

Trends in U.S. Energy Use and Supplies – How Biofuels Contribute

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The balance of energy consumption and production in the United States is a critical factor for consideration in both U.S. energy policy and prospects for growth of the U.S. economy. While fossil fuels have been the major source of energy consumed in the United States since World War II, nuclear power and renewable energy both have been growing in importance. Increases in renewable energy consumption in recent years have been due predominantly to increased biofuels use, with increases in wind energy use also occurring but to a lesser degree.

Information from the Energy Information Agency, a branch of the U.S. Department of Energy is used in this article to illustrate short and longer term trends in United States energy use, supplies, and economic growth.

Total U.S. Energy Consumption

In calendar year 2008, total energy consumption in the United States equaled 99.3 quadrillion Btu. (Table 1). Fossil fuel consumption in 2008 accounted for 84% of total U.S. energy use (i.e., 83.4 quadrillion Btu. or “q-Btu”), followed by 8.5 q-Btu (8.5% of U.S. energy use) from nuclear electric power, and 7.3 q-Btu (7.4% of U.S. energy use) from renewable fuels. A small amount of electricity net imports accounted for the remaining amount of energy consumed. Trends in total U.S. energy consumption for the 2003-2008 period were relatively flat. Average U.S. energy use during 2003-08 was 99.96 q-Btu per year, with a small upward trend of 0.24 q-Btu annually.

Table 1. U.S. Energy Consumption by Energy Source, Years 2003-2008

| U.S. Energy Source (Quadrillion Btu) | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|-------------|--------------|--------------|-------------|--------------|-------------|
| Fossil Fuels | 84.1 | 85.8 | 85.8 | 84.7 | 86.2 | 83.4 |
| Coal | 22.3 | 22.5 | 22.8 | 22.4 | 22.7 | 22.4 |
| Coal Coke Net Imports | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 |
| Natural Gas | 22.9 | 22.9 | 22.6 | 22.2 | 23.6 | 23.8 |
| Petroleum | 38.8 | 40.3 | 40.4 | 40.0 | 39.8 | 37.1 |
| Electricity Net Imports | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 |
| Nuclear Electric Power | 8.0 | 8.2 | 8.2 | 8.2 | 8.5 | 8.5 |
| Renewable Energy | 6.2 | 6.3 | 6.4 | 6.9 | 6.8 | 7.3 |
| Biomass | 2.8 | 3.0 | 3.1 | 3.4 | 3.6 | 3.9 |
| Biofuels | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.4 |
| Waste | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Wood Derived Fuels | 2.0 | 2.1 | 2.1 | 2.2 | 2.1 | 2.0 |
| Geothermal Energy | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| Hydroelectric Conventional | 2.8 | 2.7 | 2.7 | 2.9 | 2.4 | 2.5 |
| Solar/PV Energy | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Wind Energy | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.5 |
| Total Energy (Quadrillion Btu) | 98.2 | 100.3 | 100.5 | 99.9 | 101.6 | 99.3 |

Sources: Non-renewable energy: Energy Information Administration (EIA), Monthly Energy Review (MER) April 2009, DOE/EIA-0035 (2009/04) (Washington, DC, April 2009)

Use of Renewable Energy & Biofuels

The amount of renewable energy consumed annually in the U.S. trended higher by an average 0.23 q-Btu per year during the 2003-2008 period (Table 1). Renewable energy consumption averaged 6.6 q-Btu per year, with steady trend increases from 6.2 q-Btu in 2003 to 7.3 q-Btu in 2008. Energy use from biomass sources is counted as part of renewable energy, along with hydroelectricity, wind energy, solar and geothermal sources. Energy from biomass sources increased steadily from 2.8 to 3.9 q-Btu during the 2003-08 period.

