Annual Energy Consumption of the United States from 1949-2006

Energy (in quadrillion BTU's)

Year

Fossil Fuels
Nuclear Electric Power
Renewable Energy
Total
Natural Gas vs. Crude Oil Pricing

Natural gas (mostly CH₄): 1000 Btu / SCF (standard cubic foot)

Crude oil: $80 / bbl  \quad 5.8 \times 10^6 \text{ Btu / bbl}

Prices: natural gas $4 / 1000 SCF = $4 / 10^6 \text{ Btu}

\quad \text{crude oil } $80 / \text{bbl} = $14 / 10^6 \text{ Btu}

Oil prices and natural gas prices are now decoupled (not true 20 years ago), due to natural gas “bubble”, liquefied natural gas (LNG) installations (imported from Middle East), lack of development of compressed natural gas (CNG) vehicles.
## 2006 Energy Consumption By Sector *

<table>
<thead>
<tr>
<th>Sector</th>
<th>Coal</th>
<th>Petroleum</th>
<th>Natural Gas</th>
<th>Biomass</th>
<th>Hydro</th>
<th>Nuclear</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Power Sector**</td>
<td>20.05</td>
<td>0.65</td>
<td>6.41</td>
<td>0.42</td>
<td>2.86</td>
<td>8.22</td>
<td>1.09</td>
</tr>
<tr>
<td>Residential (21.08)</td>
<td>0.03</td>
<td>4.76</td>
<td>14.73</td>
<td>1.28</td>
<td>-</td>
<td>-</td>
<td>0.28</td>
</tr>
<tr>
<td>Commercial (18.02)</td>
<td>0.39</td>
<td>3.32</td>
<td>13.78</td>
<td>0.47</td>
<td>0.004</td>
<td>-</td>
<td>0.06</td>
</tr>
<tr>
<td>Industrial (32.47)</td>
<td>2.92</td>
<td>14.58</td>
<td>11.95</td>
<td>2.88</td>
<td>0.05</td>
<td>-</td>
<td>0.09</td>
</tr>
<tr>
<td>Transportation (28.44)</td>
<td>-</td>
<td>27.37</td>
<td>0.62</td>
<td>0.45</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

| Total                   | 3.34  | 50.03     | 41.08       | 5.08    | 0.054 | 0       | 0.426 |

*As percentages of total energy consumption in the U.S. (9.9X10^16 Billion Btu)

**Electricity-only and combined-heat-and-power (CHP) plants within the NAICS (North American Industry Classification System) 22 category whose primary business is to sell electricity, or electricity and utilities and independent power producers.
(Quadrillion Btu)

- Coal 23.79
- Natural Gas 19.02
- Crude Oil 10.87
- NGPL 2.35
- Nuclear Electric Power 8.21
- Renewable Energy 6.79
- Domestic Production 71.03
- Imports 34.49
- Other 5.46

- Petroleum 2.79
- Exports 4.93
- Residential 21.05
- Commercial 18.00
- Industrial 32.43
- Transportation 28.40
- Supply 104.80
- Consumption 99.87

- Adjustments 0.72

---

a Includes lease condensate.
b Natural gas plant liquids.
c Conventional hydroelectric power, biomass, geothermal, solar/PV, and wind.
d Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.
e Natural gas, coal, coal coke, fuel ethanol, and electricity.
f Stock changes, losses, gains, miscellaneous blending components, and unaccounted-for supply.
g Coal, natural gas, coal coke, and electricity.
h Natural gas only; excludes supplemental gaseous fuels.

Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.

Includes 0.06 quadrillion Btu of coals coke net imports.

Includes 0.06 quadrillion Btu of electricity net imports.

Primary consumption, electricity retail sales, and electrical system energy losses, which are allocated to the end-use sectors in proportion to each sector’s share of total electricity retail sales. See Note, “Electrical Systems Energy Losses,” at end of Section 2.

Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

Sources: Tables 1.1, 1.2, 1.3, 1.4, and 2.1a.
Estimated Energy Usage in 2006 ~97.1 Quads

- Solar: 0.07
- Nuclear: 8.21
- Hydro: 2.86
- Wind: 0.26
- Geo: 0.33

- Natural gas: 22.47
- Coal: 22.53
- Bio: 3.19
- Oil: 39.57

- Electricity: 38.98
- Residential: 4.62
- Commercial: 8.37
- Industrial: 23.49
- Cars: 17.16

- Unused energy: 54.59
- Useful energy: 42.51

- Aviation: 3.39
- Freight: 7.77

Total: 39.66 + 7.14 + 9.66 + 0.68 + 0.52 + 1.44 + 0.78 + 0.43 + 0.01 + 0.05 + 0.09 + 0.02 + 0.02 + 7.32 = 71.98
Gasoline Prices 1918 - Current
Adjusted for Inflation
© 2011 InflationData.com
Prepared By Timothy McMahon
Updated 6/15/11

Note: Prices are Average Annual prices not Peak Prices so peaks are smoothed out considerably

Source of Data: US Energy Information Administration
CPI-U Inflation index- www.bls.gov
**Free ride**
Taxes on gasoline in the U.S. are minuscule compared with many countries around the world.

