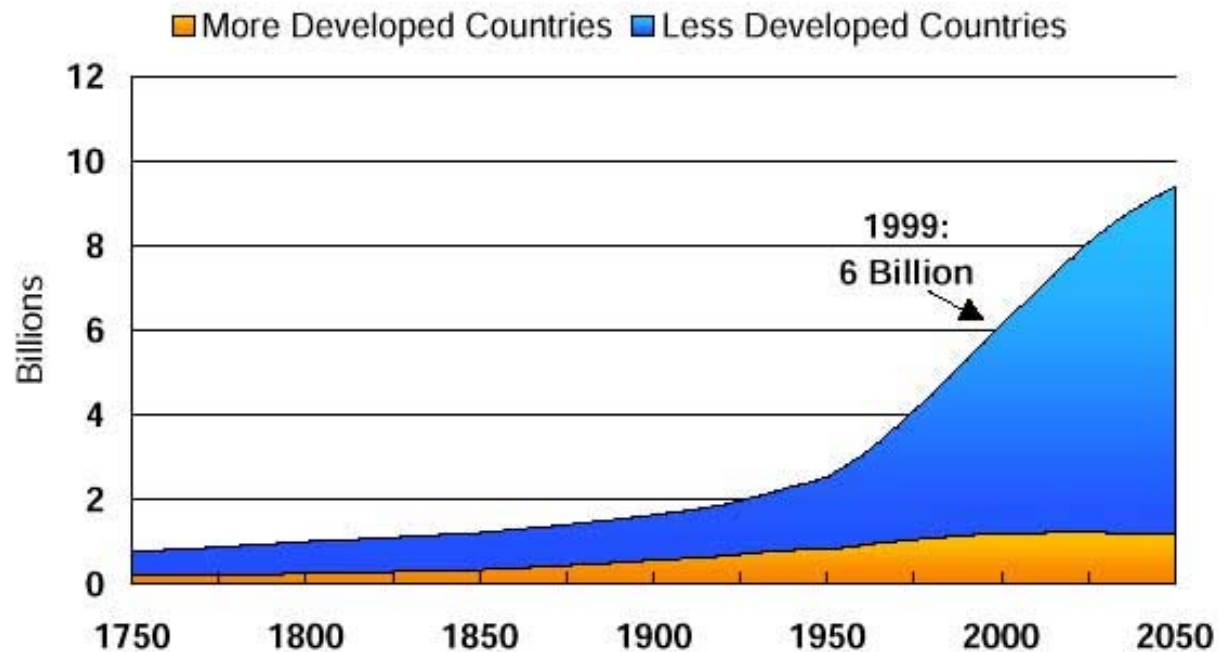


# Energy Units and Conversions

- **A BTU (British Thermal Unit) is the amount of heat necessary to raise one pound of water by 1 degree Fahrenheit (F)**
- **1 Joule (J) is a unit of energy, equal to the force of one Newton acting through one metre**
- **1 British Thermal Unit (BTU) = 1055 J**
- **1 Watt is the power from a current of 1 Ampere flowing through 1 Volt**
- **1 kilowatt = 1000 Watts**
- **1 kilowatt-hour is the energy of one kilowatt power flowing for one hour =  $3.6 \times 10^6$  J = 3.6 million Joules**
- **1 calorie of heat is the amount needed to raise 1 gram of water 1 degree Centigrade = 4.184 J**
- **1 BTU = 252 cal**
- **1 Quad = 10,000,000,000,000,000 BTU**

