Future Energy: Opportunities and Challenges

Part I. Getting Started

Chapter 3. Energy Production and Consumption

Future Energy:
Opportunities and Challenges

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3
Energy Production and Consumption

The Main Points

- **World energy consumption in the early twenty-first century was around 500 Quads per year.**

- **The U.S. has long been the largest energy consumer in the world, but was surpassed by China in 2009 when each country accounted for around 20 percent of world energy consumption.**

- **U.S. energy consumption in the early twenty-first century was around 100 Quads per year.**

- **In the early twenty-first century, imports provided around 30 percent of total U.S. energy and over 60 percent of oil and oil derivatives consumed in the U.S. (costing the U.S. around a billion dollars a day).**

- **U.S. oil production has been declining since around 1970.**

- **Unconventional oil (oil sand and oil shale) reserves are large, but they face economic and environmental issues.**

- **Large natural gas reserves exist in the U.S. Most of this gas requires advanced extraction methods, usually the fracturing of underground gas-bearing rock formations (called hydrofracturing or fracking).**

- **Coal is plentiful but dirty.**

- **Nuclear power can furnish a significant fraction of electrical energy production without greenhouse gas emissions, but it is controversial because of safety concerns.**

- **America gets around 85 percent of its energy from fossil fuels. All fossil fuels release carbon dioxide into the atmosphere when used for energy production.**

3.1 Overview

This chapter addresses levels of energy production and consumption in the past and present. Understanding where we are and how we got here is crucial in defining the changes necessary to achieve energy sustainability. Later chapters will address the possibilities for future energy production and consumption.

Statistics do not make very exciting reading, but some consideration of statistical data is needed to develop a comprehension of the world and U.S. energy situations. Various organizations have collected, tabulated, and graphed a huge volume of every sort of statistical data related to energy. Here, only the data considered essential for understanding the past and present energy story are included.

It is hard to get a feel for large-scale energy production and consumption because the numbers are so large that relating them to familiar experiences is impossible. But we can all relate to a quantity like a BTU. Recall that it is just the energy required to raise the temperature of a pound of water by one degree Fahrenheit. Compare this with U.S. and world energy consumption, which is measured in quadrillions of BTUs. Since large energy considerations often involve quadrillions of BTU, a new unit, the Quad, has been defined. A Quad is 1 quadrillion (10^{15}) BTUs.

One point of reference in considering energy production and consumption is the total energy falling on the earth from the sun every year. This energy input amounts to about 5 million Quads per year. By contrast, human activities result in producing around 500 Quads per year. The man-produced energy is around 1/100 of one percent of the energy flowing from the sun.

A comprehensive source of statistics on past energy production and consumption is the Energy Information Administration (EIA), a branch of the U.S. Department of Energy. EIA publishes an Annual Energy Review and posts it on the web at http://www.eia.doe.gov/emeu/aer. The EIA website is a source of a wealth of information on energy production and consumption. It is recommended for readers who want to dig deeper. EIA statistics were used as the main source of statistical information in this chapter.

There are other valuable sources of statistics on energy production and consumption. One of these is the British Petroleum BP Statistical Review of World Energy at http://www.bp.com/statisticalreview. This publication appears annually and was used in this chapter for more recent data than is available from EIA. Another useful source is the International Energy Agency (IEA), which publishes a report titled "Key World Energy Statistics" (available at http://www.iea.org). It should be noted that the different statistical reviews report slightly different values for the same data because of different data collection and analysis methods. However, the results from different sources generally agree within a few percent, and trends are comparable. Both BP and IEA report energy consumption in Million Tonnes of Oil Equivalent (MTOE). MTOE may be converted to Quads by multiplying by 0.03979. (Note: A tonne is a metric ton or 1,000 kilograms or 2,200 pounds.)

The most recent available data on energy production and consumption (at the time of writing) are presented in this chapter. These data suffice for giving a snapshot picture of energy production and consumption. Readers can find current information at the EIA, BP, or IEA website.

3.2 World Energy Production and Consumption

World energy production and consumption in 2009 was about 488 Quads. 2009 world energy production by source (rounded off) was as shown in Table 3-1.

