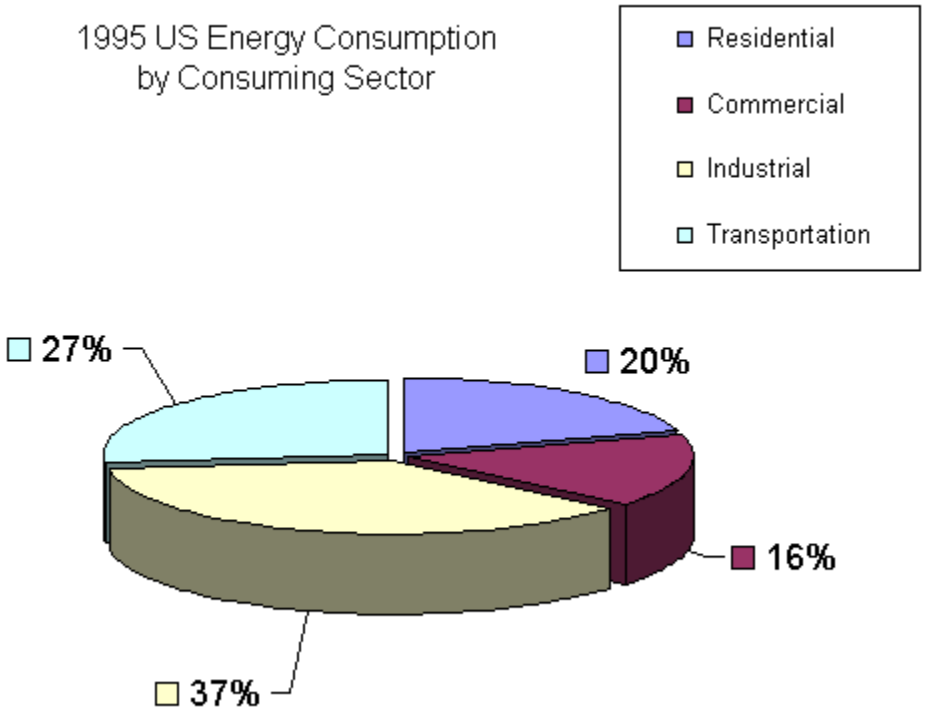
Total Energy Usage



More Recent Data by Sector

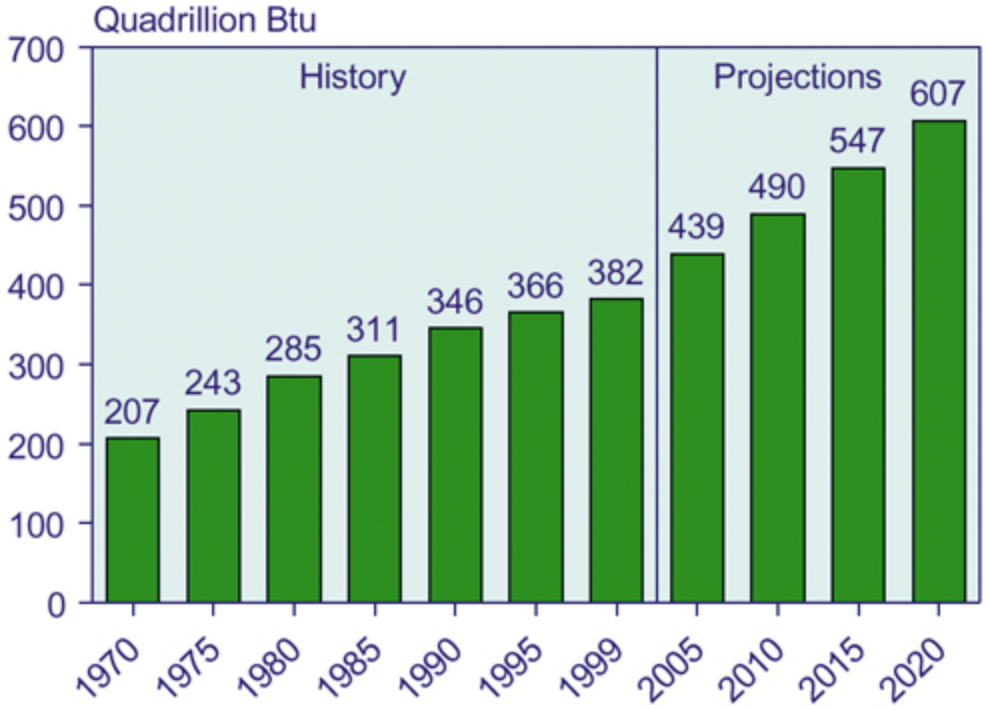
Residential Energy Use

Our total energy use can be divided into three principal areas each of which consume approximately equal amounts of energy on an annual basis:

- **Electricity Generation**
- **Space Heating**
- **Transportation**

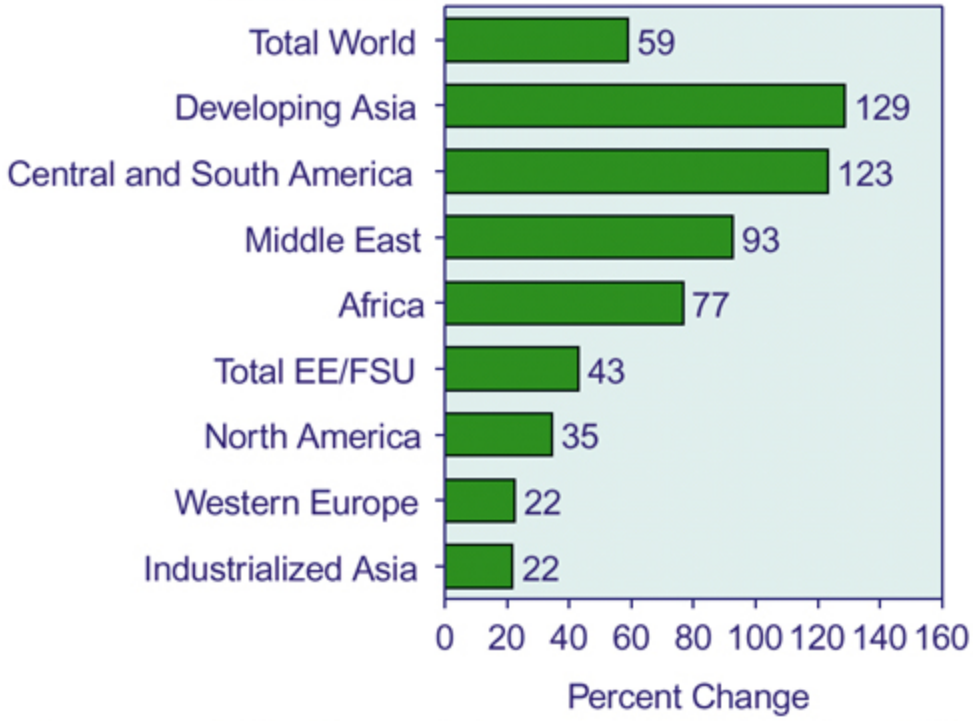
World Energy Consumption:

Figure 13. World Energy Consumption, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Figure 14. Projected Change in Energy Demand by Region, 1999-2020



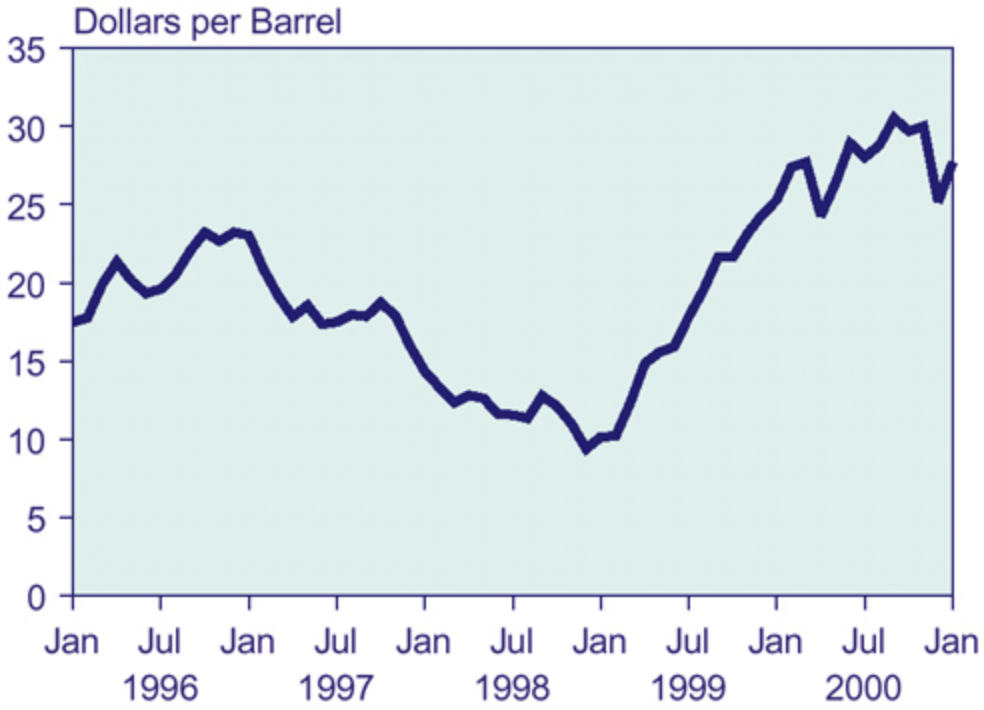
Sources: **1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

