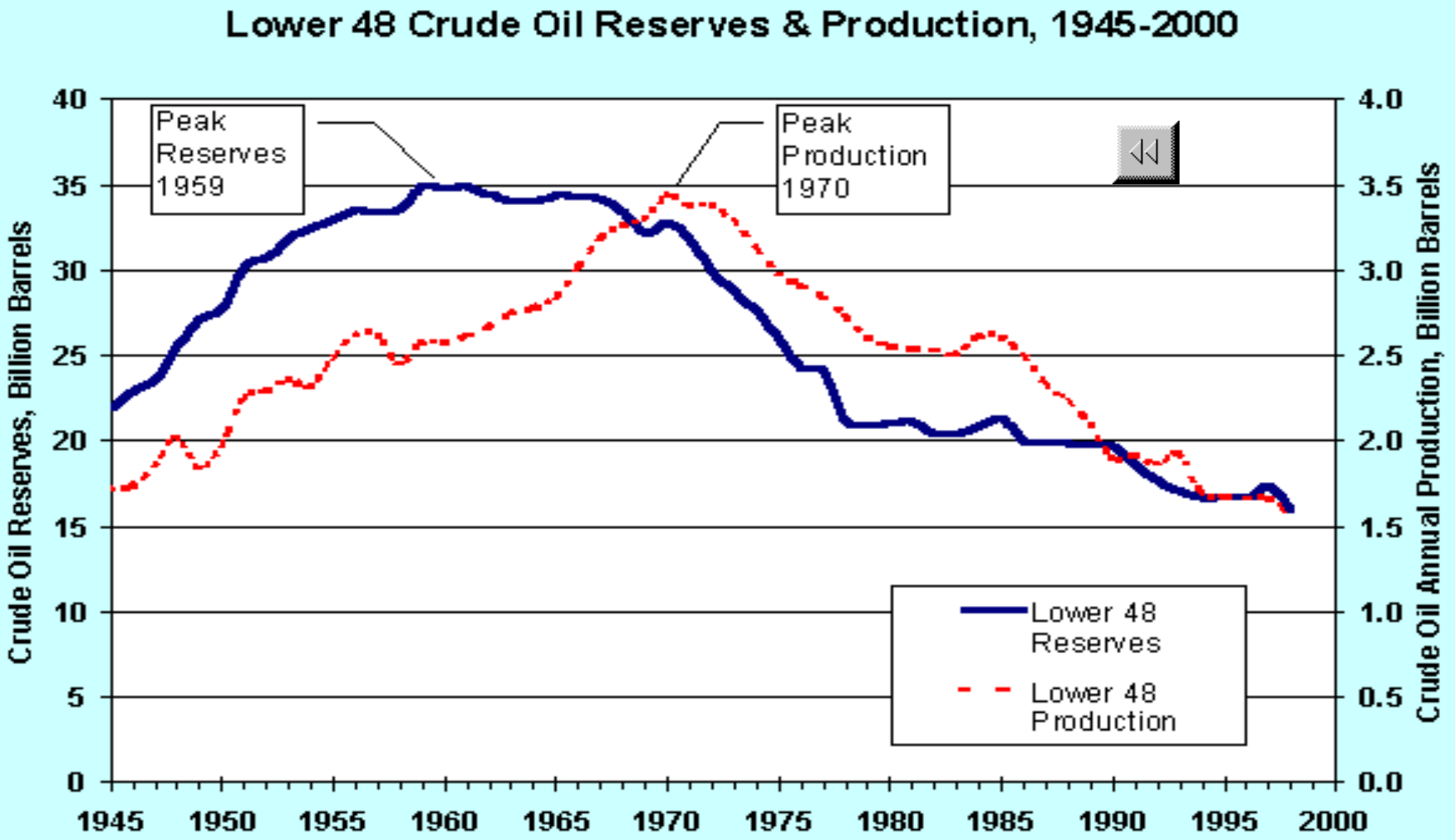


Source: DOE/EIA, 2001, Annual Energy Outlook, 2001.

Potential Oil Exhaustion
- M. King Hubbert predictions (1956)

- Hubbert predicted in 1956 that U.S. oil production would peak in 1970 (assuming a cumulative production of 200 billion barrels) or 1965 (assuming cumulative production of 150 billion barrels)
- He also predicted that U.S. reserves of oil would peak before production peaked

M. King Hubbert Analysis of U.S. Oil Reserves and Production (1956)



Source: Reported in EIA, 2000, EIA Administrator Jay Hakes presentation to April 18, 2000 meeting of American Association of Petroleum Geologists (AAPG).

Potential Oil Exhaustion

- Hubbert apparently accurately predicted U.S. reserve and production peaks
- Can the M. King Hubbert analysis be extended to estimate when worldwide oil will be “exhausted”?
- Should the Hubbert analysis be extended?

Table 1. World level summary of petroleum estimates for undiscovered conventional petroleum and reserve growth for oil, gas, and natural gas liquids (NGL).

