CHAPTER II.
THE HISTORY OF ENERGY

As you sit in a climate-controlled room, light available at the flip of the switch, eyes roaming the page, lungs breathing in, breathing out, heart beating, and electrical pulses of your brain contemplating the words on this page, it is easy to take the *energy* that powers your world for granted. As the stars in the skies were once heavenly mysteries so, also, this concept called *energy* was a mystery for our ancestors.

A. Energy

The past one hundred years are like a blink of the eye in the life of humanity and, yet, within this blink, scientists have unraveled the history of energy. This story goes hand in hand with the history of the universe. Following energy back in time takes you to the origin of the universe.

Your body is powered by the energy stored in the chemical bonds of the food you eat. The energy in this food is readily revealed by taking a match to a dried loaf of bread and watching it burn. Both your body and the fire combine oxygen and the bread into water and carbon dioxide. While the fire merely produces heat in this reaction, your body uses the energy in a considerably more complex way to move muscles and produce the electrical energy of your nervous system.

In the end, both your body and the fire use the chemical energy stored in the starch molecules of the bread. This energy is released as chemical bonds of starch and oxygen are converted to chemical bonds in water and carbon dioxide. Even the molecules your body retains will eventually revert back to carbon dioxide, water and minerals.

The energy in the chemical bonds of the food came from photosynthesis when the energy of the sun's light combined carbon dioxide and water to produce vegetation and oxygen. While the oxygen and carbon stay on earth and cycle back and forth between vegetation and the atmosphere, the sun's radiation has a one-way ticket into the process where it provides the energy to make life happen. Without this continuous flow of energy from the sun, our planet would be lifeless.

The radiation that powers the photosynthesis is produced by the virtually endless nuclear reaction in the sun. In this process, hydrogen atoms combine to form helium. When hydrogen atoms join to form more-stable helium, the total mass is reduced. The mass is not lost; rather, it is converted into energy according to Einstein's equation, $E = m c^2$. Enough mass was formed during the birth of the universe to keep the stars shining during the past 15 to 20 billion years.

The arrays of different elements in our planet, solar system, and galaxy reveal energy's history. All forms of energy on earth originated from the birth of the universe. Our life and the machines we use depend on energy's journey, catching a ride as the energy passes by. We are literally surrounded with energy in hydrogen, uranium, and chemical bonds with our limits of using this energy largely determined by our choice to use it and, in some cases, our pursuit of technology to better utilize these resources.

B. Nature's Methods of Storing Energy

All forms of energy; whether nuclear, chemical energy in coal, chemical energy in petroleum, wind, or solar; are part of energy's journey that started with the birth of the universe. In our corner of the universe, the energy output of the sun dwarfs all other energy sources. Nuclear fusion in the sun releases massive amounts of energy. The only way this energy can escape from the sun is in the form of radiation. Radiation output increases as temperature increases. Somewhere along the journey, the sun came into a balance where the sun's radiant energy loss tends to decrease the sun's temperature at the same rate as the sun's nuclear fusion tends to increase the sun's temperature. In this process, the outward force of the constant nuclear explosions is balanced by the sun's gravitational force to form a nearly perfect sphere.

Even before life evolved on earth, the sun's energy reached earth. The sun's rays hitting the earth are like the rays contacting your face. If you close your eyes and look at the sun, the front of your face would receive the warmth while the top of your head would receive little. The sun's radiation causes the Earth's equator to be warmer than the poles. These temperature differences cause wind and ocean currents[1].

The Nature of Wind

The principal is easy to understand. At warm locations like the Texas coast, warm water rises in the oceans and warm air rises in the atmosphere. The space is filled from the flow of cooler water or air coming in from the sides. The cooler fluid is now warmed and keeps the process going.

Meanwhile, at colder locations like Greenland, the warmer fluid high in the sky or on the ocean surface is cooled and displaces the cooler fluid below. The cooler fluid moves outwards to "lower pressure" areas where fluids are rising.

Water tends to amplify wind patterns since water vapor, evaporated by the sun, is even lighter than heated air at the same temperature. When water cools, it can become a thousand times more dense by condensing into rain or snow. This can happen on massive scales like the gulf stream or, on smaller scales, like the flow of air and moisture that keeps the skies clear of clouds on the Costa De Sol in southern Spain.