# World Population Growth

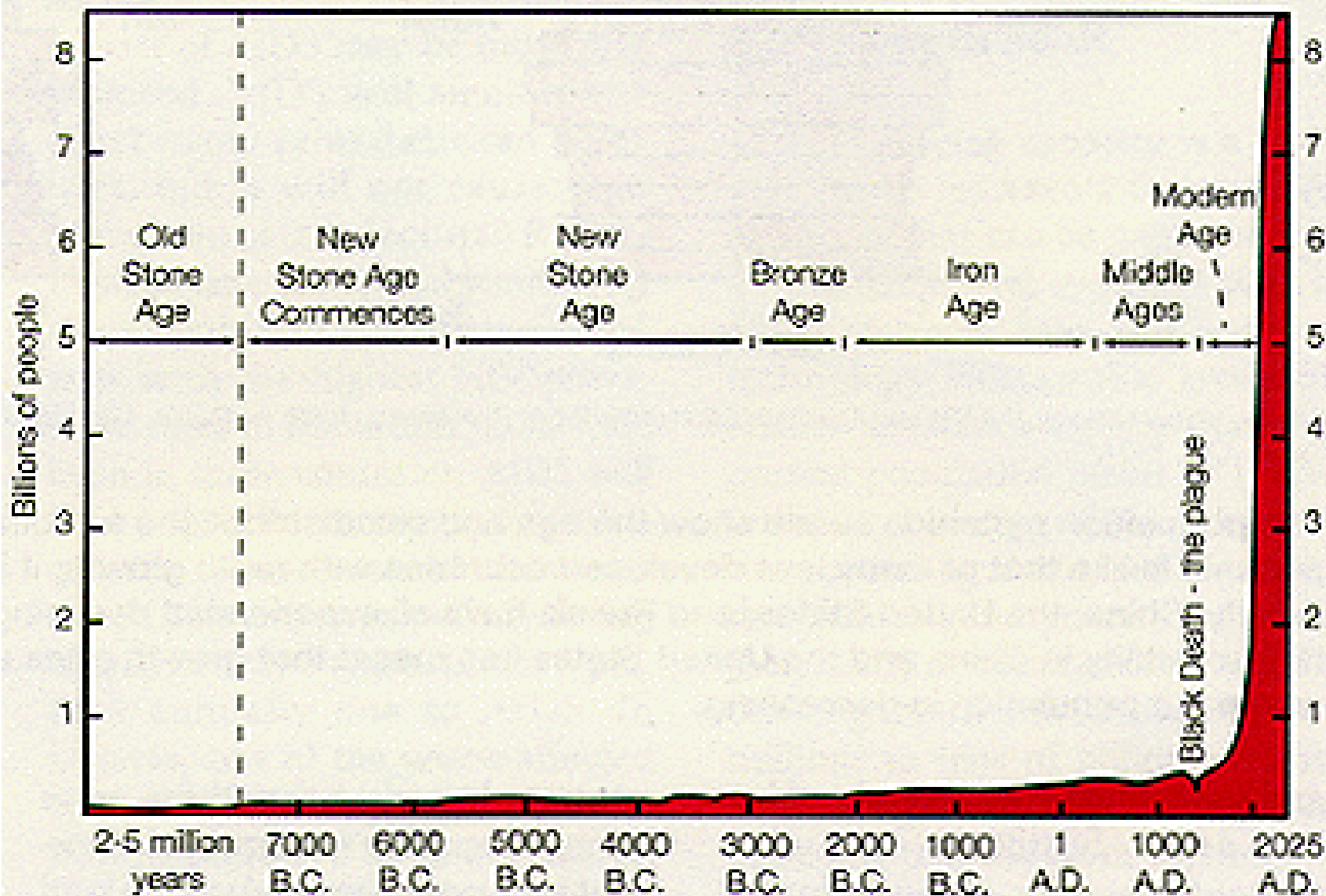
## Population growth, 1750-2050



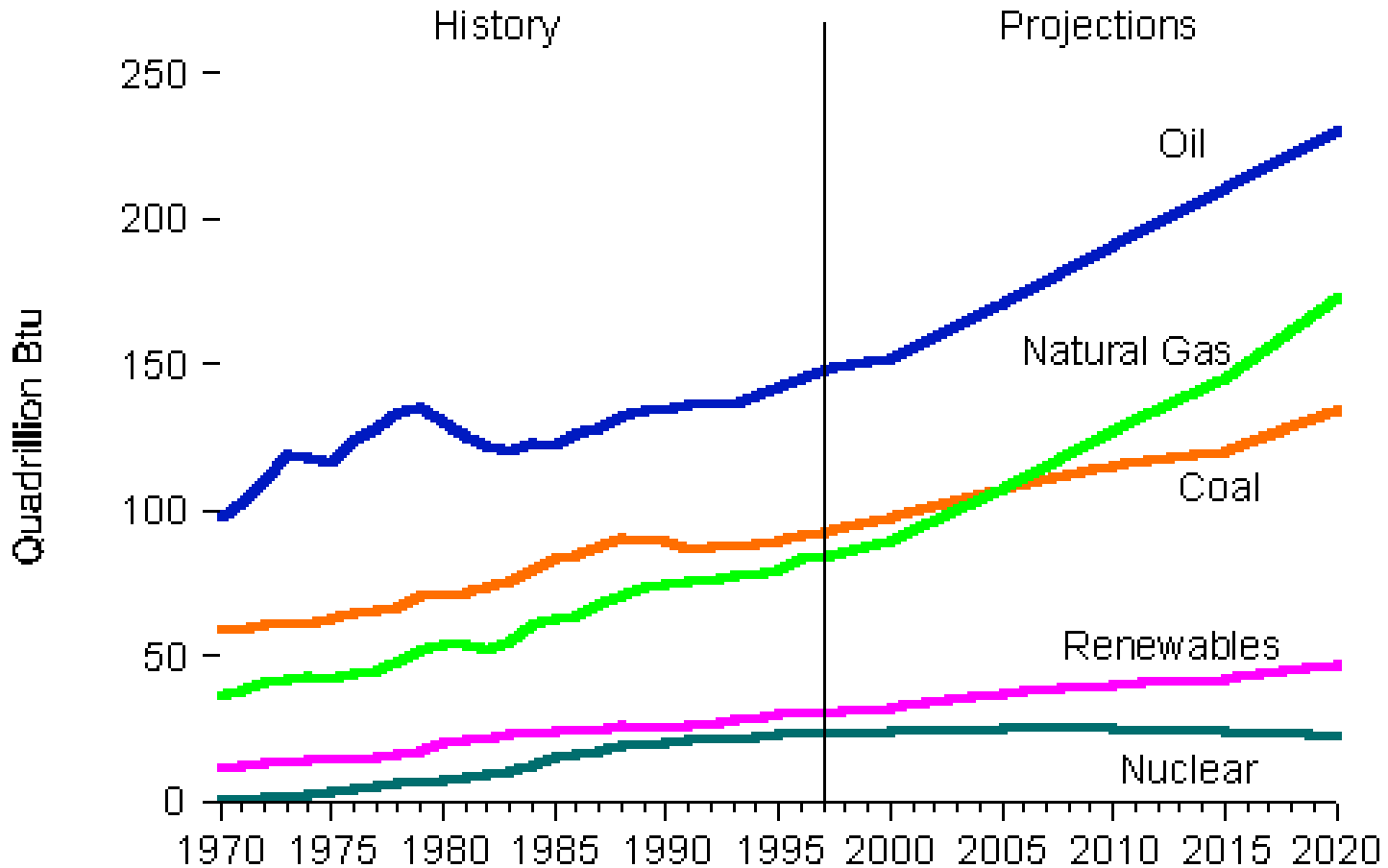
Sources: Before 1950: PRB estimates; 1950-2050: UN, *World Population Projections to 2150*, 1998 (medium scenario).



