U.S. Energy Use & Production

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101 Fact Sheet

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The ravaging effects of anthropogenic global warming (climate change caused by human activity) on the land, the oceans, and the air have been a topic in local, national, and international news with increasing urgency. Unfortunately, this has caused Earth's climate to change for the worse. As a result, we are experiencing more severe and frequent extreme weather events such as hurricanes, tornadoes, heatwaves (and associated wildfires), and polar vortices. These events have caused loss of life and have also caused significant damage to economies worldwide through drought, failing crops, flooding, disaster relief, job loss, and weakened infrastructure.

Although climate scientists have sounded the alarm with in-depth and credible scientific evidence for decades, meaningful unified action has been painfully slow, becoming a hot-button political issue. Most of the public accepts the expertise of scientists, engineers, and other environmental experts. However, unfortunately, many people still deny the greenhouse effect and the resulting dangers of global warming and climate change.

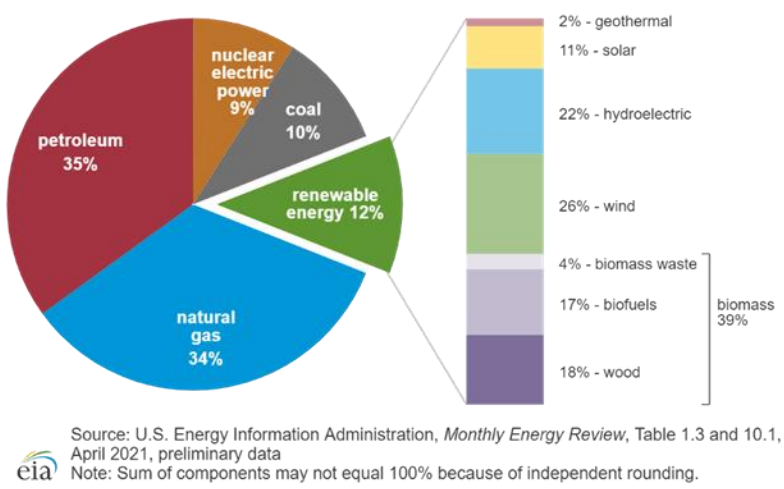

Figure 1. 2020 primary energy consumption in the U.S.

The biggest problem facing the U.S. and the rest of the world is energy consumption. If we want to transition from fossil fuels to more environmentally sound energy sources, an *enormous amount of fossil energy* would need to be replaced.

Figure 1 shows a breakdown of the energy consumed in the United States in 2020. The total energy use was about 93 quads. A quad of energy is equivalent to one quadrillion (10^{15}) British Thermal Units (1,000,000,000,000,000 Btu). *One Btu is the amount of energy needed to increase the temperature of one pound of water by one degree Fahrenheit.*

To put such an enormous figure in perspective, a typical forced-air gas furnace in a medium-sized U.S. home produces about 100,000 Btu/hour of heat. For comparison, the country uses 93×10^{15} Btu/year, almost 11 trillion Btu/hour! One quad is an *enormous* amount of energy (Table 1).

Figure 1 (above) shows that 79% of U.S. energy still comes from fossil fuels (35% oil, 34% natural gas, and 10% coal), whereas nuclear (9%) and renewables (12%) make up a much smaller fraction. Thus, completely replacing fossil fuels (even when keeping nuclear) would require increasing renewables share from 12% (11.2 quads) to 91% (84.6 quads).

Ignoring the political aspects of such a transition, this represents an enormous technical and infrastructure challenge that would require a Manhattan-project scale investment in time and money to accomplish. Nevertheless, such a transition is possible, although it will likely take several decades to complete (so we should start ASAP).

Table 1. Fuel quantities with ***one quad of energy*** (giga = 1 billion, tera = 1000 billion, and a tonne = 1000 kilograms).