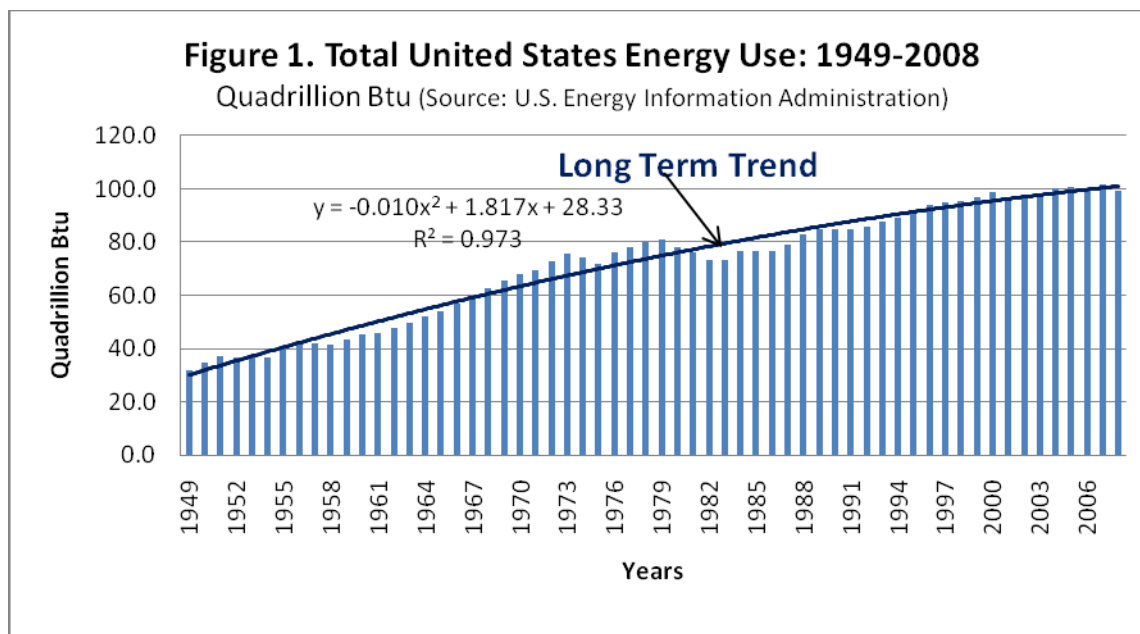
Biofuels are included as part of biomass energy sources along with waste and wood-derived energy (Table 1). Biofuel energy use increased from 0.4 to 1.4 q-Btu during the 2003 to 2008 period, accounting for virtually all of the increase in biomass energy consumption, and a large proportion of the increased renewable energy consumption during this time period. While biofuel energy use increased by 1.0 q-Btu, wind energy use increased by 0.4 q-Btu, and hydroelectric energy use declined by 0.3 q-Btu from 2003 through 2008.

Fossil Fuels & Nuclear Energy

Coal, natural gas and petroleum energy sources are all classified as fossil fuels (Table 1). The amount of energy consumed from coal in the U.S. in 2008 was 22.4 q-Btu, nearly identical to the average amount consumed annually in the U.S. over the 2003-2008 period. The amount of energy consumed from natural gas in 2008 in the U.S. was 23.8 q-Btu, which was slightly higher than the average natural gas-based U.S. energy consumption from 2003 to 2008 (i.e., 23.0 q-Btu). Energy consumption from petroleum in the U.S. in 2008 was 37.1 q-Btu, the lowest amount during the 2003-2008 period during which petroleum-based energy use averaged 39.4 q-Btu. Nuclear energy provided 8.5 q-Btu of the energy used in the U.S. in 2008, following a steady trend increase from a low of 8.0 q-Btu in 2003.

Long Term U.S. Energy Use

Total energy use in the United States has generally been increasing since 1949, but the rate of increase has been declining over the time period (Figure 1). With some variation, long term U.S. energy use fits a “quadratic” trend, in which relatively large yearly increases in energy use in the early years of the time period are followed by declining annual increases in energy use over time.