# World Population Growth Through History

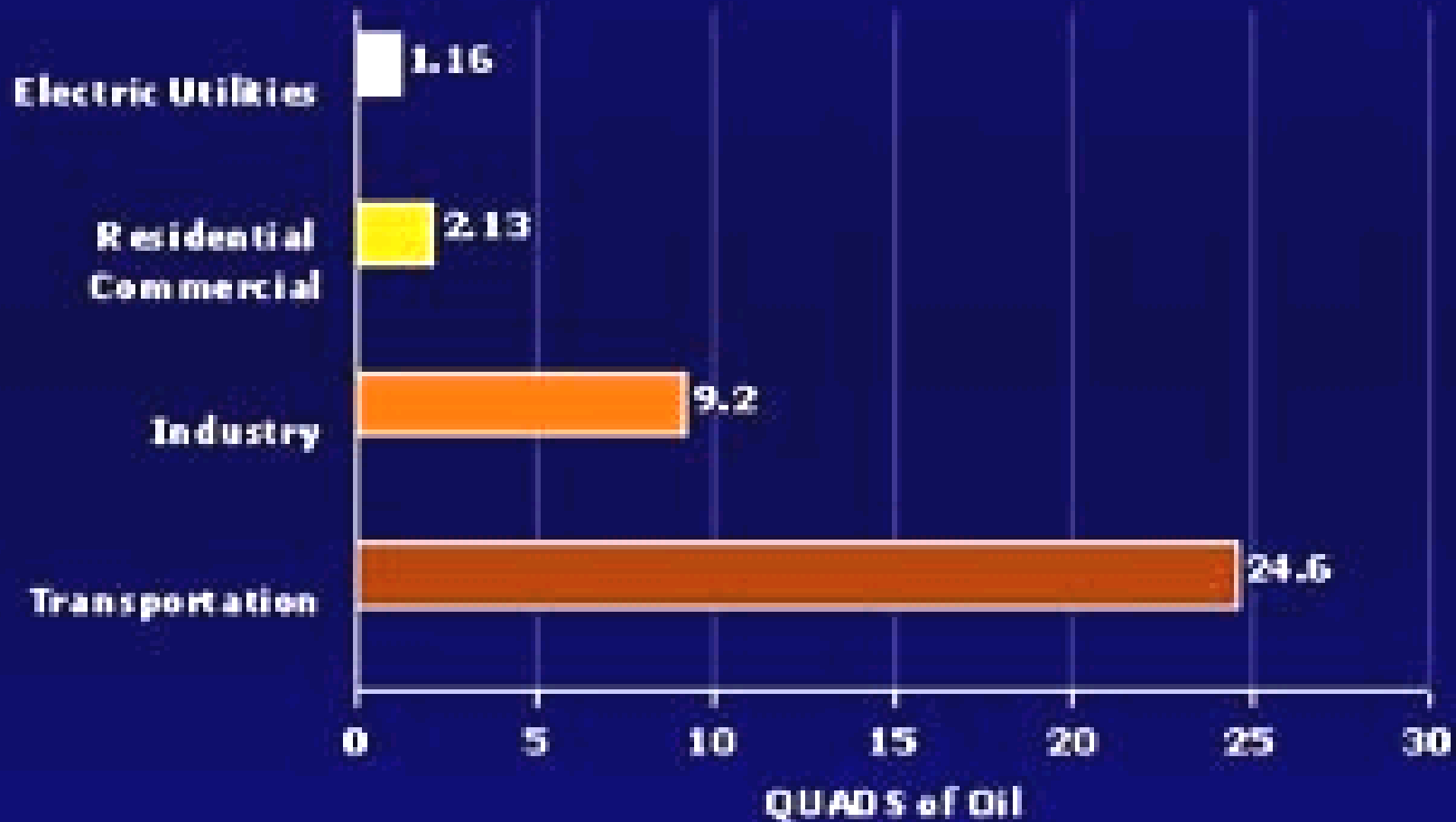


# World Energy Consumption by Fuel Type, 1970-2020

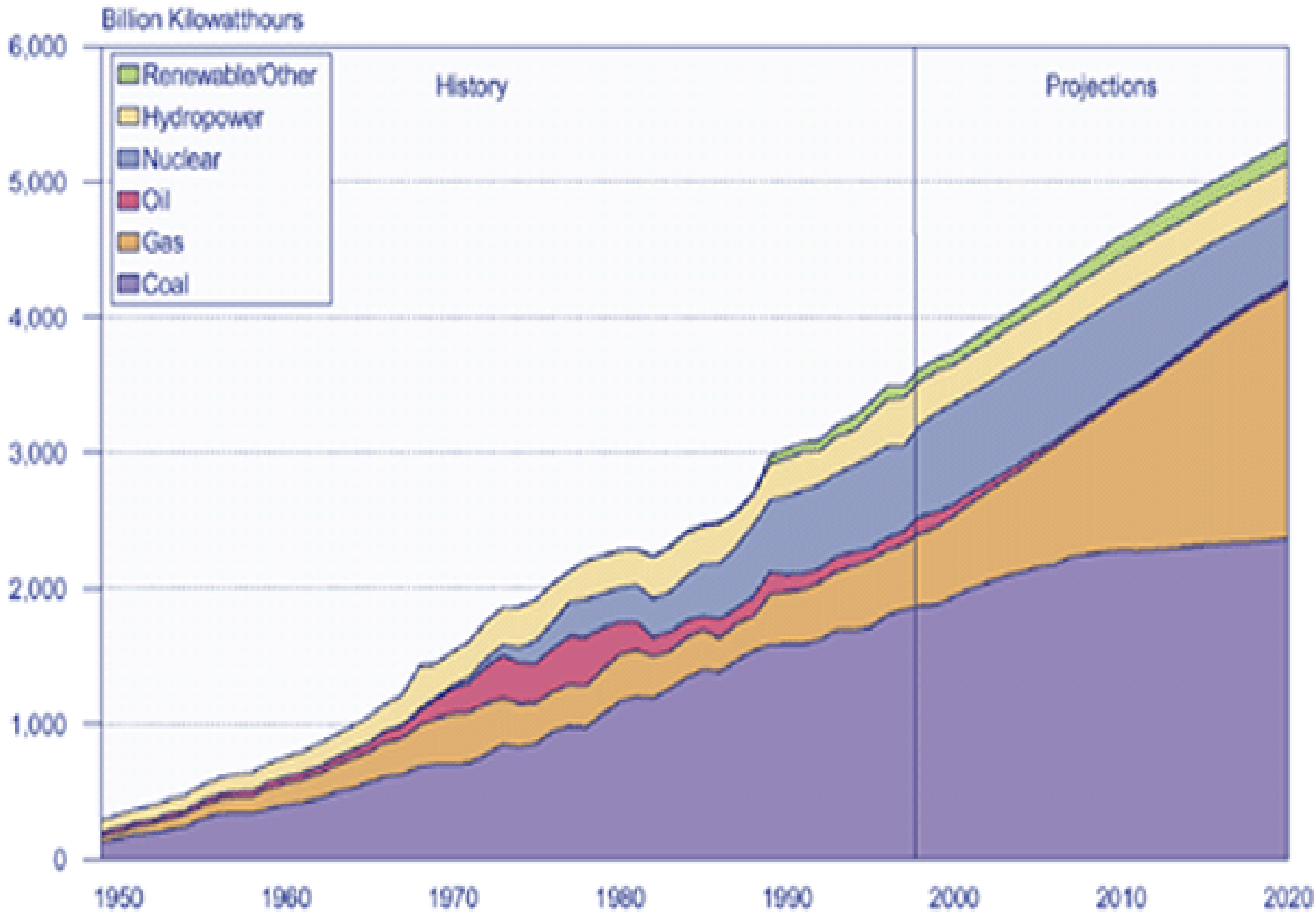


Source: EIA, International Energy Outlook 2000

# Oil Consumption by Sector (1998)



**Figure 2. Electricity Generation