- 8,007,000,000 gallons (US) of gasoline
- 293,071,000,000 kilowatt-hours (kWh)
- 293.07 terawatt-hours (TWh)
- 33.434 gigawatt-years (GWy)
- 36,000,000 tonnes of coal
- 970,434,000,000 cubic feet of natural gas
- 5,996,000,000 UK gallons of diesel oil
- 25,200,000 tonnes of oil

How Much Energy? Using 93 quads of energy per year in the U.S. corresponds to using about 745 billion gallons of gasoline a year or about 3.4 billion tonnes of coal. A tonne is a metric ton (1000 kg) or 2200 pounds.

We can increase the energy efficiency of technologies we currently use in transportation (e.g., electric vehicles), industrial and residential sectors (e.g., distributed PV, solar thermal heating, and heat pumps), and make behavioral changes to waste less energy. At the same time, we can continue developing and transitioning into more renewable sources of energy.

When coupled with using natural gas as a bridge (interim) fuel for electricity generation (instead of coal), we can slow climate change while developing the technology and infrastructure needed for a minimal carbon society. While natural gas is still a fossil fuel, it has a *much lower carbon footprint than coal* when used to generate electricity (Table 2).

Table 2. CO_2 emissions during power generation (EIA 2021).

U.S. electric utility and independent power electricity generation and resulting CO2 emissions by fuel in 2019

	Electricity generation	CO2 emissions		
	million kWh	million metric tons	million short tons	pounds per kWh
Coal	947,891	952	1,049	2.21
Natural gas	1,358,047	560	617	0.91
Petroleum	15,471	15	17	2.13

Electricity generation is net electricity generation.
Includes electricity-only power plants. Combined heat and power plants are excluded because some of their CO2 emissions are from heat-related fuel consumption.

Figure 2 (below) shows how the U.S. used its energy in 2020. The energy flow chart shows that the overall efficiency of energy use in the U.S. is about 75%, which is reasonably good but could be improved.

For perspective, the fuel-to-electrical energy efficiency of a pulverized coal-fired power plant is about 40%. The efficiency of a single-pass, natural gas turbine power plant is about 47%. Using a natural-gas-combined-cycle (NGCC) power plant, the energy efficiency can approach 65%. In an NGCC plant, hot exhaust from the gas turbine is used to generate steam for a steam turbine so that both the gas and steam turbines generate electricity.

Figure 2 shows that energy consumption in the U.S. broadly falls into three main categories: industrial, transportation, and residential + commercial (combined).

- Industrial includes heavy industries such as steel production, petroleum refining, large-scale manufacturing, etc.
- Transportation includes all modes – car, truck, bus, train, air.
- Residential is housing for individuals and families, and commercial is small businesses, shopping centers, restaurants, etc.

