Energy: The American Perspective

Energy Resources in the Nineteenth Century

The major sources of energy in the United States for most of the nineteenth century were wood, water, and wind. Wood was important to both home and industry as a source of fuel and heat. It was the principal fuel for railroads and steamboats until about 1879, and was used in the form of charcoal by about half the iron producers in 1850. The abundance of wood during the first half of the nineteenth century resulted in a great deal of misuse. Most of it was consumed in open fireplaces rather than in the more efficient Franklin stove. (As much as 90 percent of the heat produced by burning wood in old-style fireplaces goes up the chimney---not a very efficient way to use fuel!) There are no statistics on the number of waterwheels and windmills that existed across the North America in the 1800's, but both were significant sources of power for farms and industries.

Work derived from animals was a major source of energy for the US well into the second half of the nineteenth century and, in absolute terms, it continued to increase until 1910. The following table compares animal work output to inanimate work output in terms of billion horsepower hours:

	Work Output (billion horsepower hours)	
Year	Work Animals	Inanimate Energy Sources
1850	5.4	3.6
1860	7.6	5.9
1870	8.4	8.5
1880	11.1	16.0
1890	14.4	30.3
1900	16.9	57.6
1910	19.0	142.8
1920	15.2	268.1

One horsepower hour is defined as the work performed or energy consumed by working at the rate of one horsepower for one hour; it is equal to 1,980,000 foot-pounds (one foot pound is equal to the work done in raising one pound against the force of gravity the height of one foot) and is approximately equal to the output of a motor consuming 750 Watts of power for one hour.

Although coal was used by the Hopi Indians in Arizona as early as 1000 AD, American Colonialists did not mine it because wood was so abundant. America, unlike Britain, did not use coal during its early industrialization until, by the middle of the nineteenth century, it was realized that two tons of wood could be replaced by half a ton of coal at half the cost. As wood became scarce and more expensive, and with techniques for burning coal resulting in greater efficiency (such as coal-fired steam generators), the use of coal increased. By 1895, half of America's energy came from wood, and half from coal.

By the middle of the nineteenth century, efficient and cheap lubricants and illuminates were needed to replace scarce and expensive whale oils. The Pennsylvania Rock Oil Company struck oil in 1859. During that year, 4,215,000 barrels of oil (the equivalent in energy content to nearly a million tons of coal) were produced in the US Only 30 years later, fuel accounted for 35 percent of total petroleum sales. During the nineteenth century, petroleum production increased at a rate faster than domestic consumption.

Natural gas has not always been a valuable energy source. During the first half of the nineteenth century it was considered a nuisance whenever it was encountered in water and salt wells. Gas was often found during searches for petroleum, but it was still considered a waste product and was burned off at the well; wood and coal provided necessary heating, and kerosene was used for lighting. There were, however, exceptions to the general attitude toward natural gas. Fredonia, New York, was using natural gas as fuel for lights in 1821, and by the late 1860's it was used on a small scale for making firebricks and as a source of lampblack for printers' ink. Furthermore, isolated experiments were being made on natural gas by iron and steel works neat Pittsburgh to determine whether or not gas could be used for space heating and stream generation.

In 1878, a large gas well was discovered near Murrysville, Pennsylvania and in 1883 a pipeline running from this well to Pittsburgh was opened. In the early 1880's, serious searches for natural gas were conducted in Ohio, and in 1884 the searches resulted in the discovery of large gas reservoirs which were subsequently tapped in order to supply local industrial plants with cheap fuel. But natural gas still could not be used extensively because an adequate way to transport it had not been developed.

With the new energy sources came many new technologies. The electric light was invented in 1879, but more important was the world's first electrical power generating and distribution system built in 1882 by Thomas Edison in New York. Less than a month later, the first hydroelectric power facility began generating on the Fox River in Appleton, Wisconsin. The hydroelectric plant at Niagara Falls began operating in 1896, and by 1900 hydroelectric power accounted for about 2.6 percent of all US energy consumption, or about 52 percent of all the electricity generation.