by Fuel, 1949-1998, and Projections for the Reference Case, 1999-2020**

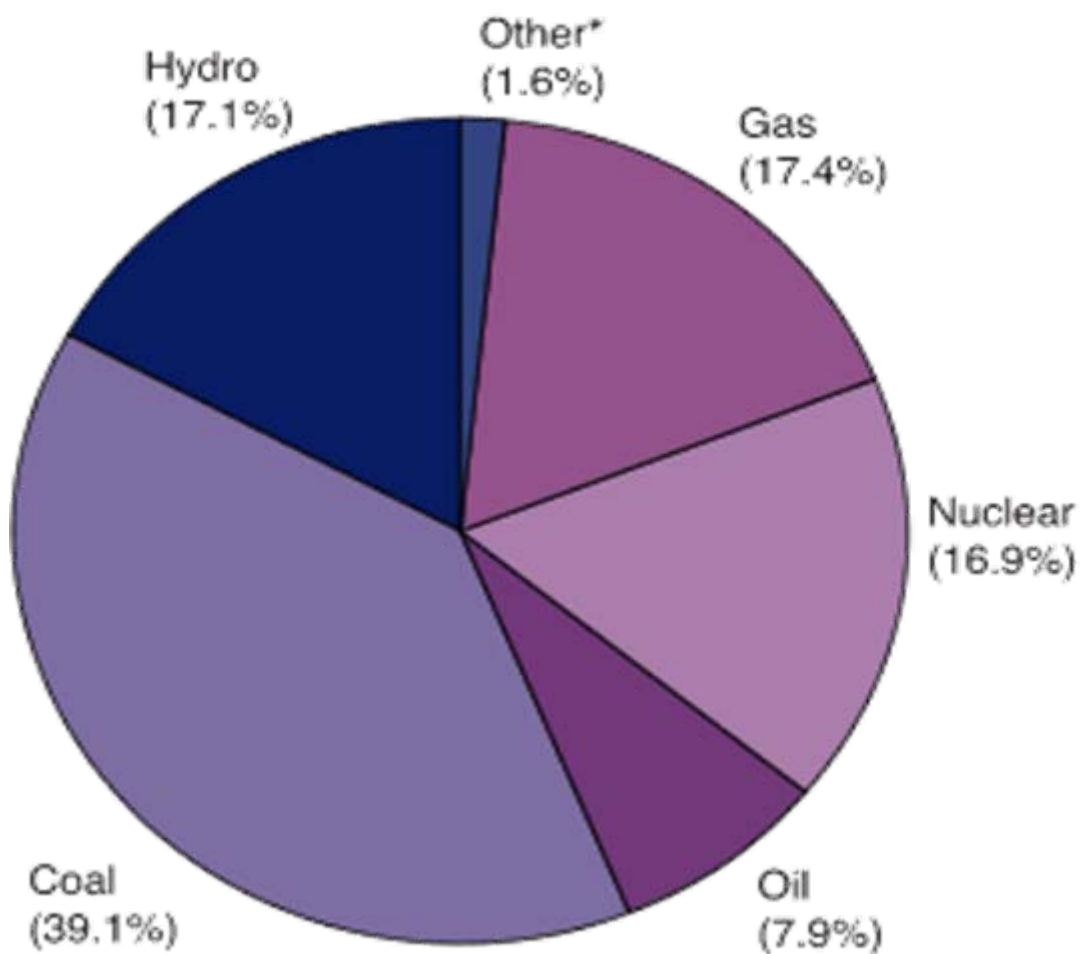


Sources: **History:** Energy Information Administration, *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000). **Projections:** National Energy Modeling System, run MCBASE.D121300A.