Figure 3-1 shows historical data for world energy consumption. Figure 3-2 shows the shares of total world energy use for three major energy consumers through 2009. The figure shows the recent history for energy consumption in the U.S. and in China and India, two developing countries that have (or will have) major impacts on world energy consumption. This is one of the

Table 3-1. World Energy Production by Source (2009)

Source	Energy Produced (Quads)	Percentage of Total
Coal/peat	132	27.0
Natural Gas	103	21.1
Oil	162	33.2
Nuclear	28	5.8
Hydroelectric	11	2.2
Other	52	10.7
Total	**488**	**100.0**

Data Source: International Energy Agency

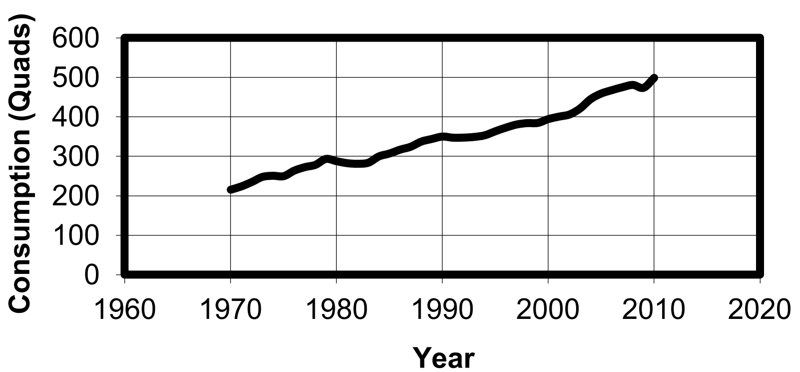

Figure 3-1. World Energy Consumption

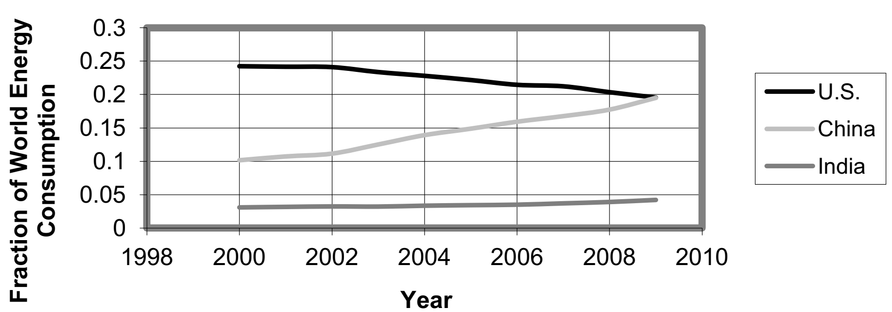

Figure 3-2. Shares of World Energy Consumption

most revealing figures in the book since it shows the shift towards consumption in China, which is now the major driver of increases in world energy demand. China's energy use surpassed U.S. levels in 2009[1]. Since China's population was over four times larger than the U.S. population, China's per capita energy consumption in 2009 was about 23 percent of U.S. per capita consumption. China's per capita consumption is expected to grow as development proceeds. India has not yet experienced the rapid growth in energy consumption seen in China, but similar growth is anticipated.

3.3 U.S. Energy Production and Consumption

In the early twenty-first century, the U.S. consumed around 100 Quads of energy per year. This amounts to about 11 kw of power per person in the U.S. (around 38,000 BTU per hour). This power is the sum of power used directly by individuals and power used in all of the business, industry, and government activities that support the human population. The rest of the world uses about 390 Quads per year for a population that is about 20 times the U.S. population, resulting in average power use of about 6,300 BTU per hour (or 1.8 kw per person). Of course, there are great variations in power use in different countries.

In 2009, the U.S. energy consumption by source (rounded off) was as shown in Table 3-2. (The consumption figures include consumption of foreign as well as domestic resources.)

Table 3-2. U.S. Energy Consumption by Source (2009)

Source	Energy Consumed (Quads)	Percentage of Total
Coal	19.6	20.9
Natural Gas	23.4	24.7
Oil and other liquid hydrocarbons	35.3	37.3
Nuclear	8.4	8.9
Hydroelectric	2.7	2.9
Other	5.0	5.3
Total	**94.6**	

Source: U.S. Energy Information Administration

The "Other" category for U.S. production includes small, but increasing, renewable energy.

Figure 3-3 shows historical U.S. energy consumption. U.S. energy consumption in 2009 by use by sector is shown in Table 3-3 (values rounded). Primary energy is energy consumed to produce delivered energy, the energy remaining after losses in production, and in delivery to the site where the energy is used.