The following table shows the total US energy consumption in 1850 and 1900:

Energy Resource	**1850**	**1900**
Coal	9.3%	71.4%
Oil	-----	2.4
Natural Gas	-----	2.6
Hydropower	-----	2.6
Fuel Wood	90.7	21.0

Energy Resources From 1900 to World War II

From 1900 to World War II, wood comprised only a small fraction of the total energy pool, but the amount of wood used was still substantial and surpassed hydropower as an energy source well into the 1940's. It was used mostly for heating and cooking in rural homes. Hydropower before 1900 accounted for 57 percent of all electricity generated but by 1950 accounted for only one third; in 1975, it provided less than 4 percent of our electricity. Electricity generation, however, increased slowly but steadily until the end of World War I when it began to accelerate rapidly; form the mid-1930's to the early 1970's the annual per capita growth rate for electricity was 7 to 9%, except for the years of World War II. (This growth rate has slowed dramatically to 1-2% in the last 10 years). A dramatic shift also and occurred in the use of coal in the early twentieth century. Between 1885 and World War I its production had doubled, but after 1920 it began to drop rapidly. In 10 years the ration of coal-to-oil consumed dropped from six-to-one (1918) to two-to-one (1930).

The demand for petroleum products began to outstrip petroleum production between 1900 and 1955. During this period, consumption expanded 70 times, while production expanded to 40 times above the 1900 level. After World War II, the increase in US demand began to surpass domestic production, with the amount of net oil imports greater than the amount of net coal imports. The natural gas production rate also rose 40 times above the 1900 level by 1955. From 1900 to 1920 natural gas was mostly used for home and commercial purposes, but from 1920 until the end of World War II industrial consumption surpassed residential and commercial consumption. In 1955, the consumption of all liquid and gaseous fuels began to exceed domestic output. By 1955 the US was a net importer of fossil fuels.

A new energy era was born on December 2, 1942, when the first nuclear chain reaction was demonstrated at the University of Chicago by Enrico Fermi and his associates. Less than 10 years later, electricity was produced from atomic energy. In 1974, approximately two percent of this nation's energy needs (almost 10 percent of our electricity) was provided by nuclear power. This figure now stands at only 4% due to the tremendous increased costs of construction of nuclear plants and regulatory licensing problems.

Energy Resources From World War II Until 1976

By the end of World War II, petroleum fuel consumption had caught up with coal consumption. From 1940 until 1971, crude oil consumption tripled and natural gas consumption increased more than eight-fold. Although oil and gas together accounted for approximately 70 percent of aggregate US energy consumption in 1960, coal was still the preferred fuel in the production of ferrous metals and in the generation of electricity. Since 1960, the use of oil and natural gas continued to grow. The following table shows the status of US energy resources in 1974:

Energy Source	Percent of Energy
Petroleum	46%
Natural Gas	30%
Coal	18%
Nuclear	2%
Hydro	4%

The total energy consumption in the US more than doubled since 1950 while the population increased by approximately one-third. In 1954, this country was a net exporter of energy; in 1974 it was importing almost 15 percent of its total energy fuels and 35 percent of its oil.

The American Energy Crisis of 1973-1974: Background and Summary

Around 1954, the major American petroleum companies began to see their profits on crude production as well as their share of the international crude oil market start to decline. In 1960, the Organization of Petroleum Exporting Countries (OPEC) was formed. Initial membership consisted of five leading petroleum producers: Iraq, Iran, Kuwait, Saudi Arabia, and Venezuela. Their goals were to gain full control over the development of their oil resources and over the rate of oil production and the oil market price. OPEC's leverage was not strong in the 1960's but during the period form 1971 to 1973, OPEC members began to force oil prices upward. By 1973, 13 states in the Arab Middle Eat , Africa, Asia, and South America were members of OPEC and accounted for 86 percent of the world's oil trade. During this period, a series of participatory agreements were negotiated by OPEC countries with companies operating within their borders. The situation changed, however, when the Arab-Israeli war broke out on October 6, 1973. Eleven days later, a conference of Arab oil ministers in Kuwait decided to use the "oil weapon" in support of the Arab cause. Petroleum-consuming countries were treated according to their stand on the Arab-Israeli issue. On October 19, King Faisal decided to impose an oil embargo when he learned that the US government planned to send $2.5 billion in arms aid to Israel. A complete embargo was declared against the US and the Netherlands; "friendly states" were exempted. Two months later , the OPEC governments were posting prices of $11.65/barrel for crude oil---almost four times the posted price that prevailed before the war began. The embargo ended with Americans waiting at the gasoline pumps, still in shock of the sudden realization of our growing dependence on foreign powers, but not yet truly convinced that anything could or should be done about it.