**2005 gasoline prices and taxes by country**
*Figures in U.S. dollars per gallon*

<table>
<thead>
<tr>
<th>Country</th>
<th>Price excluding tax</th>
<th>Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
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<tr>
<td>Italy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lithuania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jamaica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guatemala</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venezuela</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: The Wall Street Journal; International Monetary Fund
Thomas McKay | The Denver Post

**Insatiable demand**
Even though prices have risen to near-record highs...

Price of a gallon of gasoline
*Unleaded regular, U.S. city average retail price*

<table>
<thead>
<tr>
<th>Date</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 4</td>
<td>$3.01</td>
</tr>
</tbody>
</table>

...gasoline consumption remains at record high levels.

U.S. gasoline consumption
*Annual averages of U.S. motor gasoline supplied, in millions of barrels a day*

<table>
<thead>
<tr>
<th>Year</th>
<th>Average through May</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>9.0 million</td>
</tr>
</tbody>
</table>

Source: Department of Energy
Thomas McKay | The Denver Post
World oil production and consumption

Daily production and consumption

- 1 square = 50,000 barrels per day

Daily consumption as a percentage of production:
- 0-49%
- 50-99%
- 100-199%
- 200%+

Top producers

In millions of barrels per day, 2004

1. Saudi Arabia 10.5
2. Russia 9.3
3. United States 8.7
4. Iran 4.1
5. Mexico 3.8
6. China 3.6
7. Norway 3.2
8. Canada 3.1
9. Venezuela 2.9
10. United Arab Emirates 2.8
11. Kuwait 2.5
12. Nigeria 2.3
13. United Kingdom 2.1
14. Iraq 2.0
15. Algeria 2.0
16. Brazil 1.8
17. Libya 1.6
18. Kazakhstan 1.2
19. Indonesia 1.2
20. Angola 1.1
21. Qatar 1.0

Top consumers

In millions of barrels per day, 2004

1. United States 20.7
2. China 6.4
3. Japan 5.4
4. Russia 2.8
5. Germany 2.6
6. India 2.5
7. Canada 2.3
8. South Korea 2.1
9. Brazil 2.1
10. France 2.0
11. Mexico 2.0
12. Italy 1.9
13. Saudi Arabia 1.8
14. United Kingdom 1.8
15. Spain 1.6
16. Iran 1.5
17. Indonesia 1.2

Note: Oil includes crude oil, natural gas plant liquids and other forms of petroleum.
Source: U.S. Energy Information Administration
Crude Oil & Natural Gas Prices

Note: Real oil price in constant 2005 US$: US Bureau of Labor Statistics seasonally adjusted urban consumer price index (CPI-U) is used.
Source: New York Mercantile Exchange (NYMEX); www.bls.gov
Crude Oil Consumption & Net Imports, 2004

Crude Oil Production & Net Exports, 2004

World Natural Gas Supply

Source: IEA, Natural Gas Information 2004 Online Database.
World Total Primary Energy Supply by Source

1985 (7703 Mtoe*)
- Oil: 36.4%
- Natural Gas: 18.4%
- Coal: 26.4%
- Biomass: 11.3%
- Hydro: 2.2%
- Nuclear Energy: 5.1%
- Other: 0.3%

2003 (10723 Mtoe*)
- Oil: 34.4%
- Natural Gas: 21.2%
- Coal: 24.4%
- Nuclear Energy: 6.5%
- Traditional Biomass: 9.5%
- Modern Renewables: 4.1%


*Mtoe is million tonnes of oil equivalent
Power Hungry

As China’s energy consumption increasingly outstrips production, the government is enacting emergency measures to help avoid acute fuel shortages that threaten to ignite economic and social disorder. At right, drivers waited for hours Monday to fill up at a gas station in Dongguan.