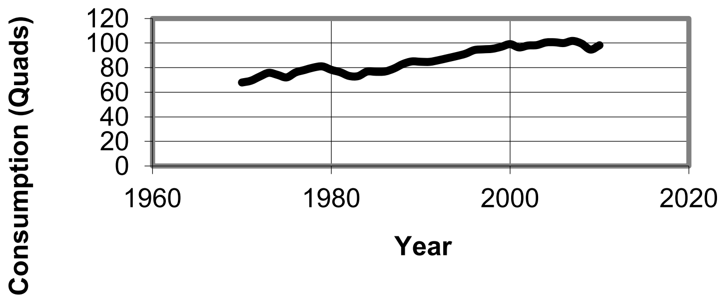

Figure 3-3. U.S. Energy Consumption

Table 3-3. U.S. Primary Energy Consumption by Sector (2009)

Sector	Consumption (Quads)	Percentage of Total
Residential	21	22
Commercial	18	19
Industrial	28	30
Transportation	27	29
Total	**94**	

Source: U.S. Energy Information Administration

2009 U.S. domestic energy production by source is shown in Table 3-4.

Table 3-4. U.S. Domestic Energy Production by Source (2009)

Source	Production (Quads)	Percentage
Coal	22	30
Natural Gas	22	30
Crude Oil	11	15
Nuclear	8	11
Hydroelectric	3	4
Natural Gas Plant Liquids	2	3
Other	4	5
Total	73	

Source: U.S. Energy Information Administration. Note: Production values and percentage values are rounded, causing a small difference between totals reported and the sum of individual entries. The total production reported is correct.

In 2009, the U.S. imported around 30 Quads of energy and exported 7 Quads.

Figure 3-4 shows the 2009 U.S. energy flows in a very useful and comprehensive format. The Lawrence Livermore National Laboratory prepares such diagrams annually[2].

3.4 Oil Production and Consumption

Because oil is crucial to the transportation sector, and because the U.S. depends heavily on oil imports, data on oil production and consumption are addressed separately.

The U.S. consumed 19 million barrels of oil per day in 2009. (A barrel of oil is 42 U.S. gallons.) U.S. production provided about 7.2 million barrels per