The international oil crisis of 1973-1974 precipitated an “energy crisis” for the US and other industrial countries. The Arab (Middle East) countries, an important source of our petroleum products, suspended shipments of oil to the US for several months. But the Arabs did not cause the “energy crisis”---they merely showed that we have a serious energy problem. The roots of the problem go back to patterns of consumption and production of nonrenewable resources which began in the US during the mid-nineteenth century.

United States Energy Use: 1975-1983

The period after the OPEC embargo of 1973-974 was characterized by tremendous increases in the prices of all forms of energy and double digit inflation in the United States. Another Arab/Israeli war in 1982 coupled with a moderate to severe recession to actually reduce the total energy consumption. This was accomplished by reducing the total industrial consumption through the business slowdown and by promoting energy conservation through economic necessity for the individual. These and other trends are summarized in the following table. They show also that while our oil usage decreased, natural gas and especially coal increased. Nuclear remained fairly stagnant at 4%. Most importantly, our dependence on imported energy was finally reduced. The exponential growth of the 40’s to early 70’s was halted, and Americans were stimulated out of economic necessity to conserve.

Energy Facts

Consumption

Fuel	**1977**	**1978**	**1979**	**1980**	**1981**
Oil	48.6%	48.5%	47.4%	45.0%	43.0%
Natural gas	25.6%	25.4%	25.4%	26.8%	27.0%
Coal	18.6%	18.1%	19.5%	20.5%	22.0%
Hydro	3.3%	4.0%	4.1%	4.1%	4.0%
Nuclear	3.5%	3.8%	3.6%	3.6%	4.0%
Other	0.1%	0.1%	0.1%	0.2%	0.2%
Total (QBTU)	76.3	78.1	78.9	76.0	74.0
Net Import (QBTU)	20.1	19.3	19.6	16.0	14.0

World Standard of Living or Energy Servant Equivalents

Relative Personal Energy Utilization by Country
(old 1980's data but still useful)

Country	**Energy Servant Equivalents Used**
US	80.0
Canada	67.0
Czechoslovakia	45.0
E Germany	42.0
Sweden	42.0
Australia	40.0
UK	39.0
Denmark	36.0
W Germany	35.0
USSR	31.0
France	25.0
Switzerland	23.0
Hungary	22.0
New Zealand	21.0
S Africa	21.0
Japan	19.0
Italy	17.0
Israel	16.0
Argentina	11.0
Spain	10.0
Mexico	8.3
Cuba	8.0
Greece	7.7
Taiwan	6.2
Lebanon	5.4
Iraq	4.9
S Korea	4.4
Brazil	3.4
Turkey	3.4
S Vietnam	2.6
India	1.6
Thailand	1.5
Ghana	1.0
Pakistan	0.8
Ethiopia	0.2
World Average	12.9

This index is obtained by taking the sustenance energy required per person per day (2200 kilocalories) and dividing it into the energy used by each person each day.

Renewable and Nonrenewable Energy Resources

All the energy resources belong to one of two groups---renewable or nonrenewable resources. Non depletable energy resources are renewable; for example, the sun is a renewable resource, as is water. Less than 10 percent of all the energy resources consumed are renewable.