Source: National Bureau of Statistics, China
Global Trends: Growth in Economy, Energy & Emissions

Note: Index: 1971=100
Energy Use per Capita & GDP per Capita

Note: Europe & Central Asia EIT (Economies in Transition) excludes EU accession countries.
Changes in GHG Emissions 1990-2003

Source: UNFCCC, 2005.
Regional Carbon Dioxide Emissions

- North America
- Developing Asia
- Africa
- Europe
- OECD Pacific
- Former USSR
- Latin America and the Caribbean

Note: CO₂ emissions are from fuel combustion; OECD Pacific includes Japan, Republic of Korea, Australia & New Zealand.

Per capita CO₂ Emissions, Population & Total Emissions, 2003

Source: UNDESA-DSD, based on IEA 2005.
What if it's a big hoax and we create a better world for nothing?

- Energy independence
- Preserve rainforests
- Sustainability
- Green jobs
- Livable cities
- Renewables
- Clean water, air
- Healthy children
- Etc. etc.
## Fossil Fuel Emission Levels

*Pounds per Billion Btu of Energy Input*

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Natural Gas</th>
<th>Oil</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>117,000</td>
<td>164,000</td>
<td>208,000</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>40</td>
<td>33</td>
<td>208</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>92</td>
<td>448</td>
<td>457</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>1</td>
<td>1,122</td>
<td>2,591</td>
</tr>
<tr>
<td>Particulates</td>
<td>7</td>
<td>84</td>
<td>2,744</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.000</td>
<td>0.007</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Source: EIA – Natural Gas Issues and Trends
GDP Growth & CO₂ Emissions Growth 1990-2003

Note: Along the dotted line, the % Change in GDP = % Change in CO₂.
Source: UNDESA-DSD, based on IEA, 2005.
Regional Sulphur Emissions

Note: Logarithmic scale; Numbers at ends of lines indicate years of measurements: e.g. 95 = 1995; PM10 data for London, Mexico City and Santiago.
Source: City specific sources are noted in the Sources for Graphics.
Sulphur Dioxide Pollution

Note: Logarithmic scale; Numbers at ends of lines indicate years of measurements: e.g. 95 = 1995.
Source: City specific sources are noted in the Sources for Graphics.
## PROJECTIONS 2000-2050

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global population (in millions)</td>
<td>6065</td>
<td>9030</td>
</tr>
<tr>
<td>Energy demand (quads)</td>
<td>385</td>
<td>1500</td>
</tr>
<tr>
<td>North America</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>Latin America</td>
<td>35</td>
<td>150</td>
</tr>
<tr>
<td>Europe</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>Africa</td>
<td>15</td>
<td>200</td>
</tr>
<tr>
<td>Asia</td>
<td>135</td>
<td>900</td>
</tr>
<tr>
<td>Carbon emission (gigatons/year)</td>
<td>7</td>
<td>26</td>
</tr>
</tbody>
</table>
Global Energy Consumption

- In 2005 total was 447 Quads/yr = 15 TW

  \[1\text{ Quad} = 10^{15}\text{ Btu}\quad 1\text{ TW-year} = 29.9\text{ Quads}\]

  US share \(\sim 22\%\quad \sim 86\%\) from fossil fuels

- By 2030, total is expected to be 702 Quads/yr

  fossil fuel fraction still \(\sim 86\%\)

- Fossil fuels are a finite resource. When will we run out?
Discovered volumes are decreasing ...
... however, unconventional scope dwarfs conventional resources

Estimates from a diverse range of sources (Trillion boe – total volume)
Big Oil: who the majors really are

Oil and gas reserves 2004 (Source: CSFB)
Fossil Fuel Reserves

10,000 Quads
Global usage = 161 Q/y
US ~ 25%

6000 Quads
Global usage = 100 Q/y

503 to 1500 Quads

World coal reserves ~22,000 Quads
RATIO OF HYDROGEN (H) TO CARBON (C) FOR GLOBAL PRIMARY ENERGY CONSUMPTION SINCE 1860 & PROJECTIONS FOR THE FUTURE

Methane: H/C = 4
Oil: H/C = 2
Coal: H/C = 1
Wood: H/C = 0.1

1935 (midpoint of process)
Δt = 300 years (length of process)

Ausubel (1996)
GAS RESOURCES AND GROWTH POTENTIAL

- +13,000 EJ unconventional
- +5000 EJ
- 15,000 EJ
- 4% per annum
- From USGS/IPCC
PRODUCTION PATTERNS OVER TIME