## Total World Electricity Generation

(% by fuel - 2000)

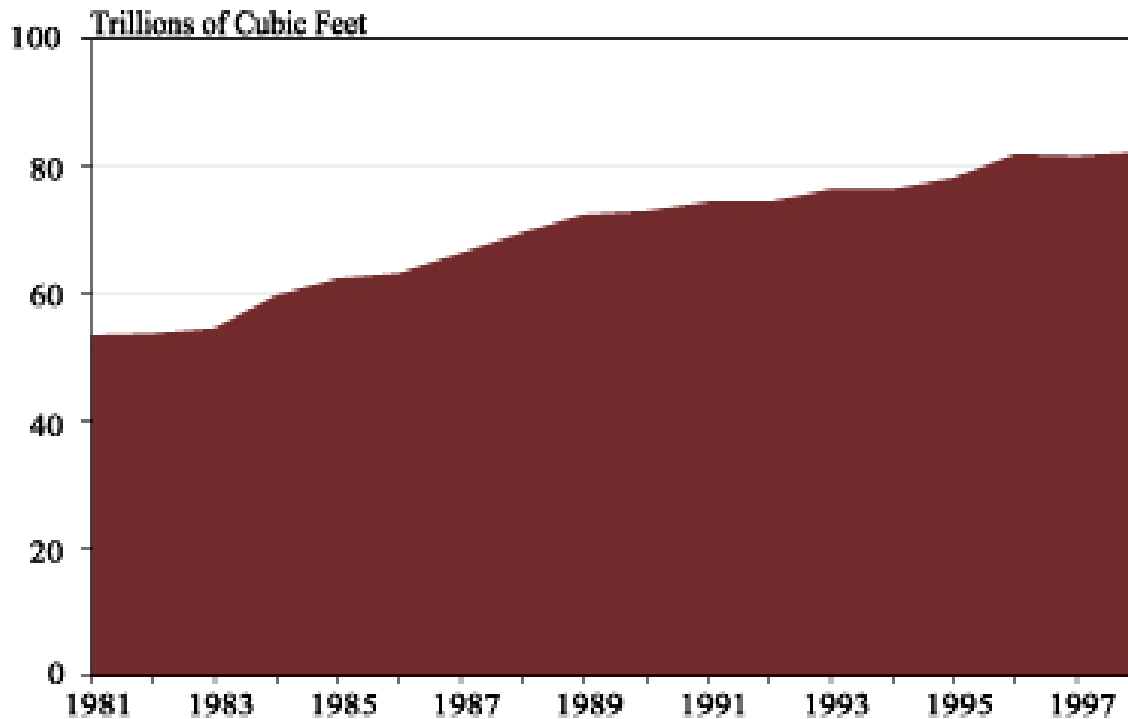
\*Other includes solar, wind, combustible renewables, geothermal and waste



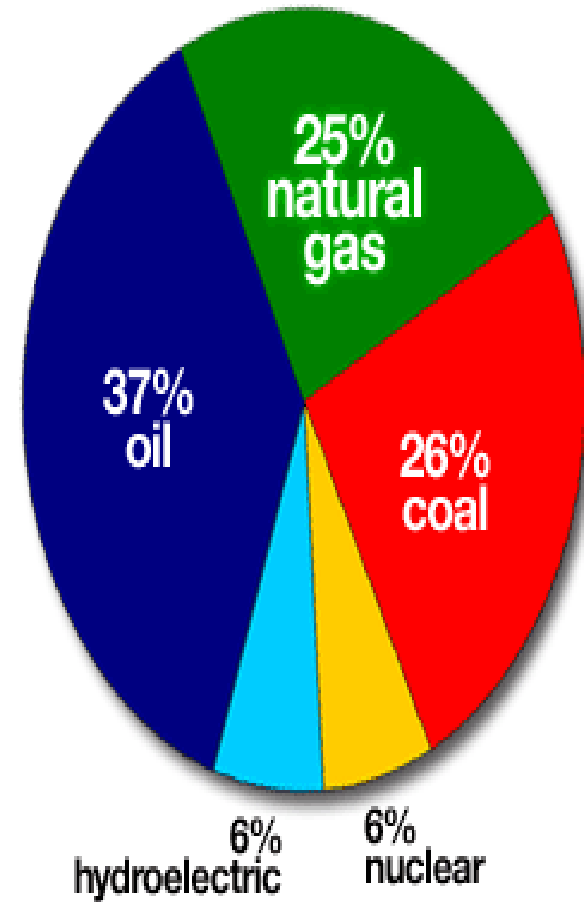
(Source - IEA Key World Energy Statistics, 2002 Edition)

# Natural Gas Consumption

## World Natural Gas Consumption



US Energy Information Administration.