[BBOE, billions of barrels of oil equivalent. Six thousand cubic feet of gas equals one barrel of oil equivalent. F95 represents a 95 percent chance of at least the amount tabulated. Other fractiles are defined similarly. Production and reserves normalized to 1/1/96. Shading indicates not applicable]

	Oil				Gas					NGL			
	Billion Barrels				Trillion Cubic Feet				BBOE	Billion Barrels			
	F95	F50	F5	Mean	F95	F50	F5	Mean	Mean	F95	F50	F5	Mean
World (excluding United States)													
Undiscovered conventional	334	607	1,107	649	2,299	4,333	8,174	4,669	778	95	189	378	207
Reserve growth (conventional)	192	612	1,031	612	1,049	3,305	5,543	3,305	551	13	42	71	42
Remaining reserves*				859				4,621	770				68
Cumulative production*				539				898	150				7
Total				2,659				13,493	2,249				324
United States													
Undiscovered conventional**	66		104	83	393		698	527	88	Combined with oil			
Reserve growth (conventional)**				76				355	59	Combined with oil			
Remaining reserves				32				172	29	Combined with oil			
Cumulative production				171				854	142	Combined with oil			
Total				362				1,908	318				
World Total (including United States)				3,021				15,401	2,567				

*World reserve and cumulative production data reflect only those parts of the world actually assessed and are from Petroconsultants (1996) and NRG Associates (1995).

**U.S. data from Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds, 1996, 1995 National assessment of United States oil and gas resources--Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS-30, release 2, one CD-ROM, and from Minerals Management Service, 1996, An assessment of the undiscovered hydrocarbon potential of the Nation's outer continental shelf: Minerals Management Service OCS Report, MMS 96-0034, 40 pages.

Potential Oil Exhaustion

- Some U.S. and European estimates give a worldwide oil production peak as early as 2004 – 2010. (e.g., Campbell, Laherrere, Scientific American, March 1998).
- USGS mean estimates for world ultimate oil resources is about 3,000 billion barrels (3 trillion barrels)
  - (this includes only conventional worldwide oil resource estimates—not potential substitutes such as heavy oil, tar sands, shale oil, many other “unconventional” energy resources)

Potential Oil Exhaustion

- Elements that impact timing and shape of production peak
  - oil prices
  - new extraction technologies
  - new end-use technologies
  - significant changes in the resource base estimates (undiscovered oil)

Potential Oil Exhaustion

- Using USGS estimates of 3 trillion barrels, the EIA base estimate is for worldwide oil production to peak in 2037.
- But EIA alternative scenarios shows peaks potentially occurring from 2026 to 2050, depending on crucial assumptions.
- This analysis becomes a curve-fitting exercise without looking at underlying implicit assumptions

Rebuttal to M. King Hubbert Oil Exhaustion Argument

- Oil will never be physically "exhausted" – i.e., the world will always have some barrels of oil that remain unproduced
- The crucial concept is actually "economic exhaustion"
  - as oil becomes more scarce, the cost (and therefore the price) of oil increases

Rebuttal to M. King Hubbert Oil Exhaustion Argument

- As oil prices increase the incentive for conserving oil increases (each saved barrel is worth more)
- As oil prices increase, oil “substitutes” that are currently more expensive than oil will ulitmately become price competetive
- The combination of decreased demand and increased supply of “oil-substitute” will ensure that the physical supply of oil will never be exhausted

Rebuttal to M. King Hubbert Oil Exhaustion Argument

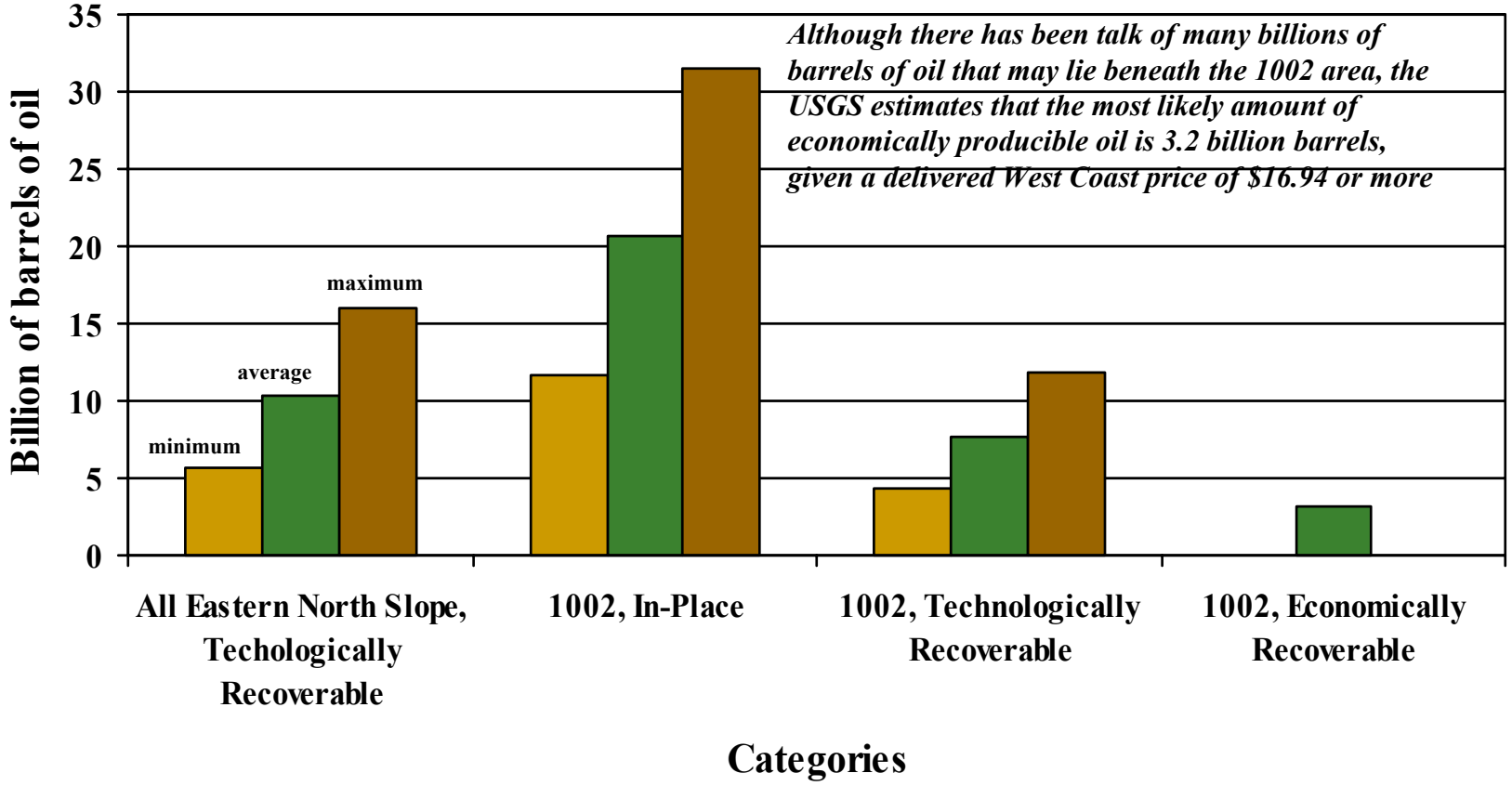
- Potential oil substitutes include (at least)
  - unconventional sources: heavy oil, tar sands, shale oil, coal gasification, coal liquifaction
  - alternative sources: solar, wind, hydropower, hydrogen fuel cells, others