Fossil Fuels come in 3 principal forms from which many other products are derived:

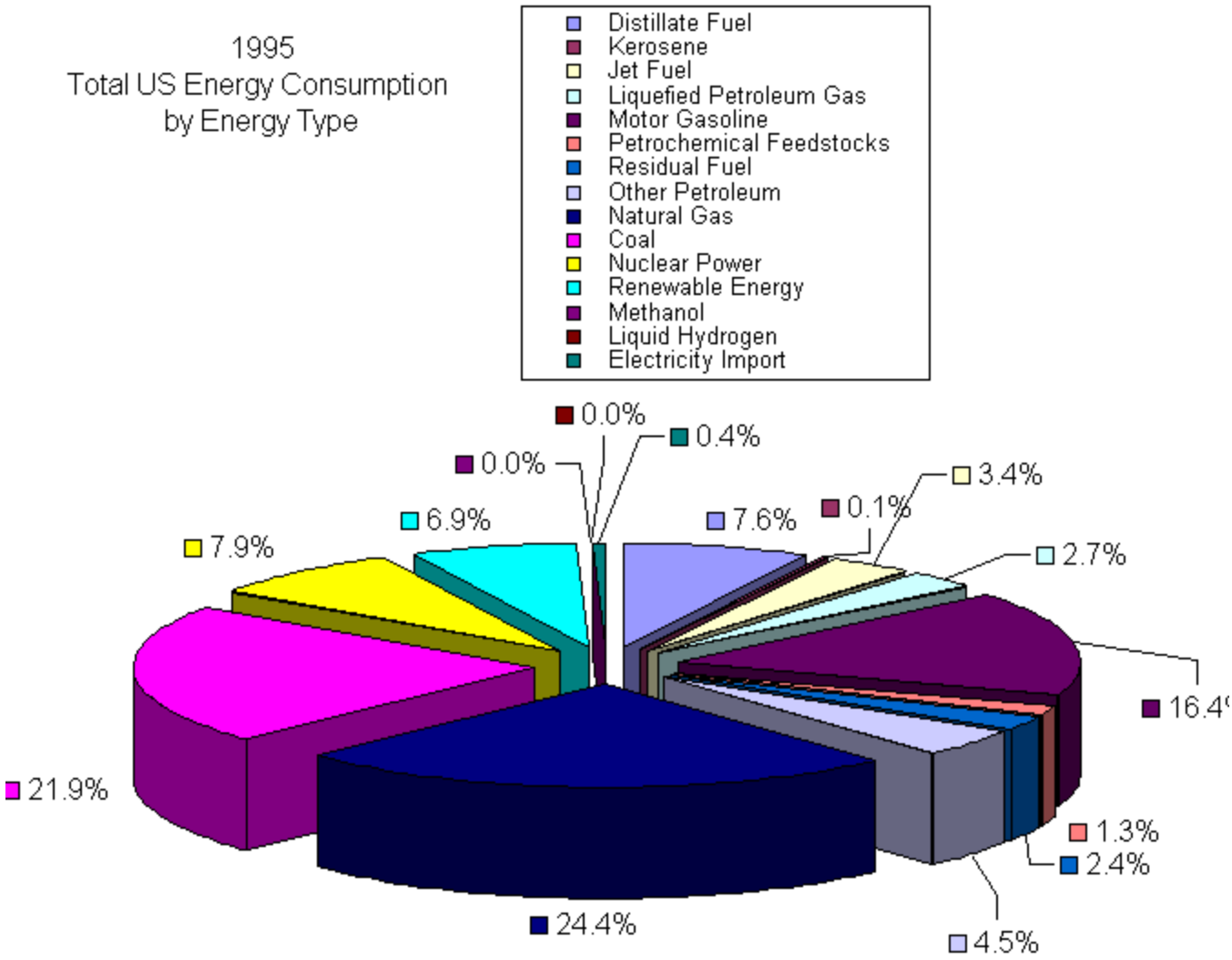
- **Coal**
- **Natural Gas**
- **Crude Oil**