Depletable energy resources are nonrenewable. Fossil fuels---coal, oil, and gas---are nonrenewable because they were produced over million of years by vegetation under pressure in the earth's crust and heated by the sun. Uranium, another important energy resource, is also nonrenewable. More than 90% of all energy resources consumed are nonrenewable; in other word, America's high energy society is based upon finite, dwindling supply of energy.

Nonrenewable Resources

Coal: Coal is the only nonrenewable energy resource which still exists in any abundance. Proven US reserves are estimated to be 400 billion tons; possible resources are estimated as high as 3200 billion tons. This adds up to as much as 200 years' supply of coal at the current energy use rate

Coal is most often used to convert water to electricity or to make steam for industry, but more and more it is being converted directly to gas or oil which reduces the number of years coal will last. Coal's greatest disadvantage is that it creates many environmental problems. Because it is a "dirty" fuel, it causes air pollution (the higher the sulfur content, the more pollution; western coal has less sulfur, but more ash, than eastern coal). Strip-mining---they easiest and least dangerous method of coal mining---causes erosion and leaches waste into streams and watersheds. Companies which strip mine for coal (about half of all US Coal is strip mined) are being pressured to reclaim stripped land at high cost.

Natural Gas: Natural gas is the cleanest of the three fossil fuels and is in great demand for space heating. It's supply in the United State is limited (as is oil) in the long term. Research continues in how to convert other more plentiful energy resources into natural gas.

Oil: The total amount of oil available in the US and offshore is unknown, though estimated undiscovered recoverable resources average 89 BBL, and nearly 200 BBL might become economically recoverable. In the future, with natural gas , the price of extracting petroleum from US oil fields may become so high that we will change our present patterns. Costs will increase because most of the easy-to-get oil has been consumed and new, harder-to-get sources requiring more complicated technologies will have to be tapped. Exploration for additional oil reserves centers on sites under as much as 800 feet of ocean water as far as 25000 feet underground. Other large reserves of oil are trapped in rock called shale. Useful fuel can be extracted from oil shale, but the net energy produced may be small, the process expensive, and the environmental problems significant.

Uranium: Uranium, as a fuel for nuclear reactors, is a controversial energy source. It is favored by some because the potential energy of a given quantity of Uranium is several million times greater than the energy available from an equal quantity of any one of the three fossil fuels. Mining Uranium is a great deal more difficult than fossil fuels, however. Even the richest Uranium ore may contain only a fraction of one percent of Uranium. Because Uranium ore is not pure and the costs of extraction vary, the amount of reserves is hard to estimate. It has been suggested, though, that we only have thirty years worth left of Uranium 235---the Uranium necessary to produce fission reactions in conventional nuclear power plants. The drawbacks to fission as it is presently to produce electricity are the radioactive wastes and the safety concerns. The reserves of Uranium may be lengthened with possible future development of the breeder reactor. At the present time, breeder technology is not well-established, costs of development will be high, and it known that the waste product is extremely toxic and politically hazardous. If breeders can be successfully developed and these obstacles overcome, the effective amount of fissionable material (the plentiful Uranium 238 after being converted to Plutonium 239) is tremendously increased, which means that our current energy reserves of Uranium could last much longer. However since the Plutonium produced can be used as bomb material, the development of the breeder may never occur.

Renewable Energy Resources

Solar: Only a relatively few US homes have been constructed with solar heating systems; but solar heating and cooling could satisfy perhaps half the needs of all new residential and commercial buildings. Presently there are some very promising approaches to using solar energy for low temperature needs such as space water and heating, but the cost is still relatively high and functional solar storage systems must be developed to operate in conjunction with the solar devices. If solar equipment (lenses, mirrors, panels, and other devices used to concentrate the energy of the sun) can be manufactured cheaply enough, we could produce electricity either by a thermal cycle (making steam and driving a turbine) or by direct conversion using solar cells. The thermal cycle alternative is much closer to practical implementation, but is still several times as expensive as present methods of energy generation. The high popularity of solar power is closely related to individuals who strongly believe in alternate lifestyles and individual energy independence. These attitudes are also reflected by the large number of non-federal research and development activities taking place in all parts of the country (and world).