Rebuttal to M. King Hubbert Oil Exhaustion Argument

- Conclusion
  - As oil becomes more expensive due to increasing scarcity it will affect both Supply and Demand
    - Demand-side: more use of fuel-efficient technologies, substitutes for primary oil-using technologies--will decrease oil demand
    - Supply-side: cheaper oil extraction technologies, use other unconventional and alternative fuels—will increase oil-substitute supply

Figure 1

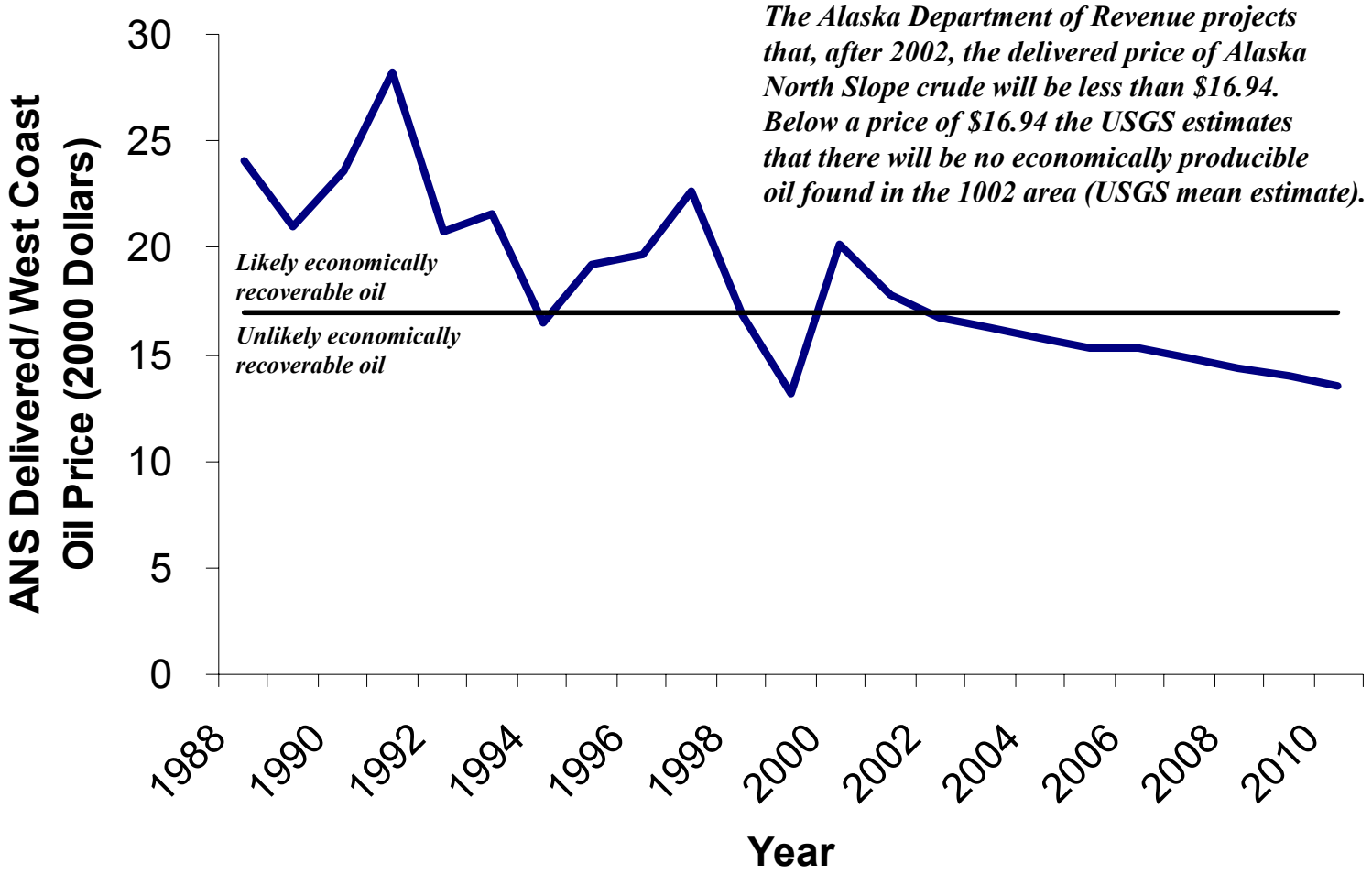
Recent USGS Oil Resources Estimates of the Eastern North Slope of Alaska



Source: USGS, 1999, The Oil and Gas Resource Potential of the Arctic National Wildlife Refuge 1002 Area, Alaska.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000.