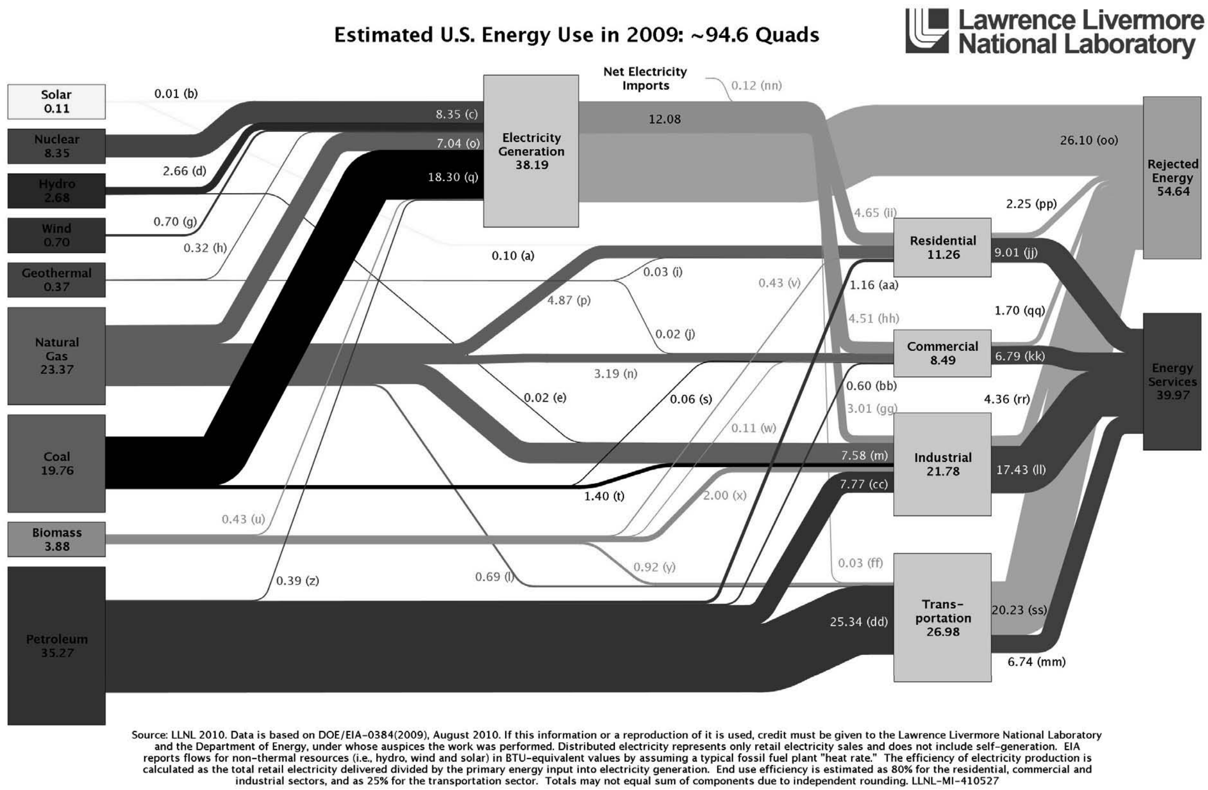

Figure 3-4. Energy Flows (courtesy of Lawrence Livermore National Laboratory)

day (38 percent), and imports provided 11.7 million barrels per day (62 percent). Historical data on U.S. oil production and consumption are shown in Figure 3-5.

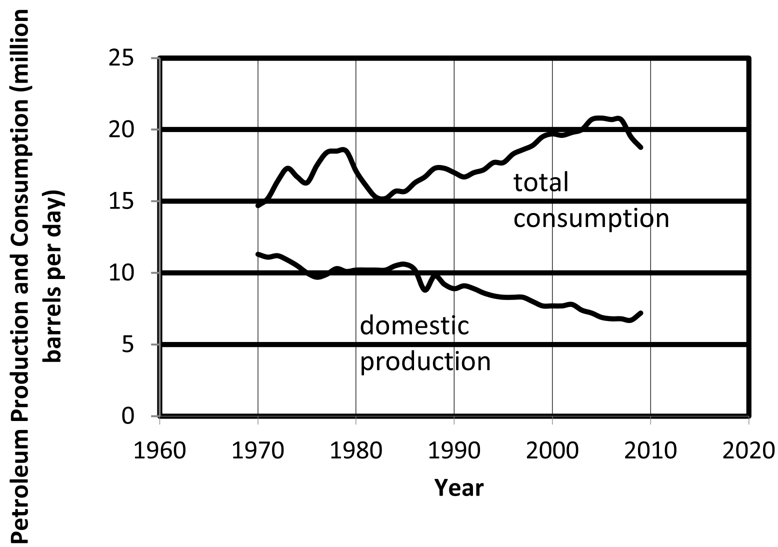

Figure 3-5. U.S. Petroleum Production and Consumption

Most of the imports of oil by the U.S. (75 percent) come from 10 countries. The amount from each foreign supplier is shown in Table 3-5.

Table 3-5. U.S. Oil Imports (2010)

Country	Imports by U.S. (millions of barrels per year)	Percentage of U.S. Imports
Canada	924	22
Mexico	467	11
Saudi Arabia	399	9
Nigeria	374	9
Venezuela	360	8
Russia	222	5
Algeria	185	4
Iraq	151	4
Angola	143	3

Source: U.S. Energy Information Administration

Clearly, this list includes countries with questionable long-term stability and friendliness toward the U.S. The peril of U.S. dependence on foreign oil is obvious.

Importing 11.7 million barrels per day (2010 rate) at a price of $100 per barrel (spring 2010 price) costs about $1.2 billion per day ($438 billion per year). Analysts expect oil prices to fluctuate, but with a continual upward trend. The point to remember is prices will vary, but the cost of imported oil is in the range of $1 billion per day.

Domestic and imported crude oil is processed to provide desired products. Most crude oil is used to produce gasoline. The breakdown of products produced from oil is as shown in Table 3-6.

Table 3-6. Products Produced from Oil

Product	Percentage
Gasoline	46
Distillate Fuel Oil	21
Jet Fuel	9
Coke	5
Still Gas	4
Residual Fuel Oil	4
Liquefied Gas	4
Asphalt and Road Oil	3
Other	4

Source: U.S. Energy Information Administration

Almost all the oil being used in the early twenty-first century is crude oil that is extracted from the earth in liquid form. Additional resources exist in the form of oil sands and oil shale. These resources are hydrocarbons that must be mined and processed to provide liquid hydrocarbons that are similar to crude oil (see Sections 4.3 and 4.4).