Before life existed on earth, the sun's radiation formed water vapor and caused it to raise from the oceans. This water vapor caught the wind and was blown to the mountains where it cooled to form rain. The high elevation of this water in the mountains gave it energy to flow down hill. Rocks and gravel dissipated this energy on its journey back to the oceans.

The first primitive organic life appeared on earth about 3 billion years ago with photosynthesis first occurring about 1 billion years later[2]. Photosynthesis allowed the carbon dioxide in the air to be combined with water to form vegetation and oxygen.

The vast majority of the vegetation fell to the ground and decomposed combining with oxygen going back to carbon dioxide and water. Some fell to the floor of swamps where oxygen could not reach it as fast as it piled up. In time these deposits were buried deeper and deeper making it even more difficult for oxygen to reach them and convert them back to carbon dioxide and water. After a sufficiently long time, the vegetation rearranged into more stable deposits we call coal. Different types of coal developed depending upon the depth, temperature, and moisture of the deposits.

In the seas, much of the surface was inhabited by bacteria called phytoplankton. The cells of these phytoplankton contained oils that are in some ways similar to the corn oil used to cook french fries. When these phytoplankton died, most of them were converted back to carbon dioxide and water by the oxygen dissolved in the water or by animals feeding. Some were swept to ocean depths where oxygen was largely absent. Here they accumulated. Some of these bacteria deposits were buried by the silt. The combination of time and pressure caused by the overburden of water and silt transformed these deposits, in the absence of oxygen, to petroleum oil.

In the turmoil of erosion, volcanoes, and general continental movement, large deposits of coal and oil made it back to the surface where, in contact with oxygen, they oxidized back to water and carbon dioxide. Other deposits persist to date for us to recover. Still other deposits were buried deeper, reaching higher pressures and higher temperatures, due to the Earth's geothermal heat. There, the coal and petroleum converted to a combination of natural gas and high-carbon deposits of hard coal or carbon in the form of graphite.

Over tens of millions of years, the sun's energy working with life on earth formed the energy deposits of coal, petroleum, and natural gas. More recently, yesterday's radiation is available as vegetation such as wood, corn, and palm oil. Today's radiation is available as sunlight, wind, ocean currents, and the hydro energy of high altitude rivers and lakes.

The legacy of the universe is all around us. Compared to our consumption of energy, the fusion energy available in the hydrogen of the waters of the ocean is almost endless. Uranium available in the soil and dissolved in the ocean can produce energy by fission. In principal, the nuclear energy extends far beyond that. All atoms smaller than iron could be fused to form iron while all atoms larger than iron could undergo fission (splitting) to form iron, both processes releasing vast amounts of energy.

The geothermal heat of the earth originated at the birth of the universe. In part, the great velocities created by the Big Bang were released in the form of heat and molten rock during the collisions that ultimately formed this big rock called earth. However, if the heat were left unreplenished the core of the earth would have long since cooled. Adding to the heat of colliding masses, uranium and other larger molecules are constantly undergoing fission from earth's surface to its core. This fission energy release occurs one atom at a time, but the energy adds up. The released heat maintains molten magma from Earth's core to near the surface. On the surface this energy is released as volcanic eruptions and geysers.

We have options on where we can tap into energy's journey to power our modern machines. But one thing is certain, all the energy around us came from the atomic energy of atoms formed at the birth of the universe. The energy is abundant and attainable.

C. Man's Interaction with Nature's Stockpiles and Renewable Energies

Primitive man was successful in tapping into the easily available and easily usable forms of energy. He lived in warmer climates where the sun's solar warmth protected him from the cold. Even the most primitive animals, including early man, recognized the need to nourish their bodies with food.

As the usefulness of fire was discovered, man was able to move into colder climates where the energy in wood was released by burning campfires. Animal fat and olive oil were also soon discovered to be useful sources of fuel to feed the fire. These fats and oils were observed to burn longer and could be placed in containers or wrapped on the end of a stick to create a torch—hence, they are early endeavors into fuel processing. Whale blubber soon was added to animal fat and olive oil for food and fuel.