Geothermal: Large amounts of geothermal energy (heat in the form of steam, such as that found in geysers) are present in the earth's crust, but it is possible to tap these resources only in limited locations. Thus far development and exploration in the US has been conducted mainly in the West (California) because the most promising sites are found there. Geothermal energy is also being used in Japan, the USSR, New Zealand, Iceland, and Hungary for air conditioning and heating houses, heating greenhouses, processing paper, drying timber, and refrigeration.

Experts estimate that geothermal plants, where steam from the earth is used to drive turbines which generate electricity will also be used in the future. There are, however, a number of disadvantages to using geothermal energy in this manner. Equipment used in the plants tends to corrode quickly because of minerals which dissolve in the hot water. These same minerals can create some environmental problems in the form of ground water contamination, waste salts, and air pollution (including escaping hydrogen sulfide, which smells like rotten eggs). Finally, geothermal steam is not very hot, and so is an inefficient means of producing electricity (it also produces a lot of "waste heat").

Wind: Like geothermal energy, practical wind energy is found only in certain locations, mostly in the Midwest and Northeast. Even there, it is variable and must be accompanied by storage devices or used only for special purposes, such as pumping water for stock ponds. At present, however, wind power generators are being tested and used in Northern Europe, Russia, and the US. Unless research designers prove otherwise, many windmills will be needed to obtain a reasonable quantity of energy (thousands would be needed to equal the output of a single modern electric generating plant). Other difficulties to be faced by technologists are intermittent winds, lack of efficient storage units (e.g. batteries), and few favorable sites.

Tidal: Although suggestions have been made to harness the energy in tides, the total amount of tidal energy potential (20 million MW) would make a negligible impact on the world's energy supply. Furthermore, suitable locations are not where the demand is, and severe environmental problems could be cause by massive movements of water in and out of coastal areas. Other disadvantages are visual pollution if the generating facilities were in a resort area, corrosion of equipment by salt water, and high capital costs.

Hydro (Water): Most hydroelectric potential in the US is already being used and environmental problems will probably prevent the development of additional sites. It is estimated that it will provide only

10% of the nation's electricity demand. More hydro will be used for pumped storage systems which will use the spare capacity of "base load" electric plants (for example in the middle of the night) to provide power during periods of peak demand in the next day. Water will be pumped uphill for storage, and power will be produced later when it is released downhill. Thus, a pumped storage system is not a power source, but a means to avoid wasting unused power produced by any type of electricity generating facility (nuclear, hydro, coal-fired, etc.).

Wood: Wood is still an important energy source in "third world" nations and can provide a great deal of power for short periods. Wood could continue to be used as a renewable fuel if it were grown on "plantations" and then burned to produce electricity. The obvious disadvantage, however, is the competition for land use by the agricultural sector.

Refuse: Using our solid wastes as a supply part of our electrical demand is an idea which appeals to many people and , indeed, some small plants are already in operation or under construction which can produce electricity from solid wastes, such as the Nashville Thermal Transfer plant. Other possibilities being considered for refuse are converting it to methane and wood alcohol. But even if we took full advantage of the energy contained in all refuse, less than 10% of our energy needs would be met. Despite this small impact and regardless of its cost, we may be forced to use municipal wastes in these manners in order to avoid a serious environmental crisis in the near future.

Fusion: Although the key concepts and technologies which will unlock the intricacies of fusion are not yet known, fusion remains a major hope for significant quantities of power. Once developed, fusion could provide a long-range solution to the world's energy shortages because a nearly inexhaustible supply of deuterium (the fuel necessary to produce fusion power) is found in water. Two problems which must be overcome by scientists are 1) containing over a long period of time and under correct pressure, temperatures of 100,000,000 degrees Celsius reached during a fusion reaction and 2) disposing of fusion wastes. The date at which a fusion system can be implemented cannot be predicted; certainly it will not be commercially possible until the twenty-first century.