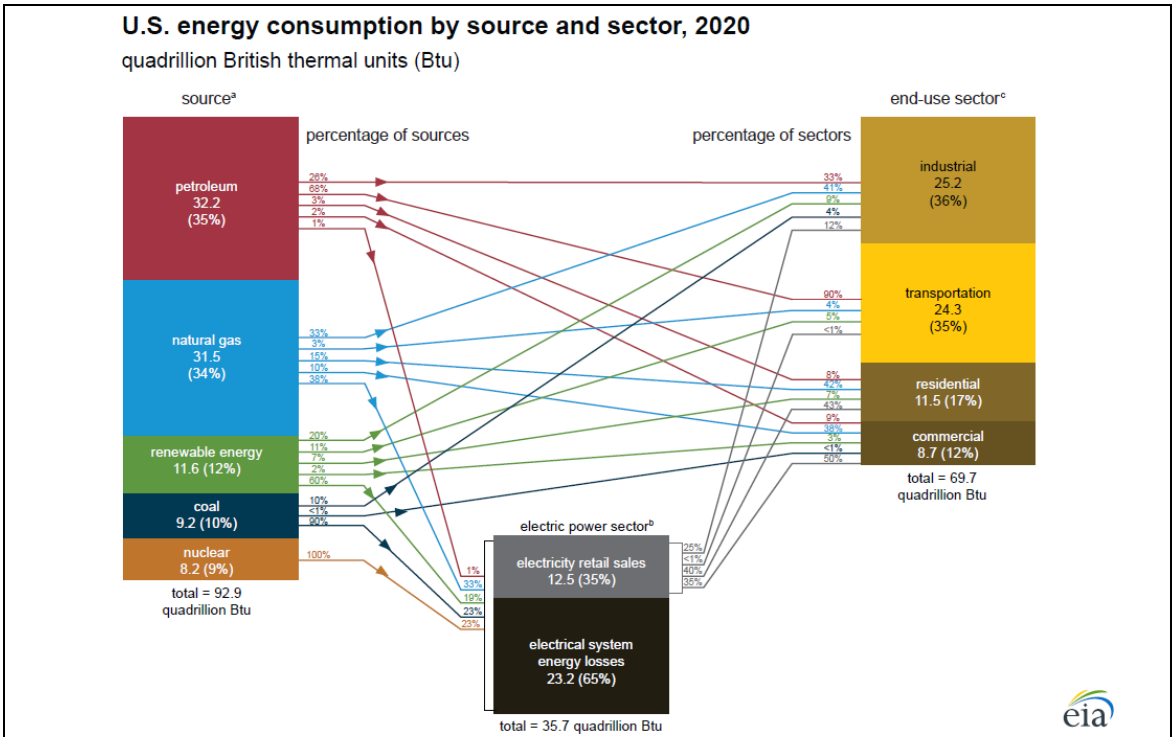

Figure 2. How is this energy used? The total energy input was 92.9 quads, and the total energy used was 69.7 quads leaving 23.2 quads of energy lost to waste-heat, friction, and other inefficiencies. About 38% of all energy (35.3 quads) is used to generate electricity, while 23.2 quads are lost to heat, etc. thus, yielding only 12.1 quads of usable electricity. Therefore, about 17% (12.1/69.7) *100% of consumed energy is *usable* electricity.

Figure 3 (below) shows energy produced domestically in 2020.

- Natural gas accounted for 34.7 quads.
- Petroleum was the next largest at 23.6 quads, followed by coal and the others.
- *Renewables only made up about 10% of the total in 2020.*

The U.S. is more-or-less energy independent; however, the bulk of our needs are still met using fossil fuels. Encouragingly, the use of coal has decreased substantially over the last few years, and more electricity is now made from natural gas (Figure 4), which emits *half* the CO_2 per unit of energy (Table 2).

To make a significant impact on climate change, we need these trends to continue in this direction while increasing the use of wind, hydro, biomass, and solar energy. Expanding the use of renewable energy can provide ever-increasing amounts of the energy we need to live while decreasing the impacts of climate change. Continuing to move toward renewable energy will help us rewrite the energy story in the United States.