Alaska Deptartment of Revenue Oil Price Historical and Projections

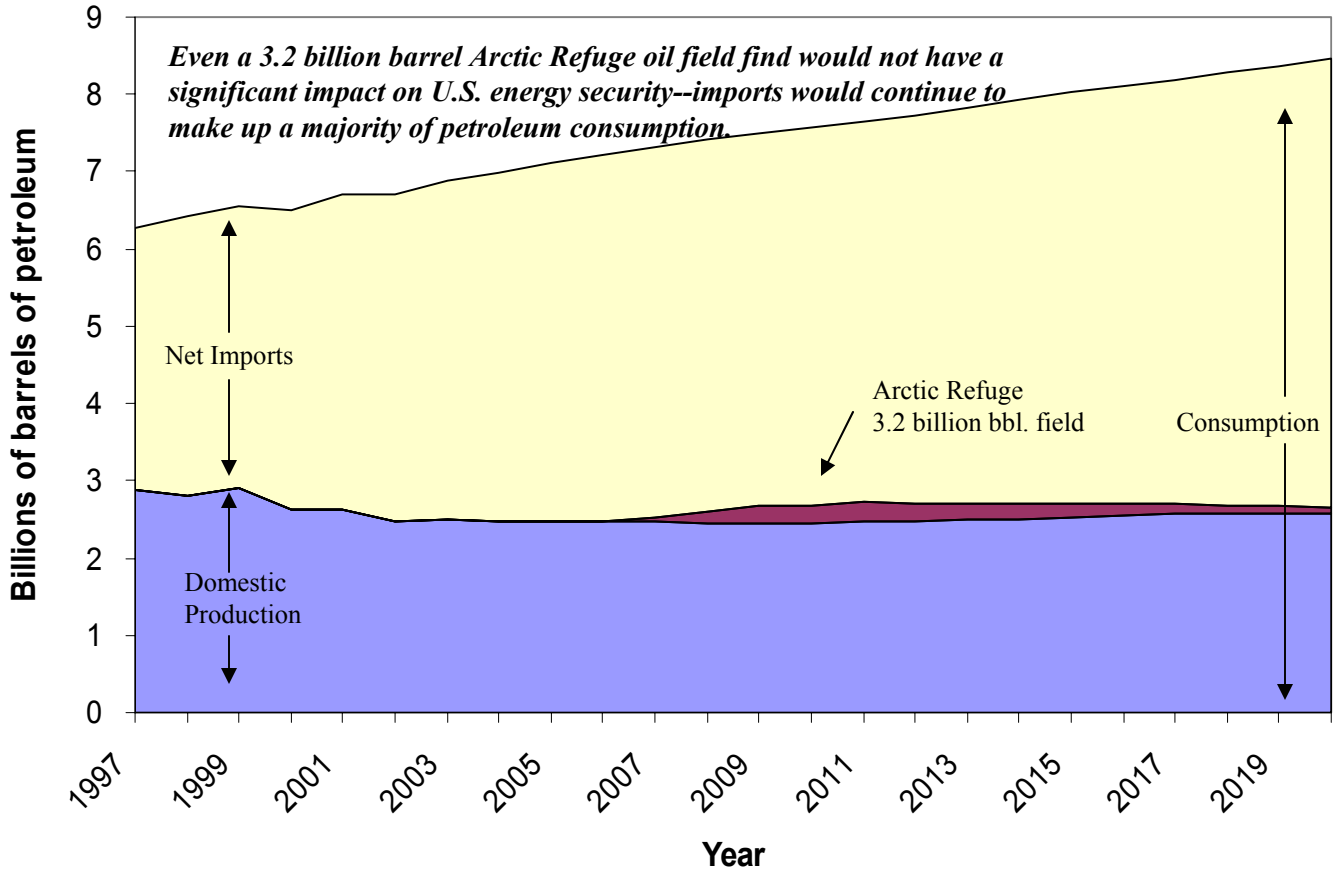


Sources: USGS, 1999, The Oil and Gas Resource Potential of the Arctic National Wildlife Refuge 1002 Area, Alaska, and State of Alaska Fall 1999 Revenue Sources Book, p. 18, as obtained from their website.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000.