The wheel and axle were another early step in developing energy technology. The wheel and axle allowed man to use his physical energy to move heavier loads. The cart was made more effective by using domesticated animals. For stationary applications, water wheels and windmills converted the hydraulic and wind energies into shaft work for many applications including pumping water and grinding grain. Wind energy powered ships to explore new lands, establish trade, and expand the fishing industry.

Machines using wind and hydraulic energy made it possible for one person to do the work of many—freeing up time for them to do other tasks. A most important task was educating the youth. Time was also available for the important tasks of inventing newer and better machines. Each generation of new machines enhanced man's ability to educate, invent, discover, and add to leisure time.

Societies prospered when they used the freedom created by machines to educate their youth and to create new and better machines. Inventions / discoveries extended to medicines that conquered measles and polio. The benefits of modern society are available because of the effective use of energy and the way energy-consuming machines enhanced man's ability to perform routine tasks freeing time for education, discovery and innovation. Civilization emerged.

More importantly, civilization evolves based on technology. For man, the "survival of the fittest" is largely the survival of the culture most able to advance technology. Even in modern history, while Hitler's technology dominated the WW II battle fields, Germany was winning the war. As Ally technology surpassed German technology, the Allies began to dominate the battlefields until ultimate victory.

If you drive through the Appalachian mountains, you will observe how coal seams (varying from an inch to over a foot) once buried a few hundred feet in the earth are now exposed on cliffs. The upheavals that created mountains also brought up nature's deposits of coal and oil. At cliffs like these, man first discovered coal. Coal was considerably easier to gather at these locations than firewood, rapidly replacing firewood. Marco Polo observed "black rocks" being burned for heat in China during his 1275 travels.[3] Coal's utility caught on quickly. Between 1650 and 1700, the number of ships taking coal from Newcastle to London increased from 2 to about 600.[3] In 1709 British coal production was estimated to be 3 million tons per year. Benjamin Franklin noted (1784) that the use of coal rather than wood had saved the remaining English forests and urged other counties to follow suit.

When oil was found seeping from the ground, it could be collected and used to replace an alcohol-turpentine blend called camphene (camphene being less expensive than whale oil).[4] Eventually, we developed mining and drilling techniques to produce larger deposits of coal and oil found underground.

From an historic perspective, energy technology has tended to feed upon itself and make its utility increase at ever-faster rates. Large deposits of coal allowed a few men to gather as much fuel as everyone in a community gathered a few centuries earlier. Easy and efficient gathering of fuel freed up more time and resources to develop new and better machines that used the dependable fuel supply.

Prior to the 19th century the decisions to proceed with newly demonstrated technology were easy because the benefits were obvious. The vast amounts of virgin wilderness dwarfed the small tracts of land being devastated by poor mining practices, and an energetic entrepreneur could simply go to the next town to build the next generation of machines when local markets were dominated by established businesses/corporations.

At the end of the 19th, century vast tracts of land or oceans were no longer barriers to the ambitions of the people managing corporations. The telegraph allowed instant communication and steam engines on ships and locomotives allowed most places to be accessed in a matter of days. The time arrived when a budding entrepreneur could no longer go to the next town to get outside the influential realm of existing corporations. In energy technology, the time had arrived when companies could become monopolistic energy empires.

The growth of local businesses into corporations with expanding range of influence made their products quickly available to more people. The benefits were real, but the problems were also real. One of these problems was that innovation was being displaced with business strategy and influence in determining those technologies that would succeed.

D. Industrial Revolution and Establishment of Energy Empires

Standard Oil Monopoly - The Standard Oil monopoly of the early 20th century demonstrated what happens when a corporation looses sight of providing consumers a product and becomes overwhelmed with the greed for profit.

After the civil war, men swarmed to western Pennsylvania to lay their claims in a "black gold rush". John D. Rockefeller was among these pioneers. Within one year of discovering the potential of drilling for petroleum, the price went from $20 per barrel to 10 cents per barrel. Rockefeller realized that the key to making money in oil was not getting the oil out of the ground but, rather, refining and distributing the oil[5]. Standard Oil crossed the line when it changed its corporate philosophy to one of profiting by stifling the competition through monopolistic control of refining and distribution of all petroleum products.

