

15.4: Sources of Energy Used in the Anthrosphere

Until about 1800 the sun provided virtually all of the energy used by humans. Biomass produced by photosynthesis was burned for heat or used to feed horses, oxen, and even human who provided muscle power. Wind resulting from uneven solar heating of air masses powered sailing ships and windmills. The solar powered hydrologic cycle produced running water that drove water wheels.

Around 1800 the dramatically increased use of coal began the era of fossil fuel energy sources. This use was enabled by the invention of the steam engine, which provided abundant and reliable power for stationary sources and locomotives and the power used for mining the coal. By 1900 coal was the dominant energy source in industrialized societies, but petroleum, especially well suited as fuel for the newly developed internal combustion engine, began a century of rapid development, becoming the favored fuel for transportation. Often encountered in wells drilled for petroleum, natural gas also developed during the 1900s, predominantly as a fuel for non-transportation needs. During this century hydroelectric power took on a significant share of electrical power production and remains a substantial renewable energy source. By around 1975, nuclear energy was supplying significant amounts of electricity and has maintained an appreciable share worldwide until the present. Miscellaneous renewable sources including geothermal and, more recently, solar and wind energy are making increasing contributions to total energy supply. Biomass still contributes significantly to the total of the sources of energy used and will become even more important as emphasis on renewable sources increases.

Figure 15.3 shows U.S. and world energy sources as of 2009. The overwhelming reliance on **fossil fuel** petroleum, natural gas, and coal are obvious. These are non-renewable energy sources. Figure 15.4 shows estimated original amounts of these fuels based on data from around 1970. Although the amounts of these fuels based upon more modern estimates would certainly differ, the proportions should be roughly the same. The predominance of coal and lignite is obvious.

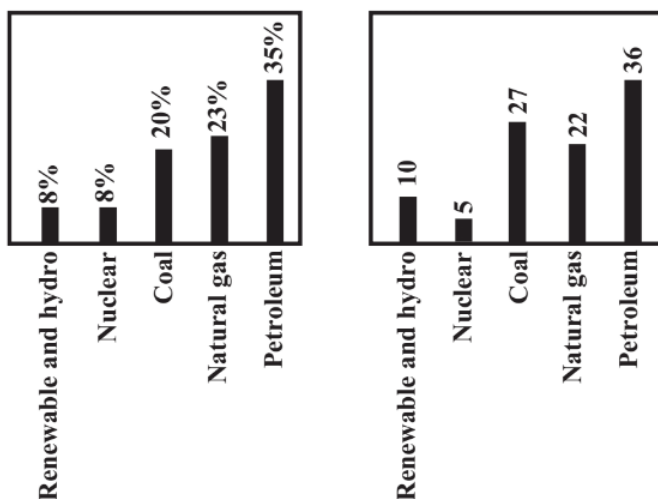


Figure 15.3. U.S. (left) and world (right) sources of energy. Percentages of total rounded to the nearest 1%.

Coal and lignite are the fuels that contribute the most carbon dioxide to the atmosphere per unit of energy generated. A measure of this contribution for fossil fuels is the ratio of water produced per molecule of carbon dioxide generated; greater relative amounts of water mean that more of the energy comes from burning chemically bound hydrogen which does not produce carbon dioxide. The best fuel in this respect is natural gas composed of methane, CH_4 , which burns according to the reaction



producing two molecules of water per molecule of carbon dioxide. For liquid petroleum, approximate empirical formula CH_2 , there is one molecule of H_2O generated per molecule of CO_2 and for coal, approximate empirical formula $\text{CH}_{0.8}$, there is somewhat less than 1/2 of a molecule of H_2O for each CO_2 molecule released.

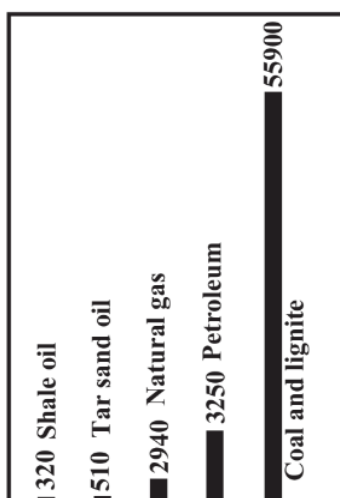


Figure 15.4. Estimated original amounts of the world's recoverable fossil fuels from 1971 (quantities in thermal petawatt hours of energy based upon data taken from M. K. Hubbert, "The Energy Resources of the Earth," in *Energy and Power*, W. H. Freeman and Co., San Francisco, 1971. A petawatt is 10^{15} watts).

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