# Average Consumption

- National energy consumption = directly proportional to GNP

Higher GNP → higher energy consumption

- Minimum energy needed by an individual = 2000 calories per day
- But in a technological society, average individual consumption  
~ 230,000 calories per day.

|                |        |
|----------------|--------|
| Preparing Food | 10,000 |
|----------------|--------|

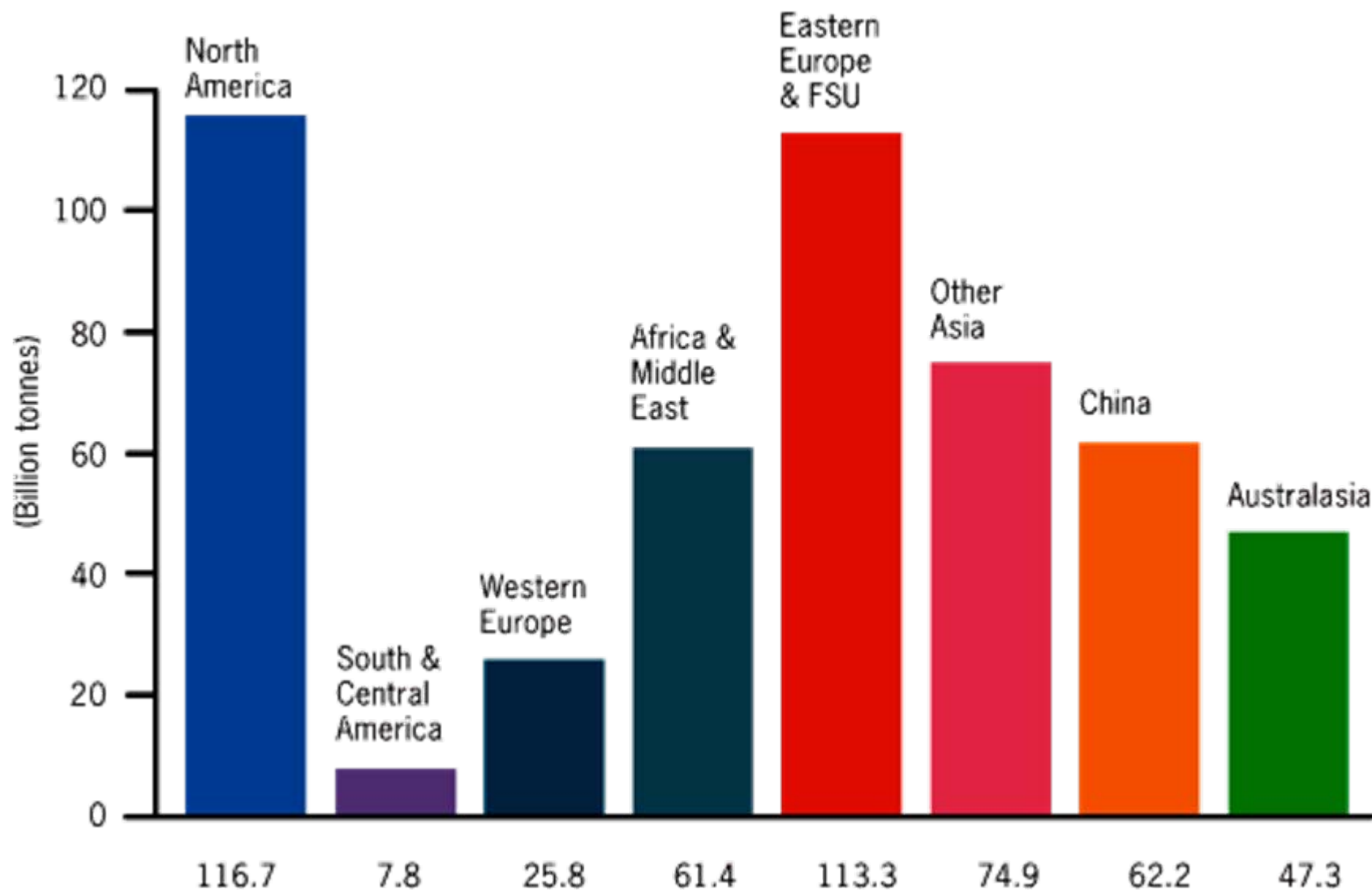
|                   |        |
|-------------------|--------|
| Home and Commerce | 66,000 |
|-------------------|--------|

|                          |        |
|--------------------------|--------|
| Industry and Agriculture | 91,000 |
|--------------------------|--------|

|                |        |
|----------------|--------|
| Transportation | 63,000 |
|----------------|--------|