Figure 3

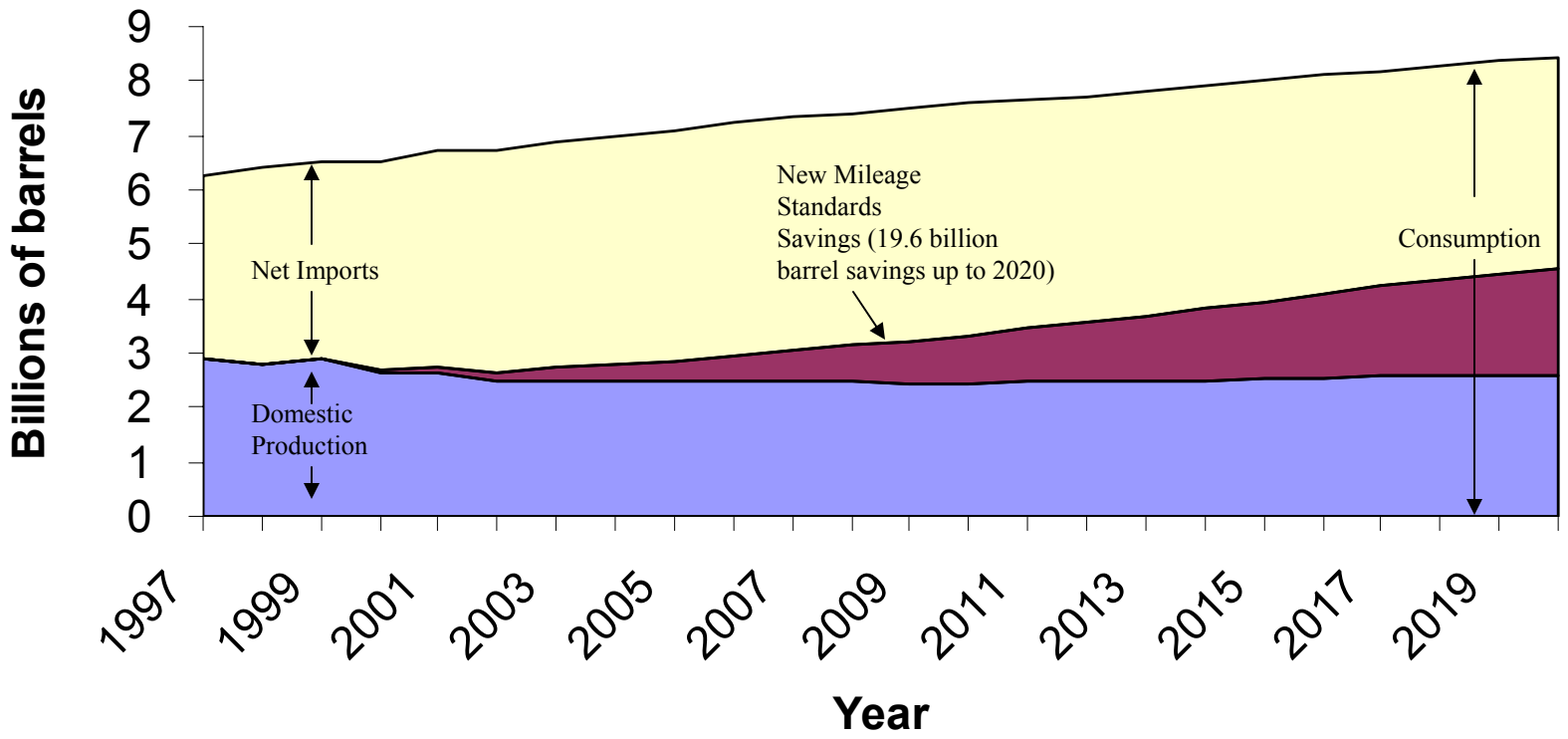
Arctic Refuge Energy Security



Sources: U.S. DOE, EIA, 2000, *Annual Energy Outlook 2000*, (historical and projected consumption, domestic production, and net imports), EIA, 1987, *Potential Oil Production from the Coastal Plain of the Arctic National Wildlife Refuge,* (annual production profiles, lease/exploration/development/production timing, and oil field decline curves).

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, April 2000.