Methods of Transporting Energy

Fuels are transported by highway, rail, water, or pipelines; electricity is transmitted by wire or cable. The method used depends upon the characteristics of the fuel, its location, its excepted use, and its comparative costs versus distance. Transportation cost is particularly important to the consumer since this can determine what is used to heat homes. Cost is related to the "energy intensiveness" of each mode of transportation; for example, it takes almost four times as much energy to move one ton of fuel one mile by truck as by water or rail. Energy intensiveness must be balanced against distance, minimum required transportation time, and end use in order to determine the most cost-effective mode of transportation.

Coal, oil, and natural gas (liquefied) are often transported by water. Approximately one out of every five barrels of crude oil is transported to refineries by tanker (supertankers carry up to 300,000 tons), and about 30% of all refined oil is moved by water carrier. Natural gas can be moved by tanker only if it is in liquefied form; due to increased cost and the few number of special LNG (liquefied natural gas) tankers, this is not yet a common means of transporting natural gas.

Oil, natural gas, and coal can also be transported by pipeline. Natural gas and oil are particularly dependent on pipelines from well-head, to processing installation, to pumping station, to distributing center, to feasible, are rare due to opposition by railroads and difficulties in acquiring rights-of-way. Recent legislation, however, granting five pipelines the right of eminent domain may bring about increased use of coal pipelines.

The most efficient form of land transport today, besides pipelines, is the railroad. Two-thirds of all domestic coal is moved by rail since shuttle cars can conveniently move the heavy, bulky load nonstop form mine to power plant or industrial site. More efficient diesel engines which can pull greater loads have reduced the cost and energy intensiveness of railroads.

Over 40% of all refined oil products are moved by truck--the most energy intensive (and the most expensive) means of transportation. Considerably, less coal is transported by truck (only 10%), usually in those cases where mines are accessible by rail or water.

Electricity is transmitted from the power plant to the user by overhead powerline or underground cable. Over 300,000 miles of power lines are supplemented or replaced by an increasing number of cables for environmental, aesthetic, and safety reasons. Unlike overhead lines, which increase the voltage of electricity without major energy loss, and then reduce it again for consumption, cables can transmit electricity at lower voltages which is a more suitable way for end distribution to consumers.

Methods of Storing Energy

Whenever possible, fossil fuels, hydropower, electricity, and solar energy are stored for future use. The type of storage depends upon the particular energy resource. The type of electrical energy storage with which most people are familiar is a battery. Unfortunately, batteries are impractical for storing large amounts of energy. Recently, however, research has begun in developing efficient, long-lasting batteries. Improvements in storage batteries (zinc-air, lithium-sulfur, nickel-zinc) will facilitate energy storage for daily peak demand periods at generating facilities, emergency generation of electricity, and vehicles.

Each of the fossil fuels requires a different method of storage, depending on its production and how/when it is consumed. Coal is usually stockpiled outside the place where it will be burned. This is not very efficient since coal tends to deteriorate in the open air, but its bulk and weight precludes the use of any other storage method. Fortunately, better rail transportation direct from mine to user means shorter stockpiling times.

Natural gas must be stored in large underground reservoirs. Because the capacity of these storage pools is small (5.2 trillion cubic feet at most), utilities must cooperate closely with the producers in order to assure adequate gas supplies in the winter, when residential demand is five times as great as in the summer.

Crude oil is stored in pipelines or large tanks until it is needed at the refineries. Refined petroleum products are stored until they are needed in the consumer sectors; for example, heating oil is stored in tanks until it is needed for winter heating. Residences that burn oil are generally equipped with 2645-gallon tanks. In the future, these tanks may have a capacity as large as 1000 gallons. Though unsightly unless buried below ground level, these tanks will lessen the oil companies' storage and transportation costs. Gasoline, another refined petroleum product, is transported to service stations where it is stored in underground tanks until it is dispensed to motor vehicles.