Schollnberger (1998)
<table>
<thead>
<tr>
<th></th>
<th>BEARS</th>
<th>USGS MEAN</th>
<th>BULLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRODUCED</strong></td>
<td>875</td>
<td>710 (1995)</td>
<td>950</td>
</tr>
<tr>
<td><strong>TO BE DISCOVERED</strong></td>
<td>150</td>
<td>732</td>
<td>900</td>
</tr>
<tr>
<td><strong>FIELD RESERVE GROWTH</strong></td>
<td>0</td>
<td>688</td>
<td>950</td>
</tr>
<tr>
<td><strong>PROVED RESERVES</strong></td>
<td>900</td>
<td>891 (1995)</td>
<td>1265</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1925</td>
<td>3021</td>
<td>4065</td>
</tr>
<tr>
<td><strong>REMAINING</strong></td>
<td>1050</td>
<td>2311</td>
<td>3115</td>
</tr>
</tbody>
</table>
Has oil production peaked?
A sampling of opinion (2008)

“For the past three years, global oil production has remained constant at roughly 85 million barrels per day. OPEC production has remained largely flat while non-OPEC supply growth has been well below levels seen just four years ago... If there are no additional supplies of oil, for every 1 percent increase in demand, we would expect a 20 percent increase in price to balance the market.”

Samuel Bodman, U.S. Energy Secretary, at a June 22 oil summit in Saudi Arabia

“Political factors, barriers to entry and high taxes all play a role here. In other words, when it comes to producing more oil, the problems are aboveground, not below it. They are not geological, but political.”

Tony Hayward, BP CEO, during a June 11 presentation on BP’s annual world energy report
Has oil production peaked?

“The imminent peak in global oil production has been predicted for a century – but incorrectly; it has not occurred. This does not mean that it will not occur ever… But we need to be aware that some of the very arguments we are hearing today have been heard before – and have, in retrospect, been scaremongering.”

Peter Davies, BP’s Special Economic Adviser, in January 16 speech to a peak oil group in London

“The global economy is facing the third great oil shock of recent decades… We are becoming increasingly aware of the technical, financial and political barriers to the production of more oil.”

Gordon Brown, Prime Minister of Britain, in a May 28 commentary published in the Guardian
Has oil production peaked?

“There is enough oil and gas in the ground, but the access is what’s impeding production. So we could have a squeeze in the years ahead if we don’t get after increasing our supplies.”

**David O’Reilly, Chevron Corp. Chairman and Chief Executive, CNN, June 17**

“it’s supply and demand… We don’t have excess (production) capacity in the world anymore. That’s why you’re seeing the oil prices.”

**Warren Buffet, CNBC, June 25**
Has oil production peaked?

“The consensus view is that oil above $100 a barrel is going to be with us for some time. So we have two choices. One, continue exporting our wealth overseas … and hope that American consumers can outbid the Chinese and Indians in the world oil market; or two, we can commit to blazing a new path, one that frees our country from the shackles of oil.”

Electricity Generation by Fuel 1970-2020

Lower 48 Natural Gas Wells Drilled 1970-2020

Projected Natural Gas Production by Source, 1990-2020

Note: Unconventional gas recovery consists principally of production from reservoirs with low permeability (tight sands) but also includes methane from coal seams and gas from shales.

“Hydraulic Fracturing for Enhanced Natural Gas Production”

Natural Gas Consumption by Sector 1990-2020

Environmental Consequences of Fossil Fuel Use

Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.ornl.gov/
Global Carbon Cycle (Billion Metric Tons CO₂)

About ½ of the anthropogenic flux accumulates in the atmosphere.
### U.S. Primary Energy Consumption

- **Natural Gas**: 24%
- **Coal**: 23%
- **Petroleum**: 39%
- **Non-Fossil**: 15%

### Resulting Carbon Dioxide Emissions

- **Natural Gas**: 21%
- **Petroleum**: 42%
- **Coal**: 37%

### By End-Use Sector

- **Transportation**: Non-Electric 10%, Electric 30%
- **Industrial**: Non-Electric 10%, Electric 30%
- **Residential**: Non-Electric 10%, Electric 30%
- **Commercial**: Non-Electric 10%, Electric 30%

*Residential and Commercial exclude transportation

### By Electricity Sector

- **Natural Gas**: 16%
- **Petroleum**: 3%
- **Non-Fossil**: 30%
- **Coal**: 51%

### Source:
Energy Information Administration
CO₂ Capture and Storage

- Separate CO₂ from flue gas in power generation
- Change combustion process to avoid this separation
- Storage - how long can we store CO₂ and how effectively
- Does not address emissions from transportation and some modes of heating
Ultimately Need a Sustainable Energy Supply

- **Renewable Energy**
  - Biofuels
  - Biomass
  - Geothermal
  - Hydro Power
  - Solar Power
  - Tidal Power
  - Wave Power
  - Wind Power
  - Nuclear (?)

- **Lower Usage**
  - Conservation
  - Efficiency
    - Automotive
    - Power generation
    - Process
    - Lighting