3.5 Natural Gas Production and Consumption

Natural gas is a fossil fuel composed mostly of methane (typically around 90 percent) and smaller amounts of ethane, butane, and propane. The heavier gases (butane and propane) are separated from the methane and ethane. The higher boiling points of the heavier gases (-28°F and -11°F for isomers of butane and -47°F for propane) make it possible to liquefy them with modest pressurization. Liquefaction increases the density of the gases and facilitates their delivery for use as a fuel. Butane lighters and propane-fueled grills are commonplace.

The methane and ethane in natural gas provide a convenient fuel for residential, commercial, and industrial applications. Natural gas use for electric power generation is increasing because of cost and environmental advantages. The chemical industry uses large quantities of natural gas as a feedstock for producing various chemicals. There is also minor use as a transportation fuel, and this type of use is increasing.

Natural gas reserves are said to be conventional or unconventional. In extracting conventional gas, it is only necessary to drill into gas-bearing underground formations. The reduced pressure at the well bore causes flow from the higher-pressure gas formation. The extraction of unconventional gas requires modification of underground conditions (specifically, fracturing gas-bearing rock to provide flow passages for the gas). Unconventional gas already contributes significantly to U.S. production, and many analysts[3] are confident that great quantities of unconventional gas can be extracted economically.

Natural gas reserves are said to be "proved reserves" if it is reasonably certain that gas can be extracted competitively under existing economic and operating conditions. Proved reserves include conventional gas and economically recoverable unconventional gas.

Some natural gas reserves occur in small pockets that are far from existing pipelines. This is called "stranded gas." It is currently uneconomical to exploit much of the stranded gas.

Methane is also produced continuously and naturally by the anaerobic digestion of dead plant and animal matter. Thus, methane may be viewed also as a renewable energy resource (see Chapter 7).

Natural gas quantities are measured in cubic feet evaluated at standard temperature and pressure (a temperature of 60°F and one atmosphere of pressure). The energy content of natural gas is about 850 to 1050 BTU per cubic foot (low heating value or LHV) and 950 to 1150 BTU per cubic foot (high heating value or HHV).

Figure 3-6 shows U.S. natural gas production and consumption. The 2008 U.S. consumption of natural gas was around 23 trillion cubic feet. The U.S. produced about 82 percent of the natural gas that it consumed in 2008. The balance was imported. Hydrofracturing has since enabled large increases in U.S. natural gas production. The U.S. is poised to become an exporter of gas.

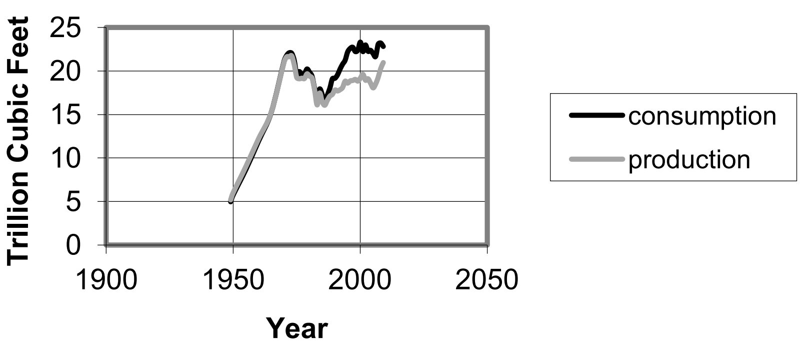

Figure 3-6. U.S. Natural Gas Production and Consumption

The end uses of natural gas are as shown in Table 3-7.

Table 3-7. U.S. Natural Gas Uses

Use	Percentage of Total Use
Industrial (excluding electric power)	30
Residential	20
Electric Power	29
Commercial	13
Oil & Gas Industry Operations	5
Pipeline Fuel	3
Transportation	0.1

Source: U.S. Energy Information Administration

World annual consumption is around 110 trillion cubic feet (2008).

Proved reserves of natural gas in the U.S. are estimated to be 284 trillion cubic feet (2011). The reserves estimate has been increasing every year in recent years because of the addition of unconventional (but proved) gas. The U.S. share of proved world natural gas reserves is around 3 percent. Estimated proved world reserves are around 6,100 trillion cubic feet, with almost 60 percent occurring in OPEC countries. Of course, new hydrofracturing extraction technology for unconventional gas provides access to much more economically recoverable gas (up to 10 times as much as current proved reserve estimates). However, as we shall see in Chapter 4, there are environmental issues related to hydrofracturing. It remains to be seen whether these issues will limit the use of hydrofracturing technology to extract natural gas.