The Atlantic and Great Western Railway controlled the cheap rail transit in the western Pennsylvania region, and this controlled the oil market. Rockefeller prevented his competition from using this railway to sell their oil.

This was a change in paradigm for the energy industry. A company controlled the market by controlling access to the commodity. While nations and shipping fleet owners had done this in the past, this was different. This was a company operating in a free country aggressively moving to eliminate all competition.

Artificially-inflated oil prices were just like taxes; like taxation without representation. When previously faced with a similar situation the people united in the American Revolutionary War. Here, the adverse impacts of the oil monopoly were difficult to quantify, unlike a tax on tea, and there was no precedent to show the way to reasonable remedies.

Competitors of Standard Oil were stifled. Some of the competition sold out. High consumer prices, higher than the free market would bear, were the result of this monopoly. Technology and innovation were also stifled. Corporate success and prosperity were determined by controlling access to the products, not by the best technology.

In the past, improving technology benefited both the consumer and the company. When business savvy replaced innovation, the actions of the company were at odds with what was good for the consumer. The creative innovation and technology that had brought us out of the caves was now forced off the highway of ideas onto the back roads where progress was slow.

For 32 years Standard Oil profited from its monopoly on oil refining. In May, 1911, U.S. Supreme Court Chief Justice White wrote the decision which mandated that Standard Oil divest itself of all its subsidiaries within six months. In 1974, assets of the living descendants of John D. Rockefeller were estimated to have the largest family fortune in the world estimated to be $2 billion.[5]

During the 19th century, pioneers had reached the end of habitable frontier. The steam engine and telegraph provided the means by which companies could extend their influence across the globe. One can argue that the international nature of today's mega corporations elevates them to a status as great as the nations they claim to serve. One can further argue that a mega corporation can be a friend or enemy to a society in the same sense that a neighboring country can be a friend or enemy.

In 1942, Senator Harry S. Truman led an investigating committee on treasonous pre-war relationships between General Motors, Ethyl Corporation, Standard Oil, and DuPont in collaboration with German companies I.G. Farben. Company memo's document corporate agreements designed to preserve the corporations no matter which side won World War II. Corporate technology exchanges compromised the competitive edge held by the U.S. entering into World War II including leaded gasoline technology (critical for high octane aircraft fuels) and non-competitive stances on synthetic rubber technology. *At the time, British intelligence called Standard Oil a ³hostile and dangerous element of the enemy.² (Stephenson, 1976, Borkin, 1978)*[6]. Continuation of this behavior led to anticompetitive-related antitrust hearings on leaded gasoline technology against these American companies in 1952.

With technology and innovation taking a back seat to business interests, politics and energy technology became perpetually intertwined. The bigger companies were formally pursuing their agendas even when these agendas were in conflict with public good and involved collaboration with the enemies of our nation's closest allies.

A corporation that profits by providing consumer products more efficiently and at a lower cost is significantly different than a corporation that makes profit by controlling the supply/price of a consumer commodity or product. The Rockefeller Oil monopoly demonstrated that the profits were greater for the business strategy that is in direct conflict with national benefit. In the end the only punishment was the mandated divestment of its subsidiaries. The Rockefeller family emerged as the wealthiest family in the world.

What was the real precedent set by the Standard Oil monopoly? Was it that monopolies will not be allowed, or was it that great fortunes can be made and kept even if you are caught? The consequences are much greater than what consumers pay at the gas pump.

Innovation in a World of Corporate Giants - There is little doubt that obstructed commercialization of technology stifles technology innovation.

Companies and individuals have little incentive to build a nuclear powered automobile since the government would not allow this vehicle to be used on the highways. Restricted commercialization can be good by redirecting efforts away from projects that endanger society. Restricted commercialization can be bad when the motivation is to maintain a business monopoly to stifle competition.

History has little evidence of the impact of unrestricted entrepreneurism because modern history has been dominated by business savvy rather than technical innovation. The true potential of unrestricted entrepreneurism is rarely seen. World War II is the best example in recent history illustrating what happens when we focus on developing the best technology available and the machines to get a job done. Within a ten-year period, the following technologies were developed:

- Nuclear Bomb,
- Jet Aircraft,
- Radar,
- Transistors,
- Intercontinental Rockets,
- Guided Missiles,
- Synthetic Oil Produced from Coal,
- Mass Production of Aircraft and Tanks,
- Swept Wing and Flying Wing Aircraft,
- Stealth Submarine Technology. and
- A Plastics Industry including Synthetic Rubber, Nylon, and Synthetic Fiber.