For example, from 1949 to 1950 the trend line increase in U.S. energy use was projected to be 1.798 q-Btu (compared to an actual increase of 2.634 q-Btu between those two years). By 2007, the projected trendline increase in U.S. energy use from 2007 to 2008 had diminished to 0.016 q-Btu (compared to an actual decline of 2.25 q-Btu for that time frame). Because of cost competition among firms, consumers' desire to use energy more efficiently, and other competitive market, energy and environmental policy factors, the rate of annual increases in energy use in the United States has been declining for most of the post-World War II period.

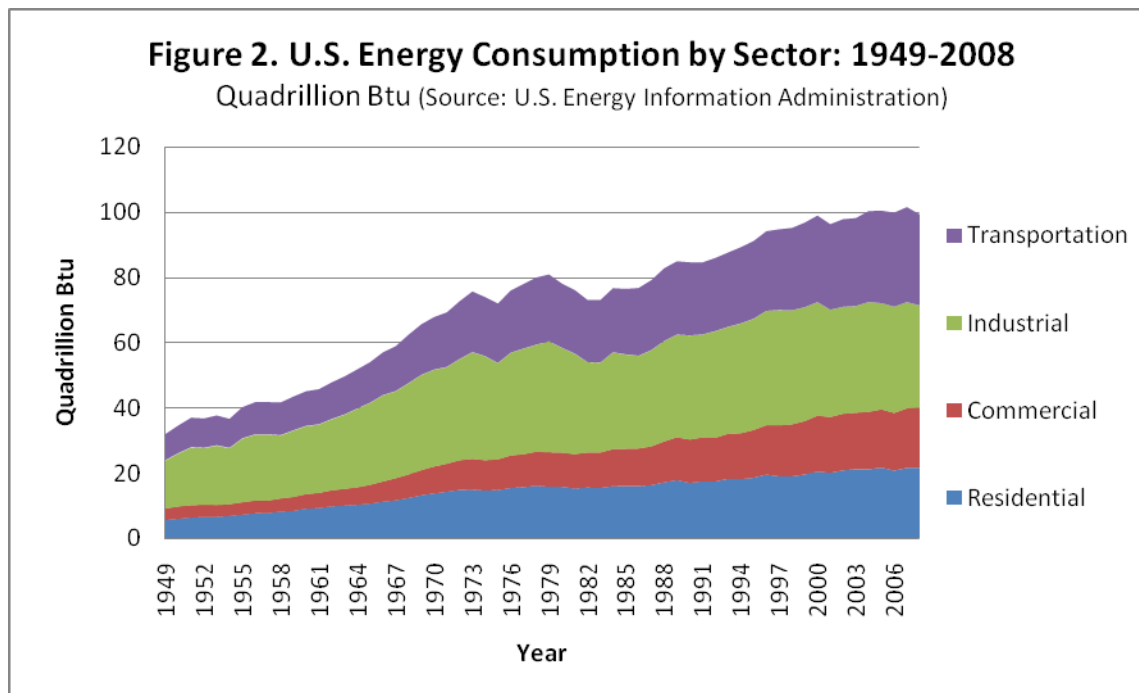
U.S. Energy Use by Sector of the Economy

The four primary categories of energy use in the United States are 1) transportation, 2) industrial, 3) commercial, and 4) residential.

Transportation: Transportation-related energy use has been increasing both nominally and as a proportion of total energy use in the United States since World War II. As a percentage of total energy use in the U.S. economy, transportation-related energy consumption averaged 24.9% during the 1949-1998 period. However, during the most recent decade (1999-2008) transportation-related energy use averaged 27.8% (Figure 2), with over 28% of total energy use occurring annually in the last four years of the period (2005-2008). In 2008, transportation-related energy use in the United States accounted for 27.93 q-Btu or 28.1% of total energy use. Biofuel consumption in the U.S. is primarily related to transportation services.