3.6 Coal Production and Consumption

The U.S. consumes about 1.1 billion tons of coal per year (2010). This was around 15 percent of world coal consumption. (Note: Coal consumption in China was double the U.S. consumption in 2010.) Over 90 percent of U.S.

coal consumption is in electric power plants. Figure 3-7 shows U.S. coal production. Essentially all U.S. coal is produced domestically.

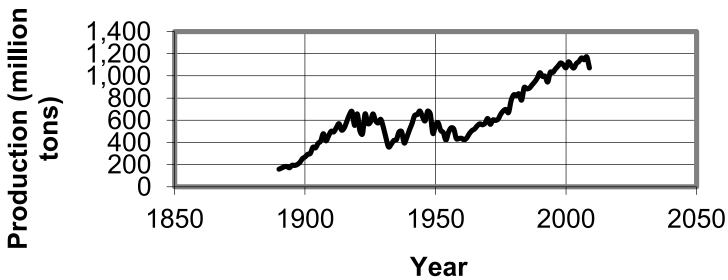

Figure 3-7. U.S. Coal Production

The estimated recoverable coal reserves in the U.S. total about 264 billion tons. There is much more coal in the ground than 264 billion tons, but not all of it is economically or technically recoverable.

The estimated world recoverable coal reserve is about 1 trillion tons.

Coal combustion yields about 20 million BTU per ton. Therefore the energy in the recoverable coal reserves is about 5400 Quads for the U.S. and about 20,000 Quads for the world.

Clearly, coal is a huge energy resource, but its use has environmental consequences. Pollution and climate change concerns may prevent full exploitation of the coal resource. See Chapter 4 for details.

3.7 Uranium Production and Consumption

Uranium occurs in low concentrations, even in the richest ores. However, since the amount of energy available from each pound of uranium is very large, high mining and refining costs are tolerable. The ore cost in a modern nuclear power plant currently contributes only about five percent to the total cost of producing electricity.

The size of the recoverable uranium resource depends on the cost of the ore. 2010 ore costs were about $130 per kilogram. Estimated U.S. reserves available at $130 per kilogram are 200,000 metric tons, and estimated world reserves are around 5.3 million metric tons. Much larger uranium reserves are available at higher cost, and using higher cost ores would have a small impact on nuclear power costs.

Current reactor designs (mostly light water reactors) require around 200 metric tons of uranium ore per year to fuel a 1000 MWe (megawatts electric) reactor that operates at full power 90 percent of the time. This translates into about 7,400 metric tons per Quad of electrical energy or 2,500 metric tons per Quad of thermal energy per year.

Current reactor designs can produce around 80 Quads of thermal energy with the estimated U.S. low-cost reserves of 200,000 metric tons of uranium ore. Advanced reactors, especially breeder reactors, require less fuel per unit of energy produced.

Extracting the energy from uranium ore requires the construction of nuclear power reactors. A power reactor with a rating of 1000 megawatts electric that operates 90 percent of the time produces about 0.08 Quads of thermal energy per year (0.027 Quads of electrical energy). Twelve large (1000 MWe) reactors would be needed to provide one Quad of thermal energy per year.

3.8 Electricity

Evaluation of the consumption of electrical energy requires special consideration. The U.S. produces about 90 percent of its electricity in thermal plants, that is, plants that use fossil fuel combustion or nuclear fission to produce heat and make steam that drives a turbine-generator, or natural gas that drives a gas turbine-generator. Fuels consumed in 2009 to produce electricity in thermal plants are coal (18.3 Quads), natural gas (7.3 Quads), petroleum (0.4 Quads), and nuclear (8.3 Quads). The remainder is hydroelectricity and electricity from other renewables.

Production of electricity in thermal plants unavoidably results in the production of waste heat. Only 35 to 40 percent of the energy released in a coal or nuclear thermal plant can be captured as electricity. (Somewhat higher efficiencies can be achieved in dual cycle natural gas powered plants, plants that use hot exhaust gases to produce steam that drives a second turbine.) The remainder of the energy is lost to the environment as heat. Further electrical losses of 5 to 10 percent occur during transmission and distribution. About 30 percent of the total energy that was consumed to make electricity in thermal plants is delivered to the end user as electrical energy.