U.S. Petroleum Energy Balance with Enhanced Mileage Standards

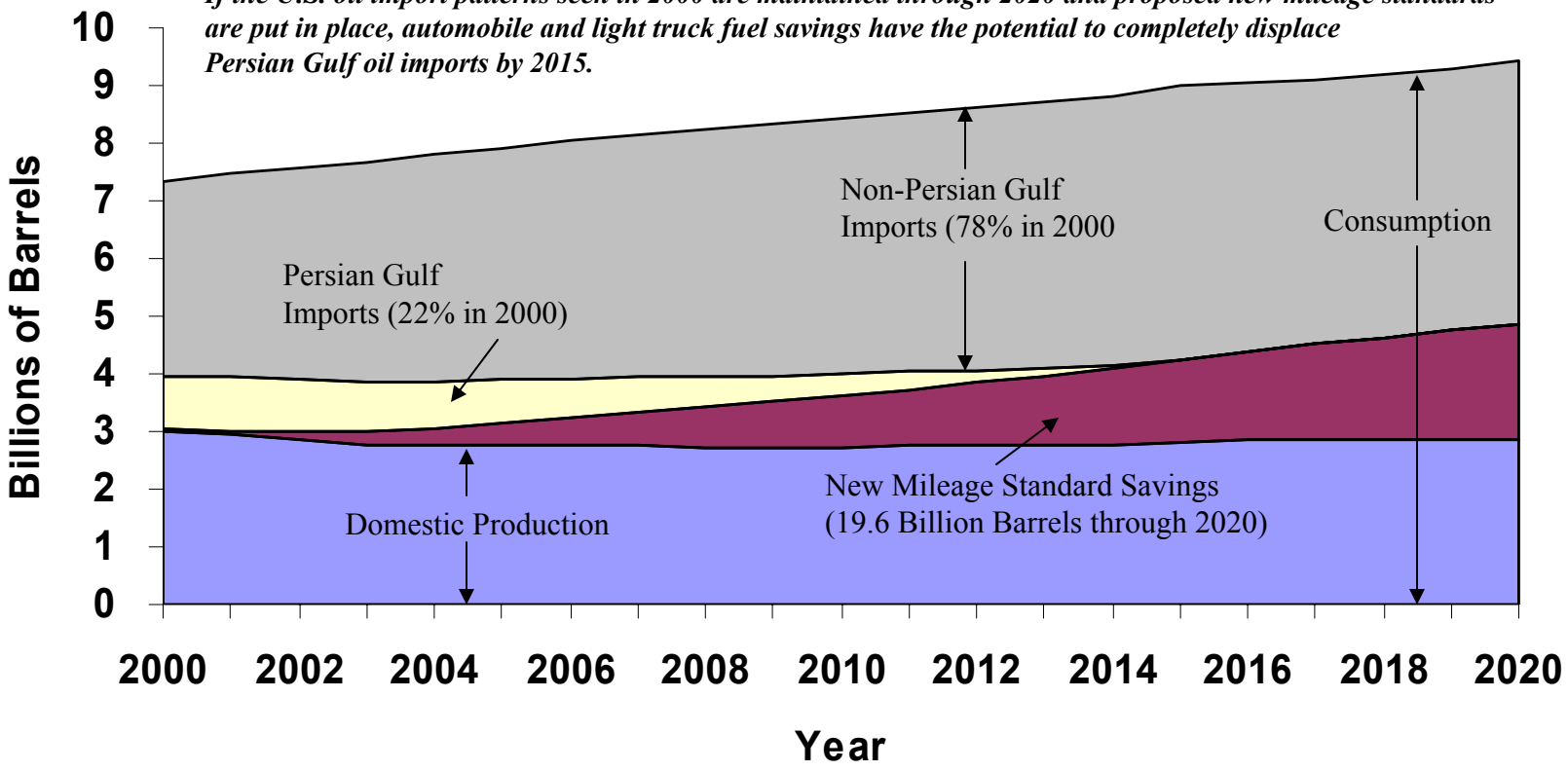


Sources: U.S. Department of Energy (DOE) / Energy Information Administration (EIA), 2000, *Annual Energy Outlook 2000*, (historical and projected consumption, domestic production, and net imports), Lookout Mountain Analysis (LMA) and U.S. DOE/EIA, 2000, *Annual Energy Outlook 2000*, crude oil savings estimate from the 2000 Technology scenario compared with an LMA analysis assuming 3 percent annual improvement in mileage standards beginning in 2000 and culminating in 53 mpg and 39 mpg standards for cars and light trucks in 2020.

Produced by Lookout Mountain Analysis for the World Wildlife Fund, September 2001.

U.S. Petroleum Energy Balance With Enhanced Mileage Standards

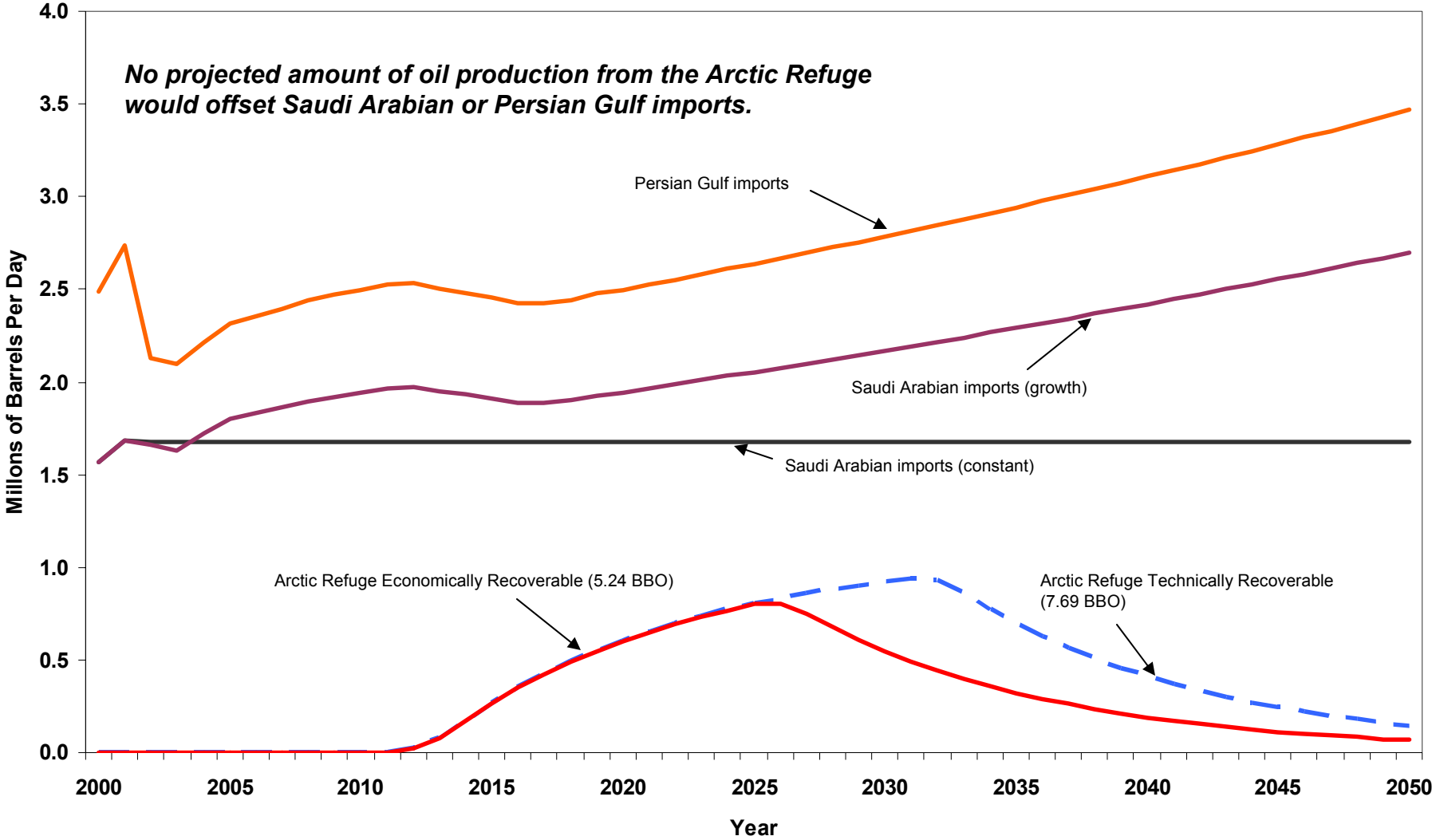
If the U.S. oil import patterns seen in 2000 are maintained through 2020 and proposed new mileage standards are put in place, automobile and light truck fuel savings have the potential to completely displace Persian Gulf oil imports by 2015.