Industrial: Industrial use of energy as a percent of total energy use has been declining since the post World War II period. Industrial energy use averaged 42.3% of total U.S. energy consumption during the 1949-1998 period, but only 33.4% during the most recent decade (1999-2008). Industrial-related energy use in the U.S. accounted for 31.21 q-Btu or 31.4% of total energy use in 2008.

Commercial: Commercial energy consumption has been increasing proportionally in the U.S. since the late 1940s. Commercial energy use averaged 12.8% of total U.S. energy consumption during the 1949-1998 period, with an average of 17.7% during the most recent decade (1999-2008). Energy use for commercial purposes in the U.S. in 2008 accounted for 18.54 q-Btu or 18.7% of total energy use.



Residential: Residential energy use as a proportion of total U.S. energy consumption has been steady to slightly increasing since the late 1940s. Residential energy use averaged 19.9% of total U.S. energy consumption during the 1949-1998 period, with an average of 21.1% during the most recent decade (1999-2008). In 2008, residential-related energy use accounted for 21.64 q-Btu or 21.8% of total energy use in the United States.

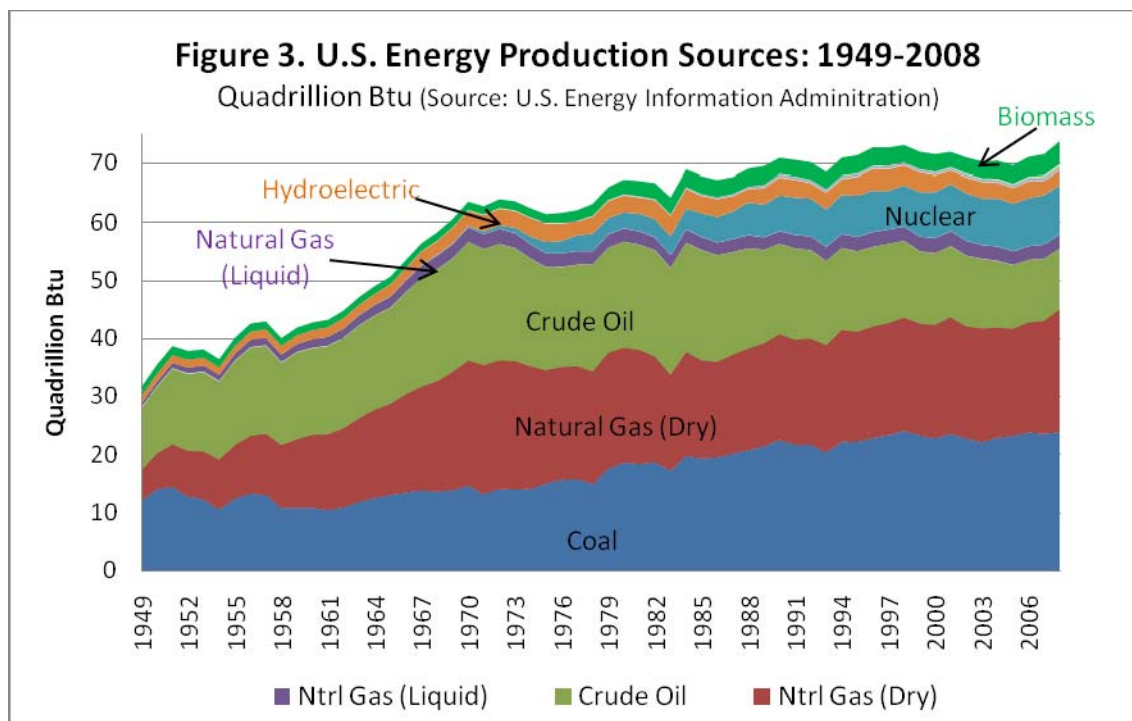
U.S. Energy Production by Type

The strong majority of energy produced in the United States since 1949 has come from fossil fuels (i.e., coal, natural gas and crude oil) with important but lesser contributions from nuclear energy, hydroelectric power, biomass, and other energy sources. Varying trends in domestic U.S. energy production among alternative sources reflect a variety of factors such as energy market supply-demand, the advancement of alternative energy production technologies, and U.S. economic, energy and environmental policy.