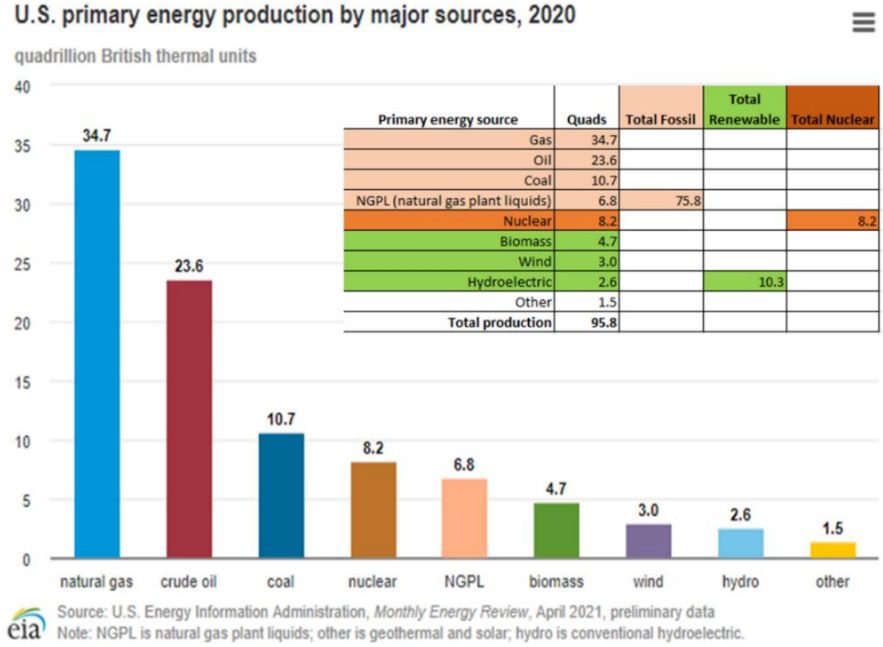

Figure 3. Do we produce all our energy?

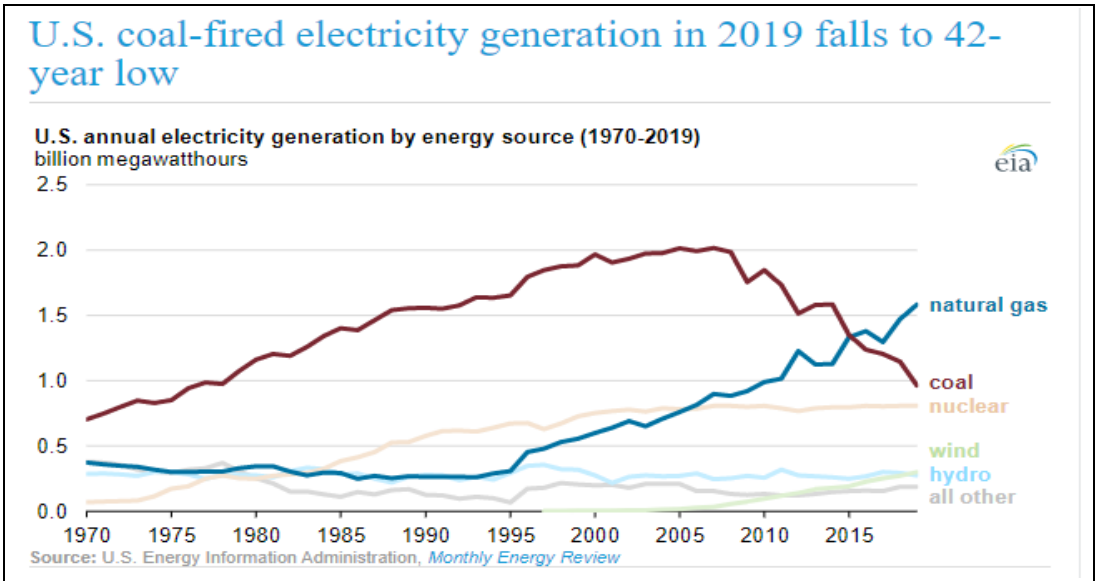

Figure 4. Comparison of electricity generation methods 1970-2019. (5/11/20)

References:

- EIA (2021) U.S. Energy Information Administration: Frequently asked questions
- EIA's Today in Energy (gateway to LOTS of data and charts)
- **Wikipedia** articles on related subjects
  - *"Quad"* unit of energy and equivalent amounts of other fuels and other energy units
  - *"Energy in the United States"* discussion of consumption and production with historical figures
  - *"List of Countries by Energy Consumption per Capita"*
  - *"Renewable Energy"* discusses wind, hydroelectric, solar, geothermal, etc. The article also includes nuclear energy for comparison. Even though it is not renewable, it is carbon-free (except for uranium mining) but generates dangerous radioactive waste.