# COAL RESERVES

Proved global hard coal reserves



Source: World Coal Institute

- **We will essentially use up world's**

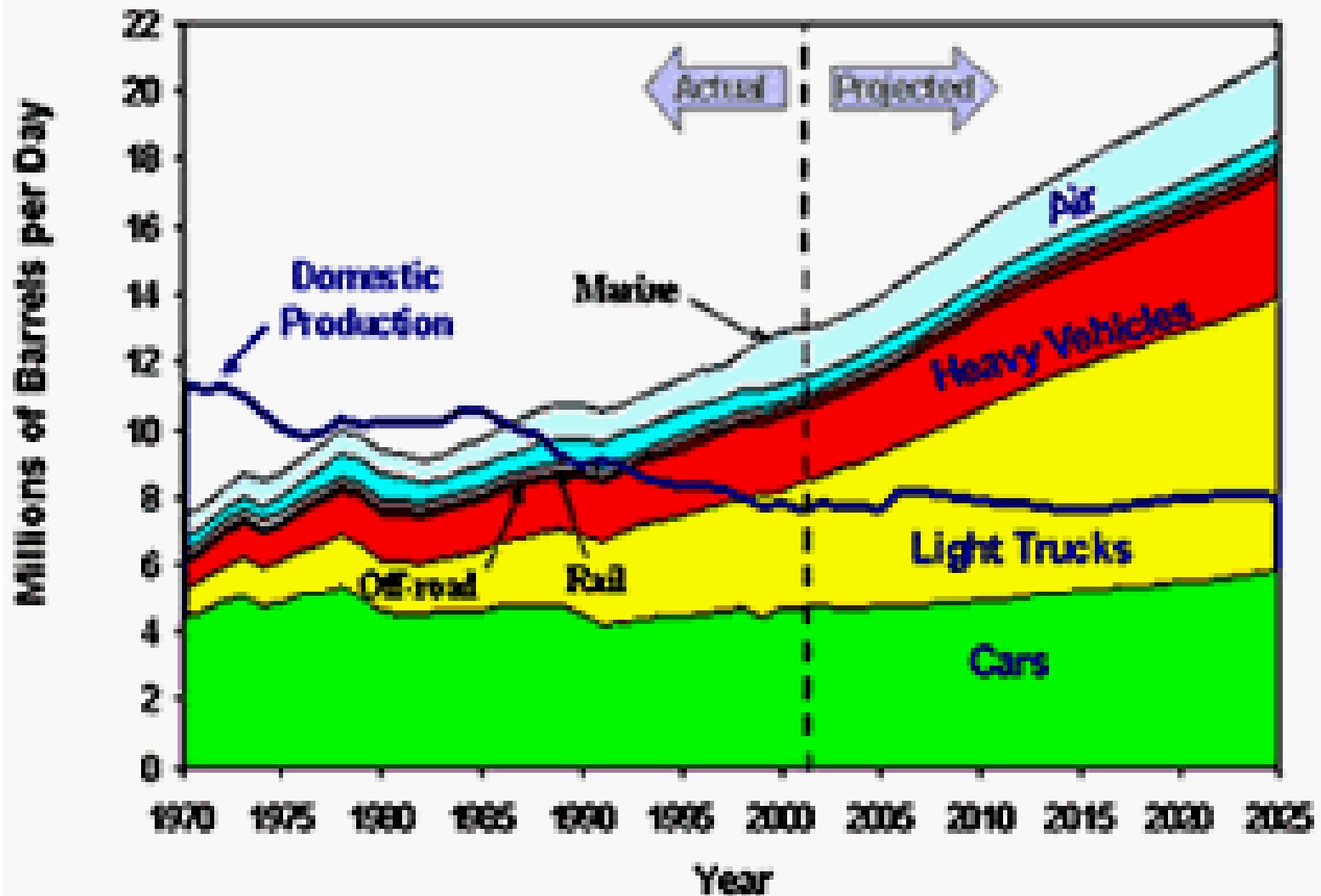
**petroleum resources:      by 2050**

**coal resources:              by 2500**

# US experience (or what not to do)

- Oil comprises 40% of total US energy use
- So far world has consumed 400 billion barrels
- Before 1950: US = major producer of oil in the world
- There are 80 billion barrels of oil resources remaining in US
- US has not been self sufficient since 1950s  
[cheaper to import oil rather than to mine remaining resources]
- US uses about 25% of world's oil, or about 6 billion barrels per year
- Alaska's North Slope contained about 10 billion barrels
- For most of 1990s US gasoline price was at or below \$1.50 per gallon *[It now stands at \$2.37 per gallon]*

# The Growing Gap in U.S. Oil Use for Transportation



Source: Transportation Energy Data Book, Edition 21, © OGDORNL, 1998, September 2001, and EIA Annual Energy Outlook 2008, January 2008

# Sustainability

- **What is a sustainable level of fossil fuel use?**
- **According to the Intergovernmental Panel on Climate Change, to stabilize carbon dioxide at twice the 1970 levels requires that we reduce carbon emissions to 2 gigatonnes/year, roughly 1/4 of the current level**
- **Such a reduction would extend the life expectancy of oil by about 250 years**
- **The current trend is clearly in the other direction**