Coal Production: United States energy production from coal has been increasing but at a decreasing rate since the early 1960s after declining during the 1950s. Coal-based energy production averaged 23.16 q-Btu (32.5% of total annual U.S. energy production) during the 1999-2008 period (Figure 3). In 2008 the U.S. produced 23.86 q-Btu of energy from coal (32.4% of total energy production).

Natural Gas (Dry) Production: Natural gas (dry-form) U.S. energy production has been increasing but at a decreasing rate since the early 1970s after a period of strong growth from 1949 through the 1960s. Dry natural gas-based energy production averaged 19.58 q-Btu (27.5% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 21.15 q-Btu of energy from dry-form natural gas (28.7% of total energy production).

Crude Oil Production: Energy production from domestic crude oil in the U.S. increased from 1949 to 1972, held fairly stable from 1973 to 1986, and declined from 1987 through 2008. Crude oil-based U.S. energy production averaged 11.58 q-Btu (16.3% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 10.52 q-Btu of energy from crude oil (14.3% of total energy production).



Nuclear Energy Production: United States nuclear energy production increased fairly steadily from 1958 to 2008. Nuclear energy production in the U.S. averaged 8.11 q-Btu (11.4% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 8.46 q-Btu of nuclear energy (11.5% of total energy production).

Biomass Production: Biomass energy production in the U.S. was somewhat stable from 1949 through 1975, increasing from 1976 to 1985, steady from 1985 to 2005, and increasing during 2006-2008. Biomass energy production averaged 3.11 q-Btu (4.4% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 3.90 q-Btu of biomass energy (5.3% of total energy production). Growth in biofuel energy production is reflected in biomass energy production from the mid-1980s on, and especially during the 2006-2008 period.

Hydroelectric Energy Production: Hydroelectric energy production in the U.S. increased steadily from 1949 to 1974, was somewhat steady with some variation from 1975 to 1999, and has been stable to declining from 2000 to 2008. United States hydroelectric energy production averaged 2.70 q-Btu (3.8% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 2.45 q-Btu of nuclear energy (3.3% of total energy production).

Natural Gas (Liquid) Production: Natural gas (liquid-form) U.S. energy production increased from 1949 through 1968, and has been stable since that time. Liquid natural gas-based energy production averaged 2.46 q-Btu (3.4% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 2.42 q-Btu of energy from liquid-form natural gas (3.3% of total energy production).

Wind Energy Production: No appreciable wind-based energy was produced in the U.S. until 1989, from which time wind energy has steadily grown, especially since year 2000. Wind energy production averaged 0.18 q-Btu (0.3% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 0.51 q-Btu of energy from wind (0.7% of total energy production).