Sources: U.S. Department of Energy (DOE) / Energy Information Administration (EIA), 2000, *Annual Energy Outlook 2000*, (projected consumption, domestic production, and net imports), Lookout Mountain Analysis (LMA) and U.S. DOE/EIA, 2000, *Annual Energy Outlook 2000*, crude oil savings estimate from the 2000 Technology scenario compared with an LMA analysis assuming 3 percent annual improvement in mileage standards beginning in 2000 and culminating in 53 mpg and 39 mpg standards for cars and light trucks in 2020.

Produced by Lookout Mountain Analysis for the World Wildlife Fund, September 2001.

Potential Arctic Refuge Oil Production and Oil Imports



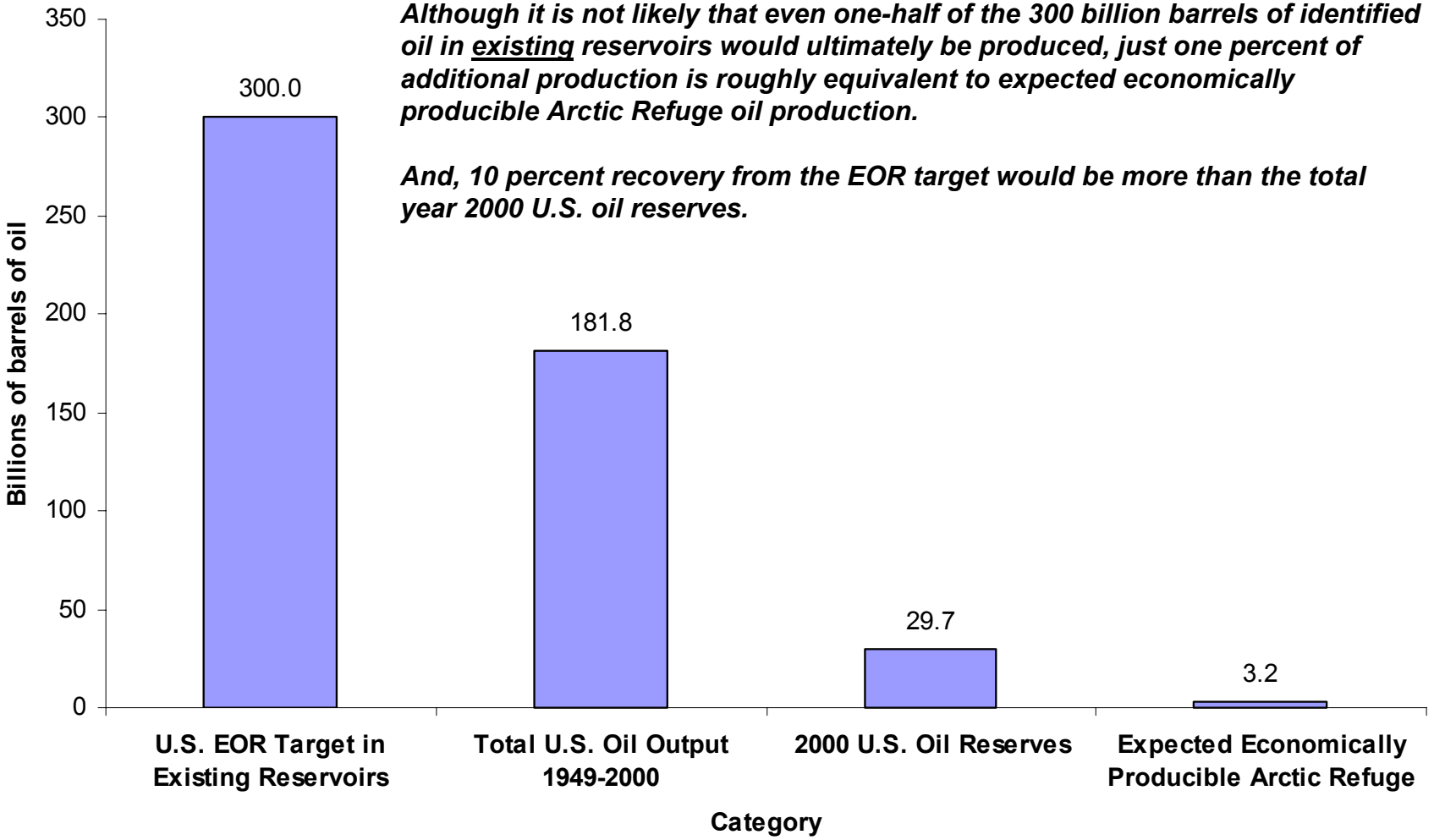
Sources: Arctic Refuge Production: CRS, technically recoverable-7.69 billion barrels, economically recoverable ($24/barrel)-5.24 billion barrels, Saudi Arabian imports, EIA, 2002, Annual Energy Outlook 2020, import projections from 2020 – 2050 at rate of growth for 19999-2020. Arctic Refuge annual production pattern and assumptions patterned after EIA, 2001, Potential Oil Production from the Coastal Plain of the Arctic National Wildlife Refuge: Updated Assessment.