Many of the commercial advances between 1946 and 2000 occurred because decisive technology was developed during World War II. Specific 20th century accomplishments that fall into this category are nuclear power, jet air travel, landing a man on the moon, guided missile technology, transistor-based electronics and communication, stealth aircraft including the B1 bomber and the modern plastics industry.

The technological developments of World War II illustrate what can be achieved when technology and commercialization become a national goal. If technology has inherent limits on the good it can provide; we are far from reaching these limits. We are limited by man's pursuit, by the willingness of environmental groups to allow new technologies to become part of our societal infrastructure, and by the willingness of corporations or governments to invest in development and commercialization.

At the beginning of the twenty-first century, politics and energy technology appear to be hopelessly intertwined. Nine out of the top ten of the Global 500 companies are in energy or energy technology (e.g. the automotive industry) and business savvy trumps innovation in these companies.

The U.S. rose to superpower status in the 1940's when the national focus was on developing and commercializing strategic technologies. History has shown powerful countries fall when the national focus switches from advancing technology to maintaining the steady flow of cash to corporations and well-connected individuals (maintaining corporate status quo). The Czars of Russia or aristocrats of Rome are two of the many examples where common people were driven to revolt against a system dominated by who you were rather than what you had contributed.

Germany's synthetic oil production from coal is one strategic technology that did not become commercial in the U.S. following World War II. This same technology is currently commercial in South Africa because there was a different philosophy toward investing in this infrastructure. Today in South Africa the industry is self-sustaining and the technology is being sold for use in other countries. These production facilities were designed and constructed by U.S. engineering firms.

Canada started developing its tar sand resources in the 1960s even though the technology could not undercut the price of crude oil. Because of continued and dedicated development, the tar sand oil now costs $10 to $12 per barrel to produce as compared to crude oil at $25 per barrel (year 2002) on the world market.

The Oil Economy - The 21st century civilization as we know it would be impossible without crude oil. We get over 90% of all automotive, truck, train, and air transport fuels from crude oil, as well as the majority of our plastics. The plastics are used to make everything from trash bags and paints to children's toys. If it is a solid device that is not paper/wood, ceramic/glass or metal, it is probably plastic.

Crude oil is inherently a good fuel. Figure 1 illustrates how this natural product can be separated by boiling point range to provide gasoline, a middle fraction (kerosene, jet fuel, heating oil, and diesel fuel), and fuel oil (oil used for boilers or large diesel engines for ships and electrical power). The natural distribution of crude oil into these three product classifications varies with the source of the crude oil.

Modern refining processes convert the crude oil into these three product categories and also provide chemical feed stocks. The modern refining process breaks apart and rearranges molecules to produce just the right amounts of gasoline, diesel, and fuel oil. In the U.S., this typically means converting most of the "natural" fuel oil fraction and part of the middle fraction to increase the amount of gasoline.