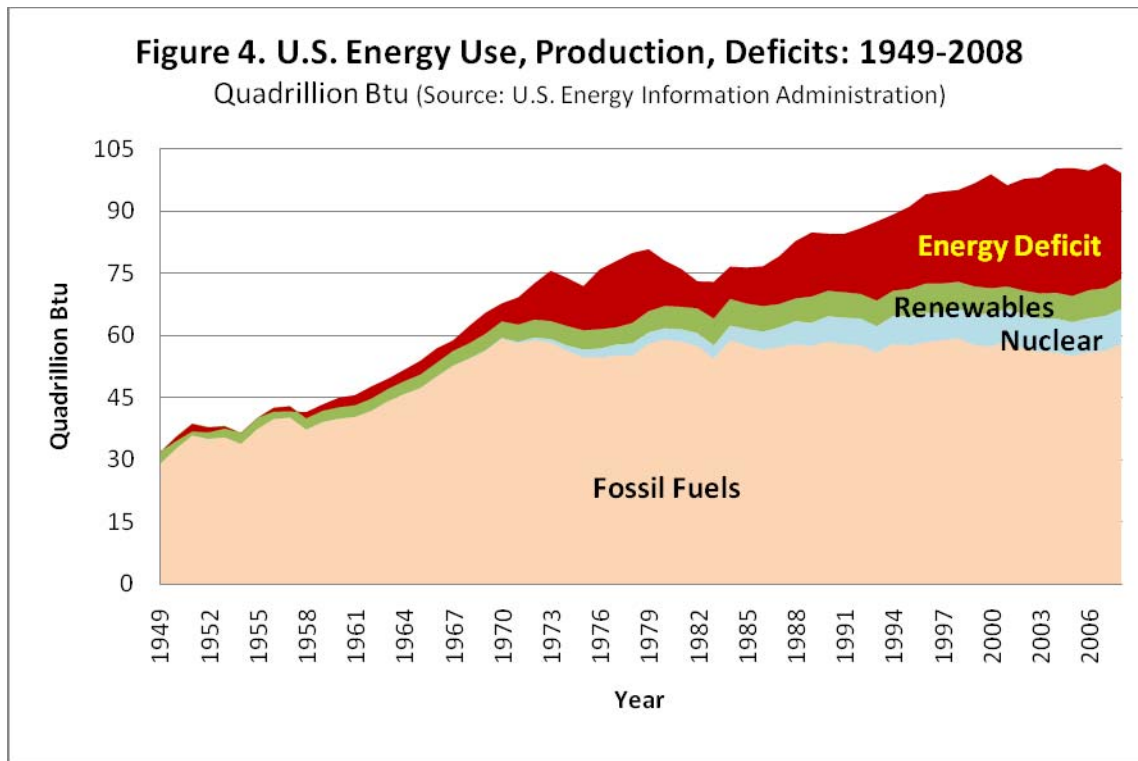
Geothermal Energy Production: No appreciable geothermal-based energy was produced in the U.S. until 1960. Geothermal energy production grew steadily from 1960 through 1993, and has been somewhat

stable since then. Geothermal energy production averaged 0.34 q-Btu (0.5% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 0.36 q-Btu of energy from geothermal sources (0.5% of total energy production).

Solar Energy Production: No appreciable solar-based energy was produced in the U.S. until 1989. Solar energy production has been relatively stable from 1989 through 2006, with a small increase during 2007-2008. Solar energy production averaged 0.07 q-Btu (0.1% of total U.S. energy production) annually during the 1999-2008 period. In 2008 the U.S. produced 0.09 q-Btu of energy from solar energy sources (0.1% of total energy production).

Domestic Energy Production Deficits

To the degree that domestic U.S. energy production falls short of consumption, energy is imported to make up the difference and meet total U.S. energy demand (Figure 4). The United States has had domestic energy deficits since 1958. The U.S. energy deficit has grown at an average rate of 0.57 q-Btu per year (0.51% annually) from 1958 to 2008. During the 1999-2008 period, the U.S. energy deficit grew at an average rate of 0.36 q-Btu per year (0.25% annually). The average energy deficit during 1999-2008 was 27.70 q-Btu or 28.0% of total U.S. energy consumption over the time period. In 2008, the U.S. energy deficit was 25.59 q-Btu, equaling 25.8% of total U.S. energy use.