Electricity is a significant part of current energy use in all sectors except transportation. In order to account for all energy consumed, consumption figures are based on the energy used to produce, transmit, and distribute electricity rather than actual electrical energy consumed by the end user. The annual U.S. consumption of energy to produce electricity is about 39 Quads, and consumption of delivered electrical energy is about 13.5 Quads: 9.3 Quads from fossil plants, 2.7 from nuclear plants, 0.9 Quads from hydroelectric plants and 0.5 Quads from other renewable sources.

3.9 Greenhouse Gas Release and Pollution from Energy Production

(All data reported in this section were obtained from Reference 4.)

The consumption of fossil fuels results in the release of greenhouse gases and pollution. Carbon dioxide is the principal anthropogenic greenhouse gas. The percentage of total releases of carbon dioxide attributable to each energy sector is shown in Table 3-8.

The main pollutants related to fossil fuel energy production are carbon monoxide, oxides of nitrogen, volatile organic compounds, particulate matter, sulfur dioxide, and ammonia.

Table 3-8. Carbon Dioxide Emissions (2009 data)

Energy Sector	Percentage of Energy-Related CO_2 Release
Residential	21.4
Commercial	18.8
Industrial	25.6
Transportation	34.2

Source: U.S. Energy Information Administration

The estimates of the release of carbon dioxide into the atmosphere by anthropogenic causes ranges from about 6.4 billion tonnes of carbon contained in 23.5 billion tonnes of carbon dioxide to about 7.2 billion tonnes of carbon contained in 26.4 billion tonnes of carbon dioxide per year. The issue relative to climate change is:

How significant are the effects due to anthropogenic causes as compared to natural effects due to natural causes?

This issue will be addressed in more detail in Chapter 19, but it is useful to examine the pertinent facts here. Anthropogenic carbon dioxide enters the atmosphere then distributes between the three natural reservoirs: the atmosphere, the oceans, and the terrestrial sinks (plants and soil). The annual anthropogenic emissions are small compared to the total carbon contained in the natural sinks (730 billion tons in the atmosphere, 2,000 billion tons in terrestrial sinks, and 38,000 billion tons in the oceans)[4]. However, the carbon dioxide accumulates in the atmosphere over time and can grow to levels that are significant compared to natural levels.

3.10 Energy Recoverable from Non-Renewable Resources

Fossil and nuclear energy reserve estimates are summarized in Table 3-9. Total estimated remaining reserves and estimated recoverable reserves are presented. These estimates are subject to various uncertainties. Total reserves are based on analysis of geology and past production histories by experts. Information for U.S. reserves is generally more reliable than estimates in some other countries. Some countries lack the expertise to make good estimates, and some may falsify estimates for economic or political purposes. Recoverable reserves are less than remaining reserves because of technical, environmental, safety, and economic constraints. Estimates of recoverable reserves are especially sensitive to the cost of extracting and processing the resource. Low-grade deposits may contain large quantities of a resource that are uneconomical to extract. Of course, scarcity could make it practical to extract previously uneconomical resources.

Table 3-9. Non-Renewable Energy Resources

Non-Renewable Resource	Reserve Quantity		Energy Content (Quads of Thermal Energy)	
	WORLD	U.S.	WORLD	U.S.
COAL (billion tons)[c]	1,000	270	20,000	5,400
OIL (billion barrels)[o]	1,000 to 2,000	20[v]	6000-12,000	120
NATURAL GAS[ng] (trillion cubic feet of proved reserves)	6,200	200	6,200	200
NATURAL GAS[ung] (trillion cubic feet of gas if unconventional reserves are exploited fully)[t]	?	1,800 to 2,000	?	1,800 to 2,000
OIL SHALE (billion barrels)[s]	3,000	2,000	60,000	40,000
OIL SANDS (billion barrels)	3,000	2	60,000	40
URANIUM (million tonnes)[u] (at $130/ kilogram or less and current reactor designs)	5.3	0.2	2120	80

c: Average coal energy content: 20 million BTU per ton. Energy Information Administration http://www.eia.doe.gov/oiaf/ieo/coal.html

o: Energy Information Administration provides the U.S. reserve estimate. http://www.eia.doe.gov/neic/quickfacts/quickoil/html

s: U.S. Energy Information Administration http://www.eia.doe.gov

t: Recovering indicated quantities depends on determining that hydrofracturing has acceptable environmental impact

ng: Energy Information Administration website http://www.eia.doe.gov

ung: Unconventional natural gas reserves are unproved, but many analysts believe that this resource is economically recoverable.

u: Based on an estimated 200 tonnes per year for a 1000 MWe reactor.

v: It should be noted that application of hydrofracturing is providing access to new oil recoverable reserves. The size of the increase over the reported 20 billion barrels is still unknown.