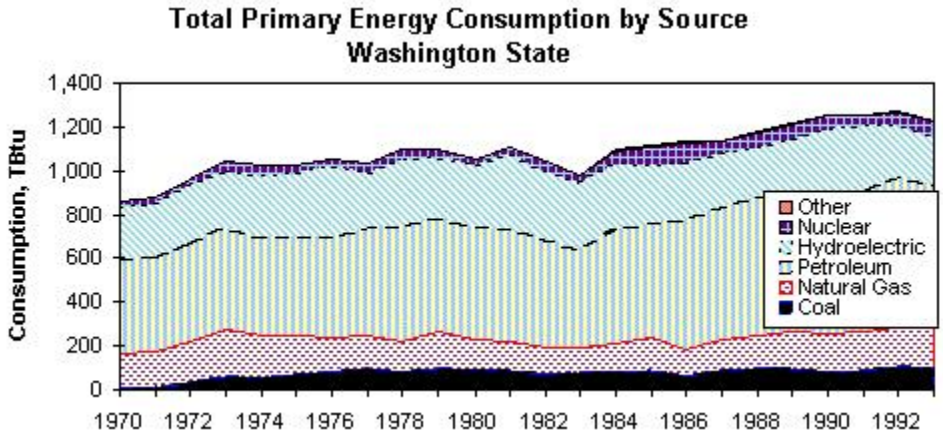
And of course, the market is Volatile:

Figure 15. Refiner Acquisition Cost of Imported Crude Oil, 1996-2000



Source: Energy Information Administration, "Crude Oil Price Summary," MER Spreadsheet, Table 9.1, web site www.eia.doe.gov/emeu/mer/prices (October 2000).





Similar Trends seen Regionally

Most traditional Energy production comes about via steam driven turbines so the heating of water is what is essential.

- **Coal Fired Steam Plants**
- **Nuclear Fired Steam Plants**
- **Oil/Natural Gas Fired Steam Plants**

Table 3. Percentage changes in the number of quads delivered by various energy forms from 1973 to 1994

oil	- 1 %
natural gas	- 6%
coal	+ 33% Large Reserves in US
nuclear	+ 87% Most of this in 1970's
hydro	+ 3%
biomass	+ 18% Co-generation in Midwest

The primary energy input to generate electricity was 30.9 quads. About 2/3 of the energy was lost in conversion processes, leaving about 10 quads as electricity . Of the delivered energy about 2/3 was delivered to the residential/commercial sector and 1/3 to industry.

Electricity as a percentage of total US energy use has been increasing ever since electricity was introduced. In 1973 about

25% of primary energy used to make electricity. In 1994 the percentage of energy used to make electricity had increased to 34% of total energy.