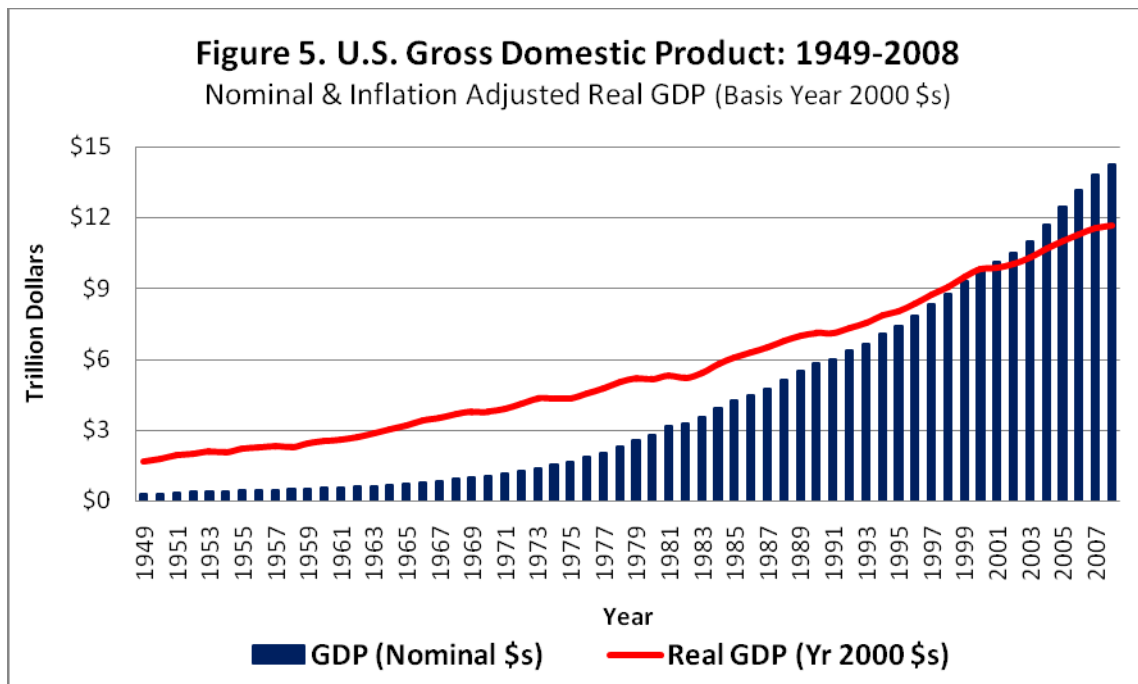
Since 1970 total U.S. energy consumption has grown at a higher average rate (0.89 q-Btu per year) than U.S. energy production (0.29 q-Btu per year), causing the U.S. energy deficit to grow larger (0.60 q-Btu per year) each year. Increasing renewable energy production during this period (0.06 q-Btu annually including biofuels) has helped the situation, but not yet provided enough additional energy to offset the expanding U.S. energy deficit.

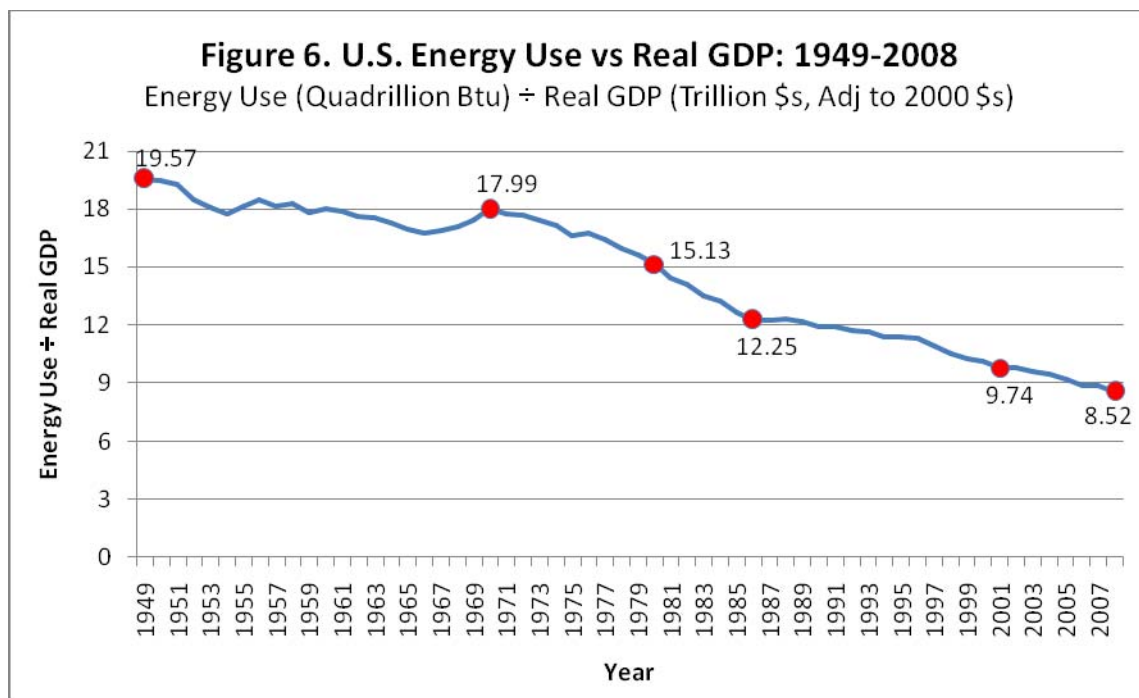
Energy Use In Relation to U.S. Economic Growth