Produced by Lookout Mountain Analysis, March 2002

Potential Sources of Domestic U.S. Oil

Although it is not likely that even one-half of the 300 billion barrels of identified oil in existing reservoirs would ultimately be produced, just one percent of additional production is roughly equivalent to expected economically producible Arctic Refuge oil production.

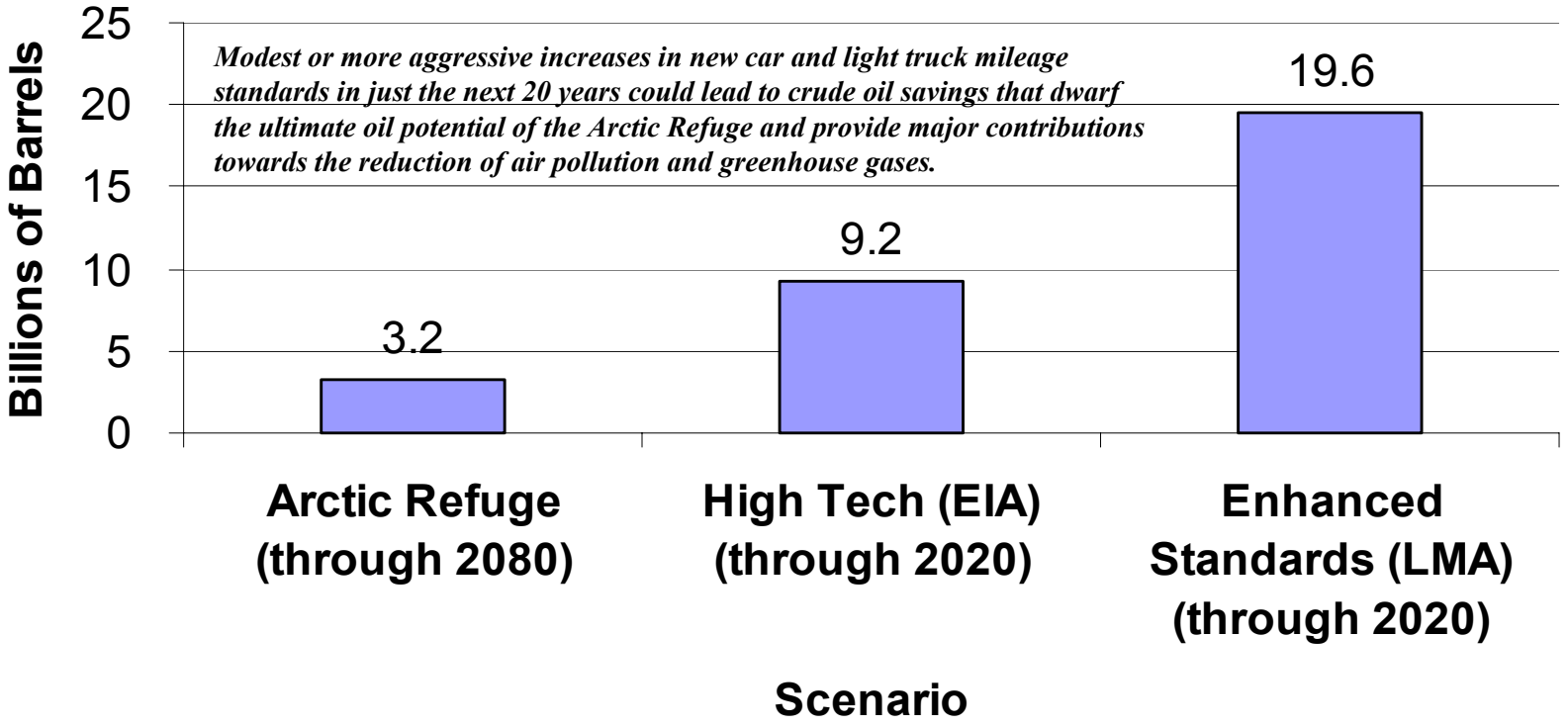
And, 10 percent recovery from the EOR target would be more than the total year 2000 U.S. oil reserves.



Sources: EOR Target: DOE, 1987, Energy Security: A Report to the President of the U.S., p. 91. U.S. Oil Output, 1949-2000: derived from EIA, 2001, Annual Energy Review, Table 5.1, Petroleum Overview. 2000 U.S. Oil Reserves: BP, June 2001, BP Statistical Review of World Energy, p. 4. Expected Economically Producible Arctic Refuge Oil Production, USGS, 1999, The Oil and Gas Resource Potential of the Arctic National Wildlife Refuge 1002 Area, Alaska.

Prepared by Lookout Mountain Analysis for Alaska Wilderness Coalition

Arctic Refuge Oil Production Versus New Automotive Mileage Standards



Sources: USGS, 1998, estimate of total economically recoverable oil from the Arctic National Wildlife Refuge, Alaska, U.S. DOE, EIA, 2000, *Annual Energy Outlook 2000*, crude oil savings estimate from High Technology scenario compared with 2000 Technology scenario through 2020, Lookout Mountain Analysis (LMA), 2000, compared with the EIA 2000 Technology scenario, assuming 3 percent annual improvement in mileage standards beginning in 2000 and culminating in 53 mpg and 39 mpg standards for cars and light trucks in 2020.

Produced by Lookout Mountain Analysis for the Alaska Wilderness League, June 2000.