Hydropower requires still different storage methods--either gravity water storage or pumped water storage. Rivers are natural energy resources that can be harnessed for their gravitational potential energy. The potential energy in the water was supplied by solar power., which earlier evaporated the water and transported it to higher elevations. Gravity water storage is used to collect and hold a at high elevations so that the potential energy available from the river can be converted to electrical energy during peak electrical demand periods.

If the rivers flowed continuously at a constant rate, the gravity water storage system would not be necessary. But rivers tend to dry up in the summer and flow at such powerful rates in the spring that most of the energy available would be lost without gravity water storage, which compensates for the minimum water energy available during the summer. Thus, storage areas or reservoirs allow hydroelectric plants to operate continuously at the highest and most efficient level possible.

Water storage which involves the pumping of water rather than the flow of a river is called pumped water storage. The simplest system of this type uses energy from a thermal plant to pump water from one reservoir to a higher one. Later, gravity causes the water to flow back to the lower reservoir and electricity is generated. Pumped water storage systems ate usually used in conjunction with gravity water storage systems. Many pumped water systems make use of some natural river flow; that is, river reservoir from the lower reservoir. Thus more water is used for generating purposes than is actually pumped to the higher level.

The advantage of the pumped water system is that during periods of low electricity demand the thermal plant can consistently use the power it generates to pump the water to the higher storage area. Then, during periods of peak demand, energy from the thermal plant and the pumped storage plant can be utilized to meet peak demand.

Efficient and sufficient methods of storage are some current obstacles facing developers of solar collectors. Currently, radiant heat collected during periods of sunlight is stored in concrete tanks filled with rocks or water. The drawback is that tanks must be extremely large in order to store enough energy to cover extended period s of cold or overcast weather. Research is being conducted to develop a better insulation and materials for storage tanks.

Patterns of Consumption by Sector

The US consumes more energy per capita than any other nation in the world. This high energy use rate is reflected in every sector of our society--commercial, residential, industrial, and transportation.

The commercial sector, the smallest of the four, includes businesses, government buildings, hotels, hospitals, restaurants, and offices. Half of their energy consumption went for space heating and air conditioning. This sector has been growing at a faster rate than the others, and depends primarily on natural gas, oil, and electricity.

Space heating is also the single largest energy user in the residential sector, which is slightly larger than the commercial sector. The uses for which energy requirements are growing most rapidly are air conditioning, clothes drying, and refrigeration. The rapid rise in air conditioning has created a new problem for utilities--providing enough electricity to meet the disproportionately large demands. The result has been “brownouts” when the generating facilities reduce the amount of power delivered to each customer. In rare cases, all power is cut off either intentionally or unintentionally--a “blackout”.

The transportation sector accounts for over one-fourth of our total national energy consumption. Three-fourths of this is spent on highway transportation; the remainder is spent on airplanes, railroads, shipping, and pipelines. Clearly, most of the transportation energy use is due to the movement of the people and the goods on US highways, with oil accounting for essentially all energy consumed in the transportation sector.

Most importantly, while the transportation sector is second largest (25%) in terms of total fuel energy consumption, and additional 15% of total fuel energy consumption comes from the other three sectors to support the transportation complex” energy required not only to fuel transport machines but also to build and maintain them. It is easy to understand why the automobile portion of the transportation sector absorbs most of the price changes in crude oil. It is also easy to see why much attention is given to improving energy efficiency in that sector.

The largest consumer of fuel energy in the US is the industrial sector. Heating processes, either by manufacturing steam or by directly burning fuel, account for half of industrial fuel consumption. The rest is used for electrolysis, feedstocks, heating/lighting, and running machines. Unlike the transportation sector which relies on oil, the industrial sector uses all three fossil fuels---gas, oil, and coal.

All of the four major energy consumption sector largely depend upon dwindling fossil fuels. It is essential that alternate energy sources be developed. Present consumption patterns will help determine the priorities which should be given a various alternate energy resources; for example, solar energy--an energy source which can provide space heating, air conditioning, and water heating--may have a significant impact on the residential and commercial sectors but little impact on the transportation sector over the next 30 years or more.