The United States has exhibited fairly steady economic growth on both a nominal and real (inflation adjusted) basis throughout the 1949-2008 period (Figure 5). The U.S. Gross Domestic Product (GDP) grew at an average nominal rate of 7.4% annually during the 1950-1998 period, and at a nominal rate of 5.0% annually during 1999-2008. On an inflation adjusted basis, using year 2000 prices, U.S. real GDP grew at an average rate of 3.6% annually during 1950-1998, and at a rate of 2.5% annually during 1999-2008.

Total energy use relative to the size of the United States economy has been declining over the 1949-2008 period (Figure 6). Using a measure of quadrillion Btu per trillion dollars of real U.S. GDP (adjusted for inflation to year 2000 dollars), the ratio of energy use to economic activity declined from 19.57 q-Btu per trillion dollars of real GDP in year 1949 to 17.99 in year 1970, 15.13 in year 1980, 12.25 in year 1986, 9.74 in year 2001, and 8.52 q-Btu per trillion of real GDP in year 2008.

It is likely that a combination of competitive economic efficiency, technological developments, and energy policy related factors are responsible for this trend. Regardless of the cause, the efficiency of energy use relative to economic activity in the U.S. economy has improved substantially since 1949. By the energy use efficiency measure presented here, the efficiency of energy use relative to economic activity in the United States has improved by 56% from 1949 to 2008 (i.e., from 19.57 to 8.52 q-Btu per trillion of real GDP).





Conclusions

Energy production and consumption in the United States are largely reliant on fossil fuels (coal, natural gas and petroleum), but other energy sources are growing in importance (nuclear energy and renewable sources such as biomass / biofuels and wind energy). Growth in total domestic energy production in the U.S. has slowed considerably since 1970, while U.S. energy consumption has continued to grow at a higher rate during this same time period. This disparity in the growth of U.S. energy supplies versus consumption has created a growing U.S. domestic energy deficit – a gap which has been filled by U.S. energy imports (primarily petroleum).

The role and position of biofuels in the U.S. energy supply-demand complex has been growing and taking on more importance, especially since 2006. The availability of biofuels was shown to have a substantial impact on U.S. gasoline prices paid by consumers during the 2007-2008 period of tight gasoline supply conditions and record high gasoline prices (reference the following study from Iowa State University, <http://www.card.iastate.edu/publications/synopsis.aspx?id=1076>). Growth in the U.S. production and use of biofuels, wind energy and other domestic energy sources will continue to be looked upon as part of the potential solution to domestic energy deficits.

This information is relevant to policy makers as they consider why growth in domestic energy production has been largely curtailed since the 1970s as well as the broader macroeconomic impacts of U.S. energy and associated trade deficits.