3.11 Interpretation

Statistics are of little value until someone analyzes them and transforms raw information into useful knowledge. The result of this analysis depends on the capability and bias of the analyst. The reader may choose to perform his/her own analysis, but some conclusions that appear to be suggested by the data are presented below with the acknowledgment that they were filtered by the author's capability and bias.

The statistics relate to two issues: energy availability and environmental effects.

The most striking availability statistic is the reliance of the U.S. on imported oil. U.S. oil production peaked years ago, and remaining reserves are far less than needed to satisfy current and anticipated demands. The expense of purchasing oil from other countries is enormous and a cause for concern. In addition to the cost, one must worry about the continued availability of foreign supplies. There is no assurance that these countries will be able or willing to satisfy America's thirst for oil. Oil sands and oil shale contain huge quantities of hydrocarbons that can be converted into a substitute for crude oil, but cost and environmental impact are limiting factors in using these resources.

Proved U.S. reserves of natural gas will satisfy domestic needs for only about a decade, but there is a huge unconventional resource that could increase supply enough to satisfy consumption at the current rate for around a century if, as expected by many analysts, this resource is exploited fully. However, there are still unresolved environmental issues that may limit the production of unconventional gas.

Coal and uranium can supply large quantities of energy from domestic resources, but both face implementation hurdles. For coal, the main issue is environmental impact. For nuclear, the main issue is safety.

Carbon dioxide releases from fossil fuel use are significant compared to the inventory of atmospheric carbon dioxide and to the natural exchanges between earth, sea, and air. As we shall see in Chapter 19, there is strong evidence that the use of fossil fuels creates undesirable environmental effects, especially global warming. The U.S. gets around 85 percent of its energy from fossil fuels. If America decides global warming concerns require a reduction in fossil fuel use, a huge transition will be required. The same can be said of fossil fuel use in other countries.

The environmental effects of hydrocarbon combustion in transportation are important (especially in urban areas where vehicle use is concentrated), but these emissions represent less than one third of total carbon dioxide emissions. Producing electricity depends heavily on coal and, to an increasing level, natural gas. Both of these fuels release carbon dioxide when burned, and coal use also releases significant quantities of pollutants. Reducing atmospheric contamination from carbon dioxide and pollutants will require changes in energy production and energy use. Options for change are outlined in subsequent chapters.

References

1. British Petroleum Report "BP Statistical Review of World Energy June 2011" available at http://www.bp.com/statisticalreview.

2. Lawrence Livermore National Laboratory website, available at http://www.llnl.gov.

3. Natural Gas Supply Association website, available at http://www.naturalgas.org.

4. Energy Information Administration Report, "Greenhouse Gases, Climate Change and Energy," November 2003, http://www.eia.doe.gov/1605/ggcebro/chapter1.html.

Exercises

3-1. World energy consumption in 2007 was 475 Quads. Use the Internet to find the world energy consumption last year. Discuss plausible causes for the new energy use level.

3-2. Repeat Problem 3.1 for U.S. consumption.

3-3. What was world energy consumption in Exajoules in 2007?

3-4. Use the Internet to discover recent energy use levels in China and India. Discuss the results.

3-5. Use the Internet to find information on recent trends in solar, wind, and geothermal energy production in the U.S. Discuss your findings.

3-6. Use the Internet to find the current price of oil and the current daily consumption of imported oil in the U.S. How much does the U.S. currently spend per day for imported oil?

3-7. Use the Internet to find current energy production with natural gas in the U.S.

3-8. How much carbon dioxide (tons) is produced by coal combustion in the U.S. by burning 1.1 billion tons? Assume coal is pure carbon. (Note that carbon dioxide is CO_2. Since carbon has an atomic weight of 12, and oxygen has an atomic weight of 16, CO_2 is 27.3 percent carbon by weight.)

3-9. Hydrofracturing (or fracking) is widely used in the U.S for extracting natural gas. Use the Internet to discover the current production of shale gas by fracking in the U.S. In 2011, the French government banned the use of hydrofracturing in France. Why do you think the French made this decision?

3-10. How many U.S. jobs could be created by the money saved if the U.S. cut its oil consumption in half by increasing vehicle efficiency and switching to renewable and electrical energy? Assume each job requires $100,000 for salaries, benefits, and overhead.