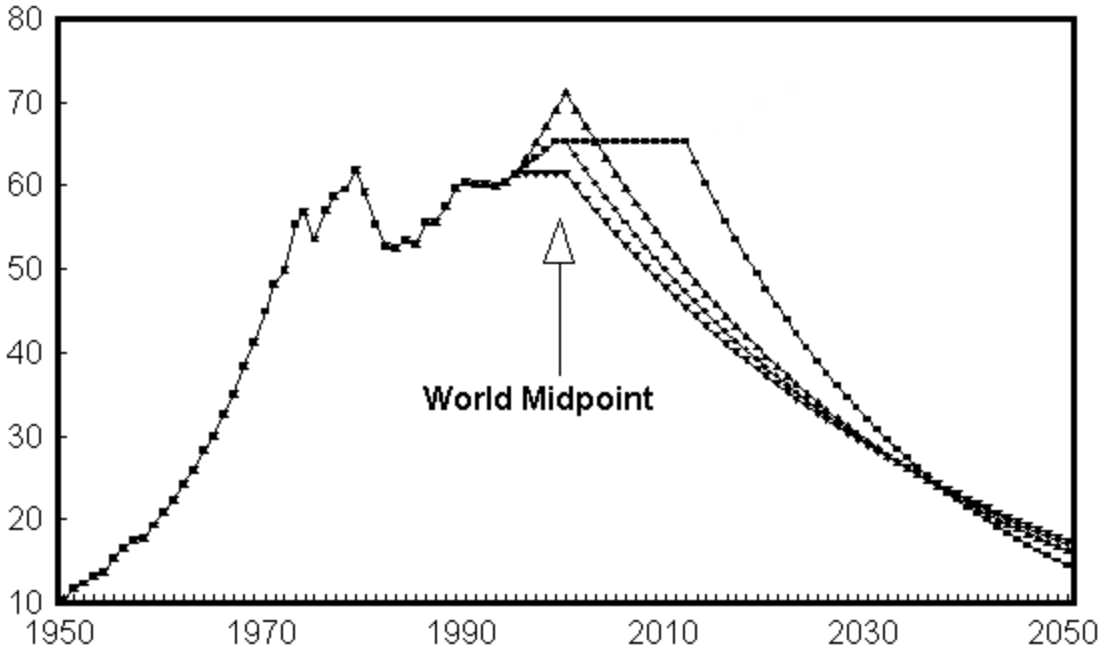
Distribution of Energy Consumption Patterns in the US

The Need for Alternative Energy

- **Basic concept of alternative energy sources relates to issues of sustainability, renewability and pollution reduction.**
- **In reality, Alternative Energy means any thing other than deriving energy via Fossil Fuel combustion**
- **Basic Barrier to all forms of alternative energy lies in initial costs!**
- **Currently we have no significant production line alternative energy source operating anywhere in the US!**

The simple problem is that there are simply not enough fossil fuels left to sustain its usage as the foundation of our energy production. Forget about global warming for the moment, the issue is more basic than that.

We have about 50 more years of production from known reserves , after that we will either have to discover more reserves are shift away from our fossil fuel based energy economy.



Campbell World Oil Production Plot

Forms of Alternative Energy:

- **Solar:**

  Advantages: Always there; no pollution

  Disadvantages: Low efficiency (5-15%); Very high initial costs; lack of adequate storage materials (batteries); High cost to the consumer

- **Hydro:**

  Advantages: No pollution; Very high efficieny (80%); little waste heat; low cost per KWH; can adjust KWH output to peak loads; recreation dollars

  Disadvantages: Fish are endangered species; Sediment buildup and dam failure; changes watershed characteristics; alters hydrological cycle

- **Wind:**

  Advantages: none on large scale; supplemental power in windy areas; best alternative for individual homeowner

Disadvantages: Highly variable source; relatively low efficiency (30%); more power than is needed is produced when the wind blows; efficient energy storage is thus required

- **Geothermal:**

  Advantages: very high efficiency; low initial costs since you already got steam

  Disadvantages: non-renewable (more is taken out than can be put in by nature); highly local resource

- **Ocean Thermal Energy Conversion:**

  Advantages: enormous energy flows; steady flow for decades; can be used on large scale; exploits natural temperature gradients in the ocean

  Disadvantages: Enormous engineering effort; Extremely high cost; Damage to coastal environments?

- **Tidal Energy:**

  Advantages: Steady source; energy extracted from the potential and kinetic energy of the earth-sun-moon system; can exploit bore tides for maximum efficiency

  Disadvantages: low duty cycle due to intermittent tidal flow; huge modification of coastal environment; very high costs for low duty cycle source

- **Hydrogen Burning:**

  Advantages: No waste products; very high energy density; good for space heating

  Disadvantages: No naturally occurring sources of Hydogren; needs to be separated from water via electrolysis which takes a lot of energy; Hydrogen needs

to be liquified for transport - takes more energy. Is there any net gain?

- **Biomass Burning:**

  Advantages: Biomass waste (wood products, sewage, paper, etc) are natural by products of our society; reuse as an energy source would be good. Definite co-generation possibilities. Maybe practical for individual landowner.

  Disadvantages: Particulate pollution from biomass burners; transport not possible due to moisture content; unclear if growing biomass just for burning use is energy efficient. Large scale facilities are likely impractical.

- **Nuclear Fusion:** ☞ Forget it, we aren't smart enough yet. ☞ But suppose we become smart enough in a few hundred years. Can adoption of sustainable energy technology get us to this point?

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