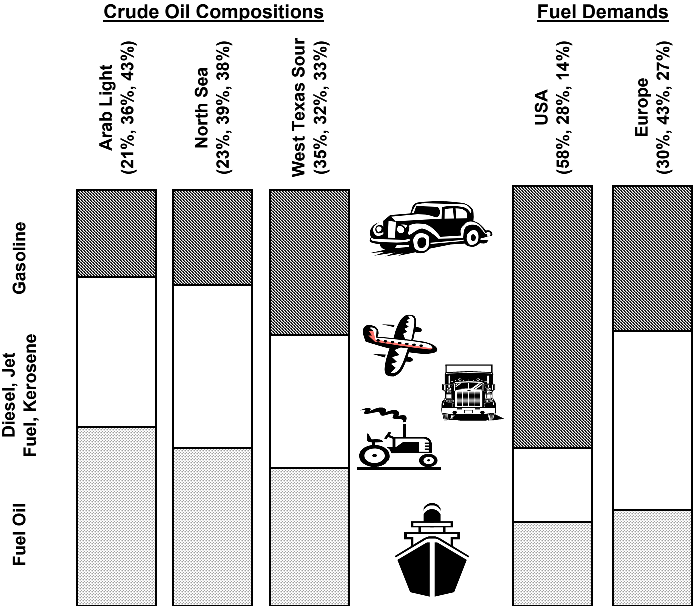
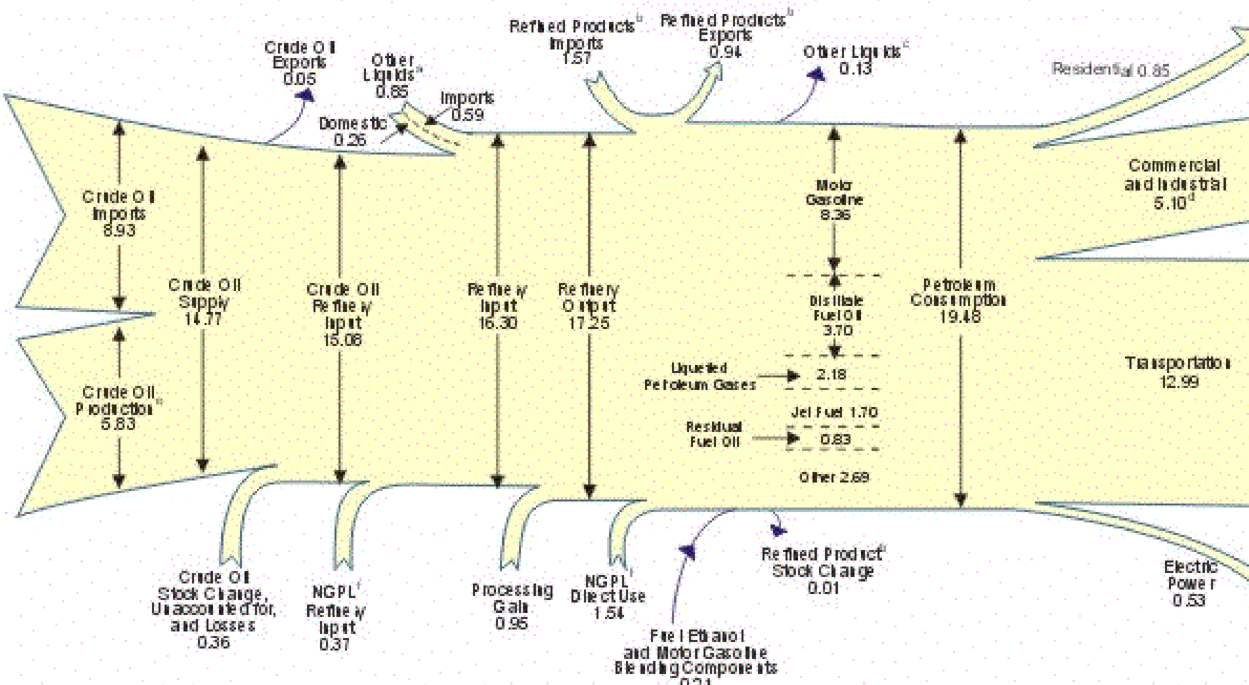


Figure 1. Typical composition of oil.[7]

Figure 2 is a detailed description of crude oil processing for the U.S. and includes import versus domestic production and includes other commercial applications. The diagram also illustrates how complex crude oil processing has become in order to provide the commercial product demands.

Figures 3 and 4 further show the extent of U.S. oil imports and how prices fluctuate. Since the year 2000 the U.S. spent over $100 billion to import crude oil. Cheap oil in 1997 and 1998 brought a prosperous U.S. economy, more expensive oil in 2001 and 2002 added to the economic downturns.

As illustrated by Figure 2, the U.S. imports well over half of the crude oil we process. One can argue whether the world will have enough oil for the next 100 years or only the next 25 years. However, one thing is certain, the useful and significant domestic oil production in the U.S. today would last less than 10 years and will continue to decline. Over half the worlds known oil reserves are in the Middle East. Figure 5 shows this breakdown with Saudi Arabia, Iran, and Iraq each with greater reserves than any other country.


Crude Oil Exports 0.05
Other Liquids 0.85
Domestic 0.26
Imports 0.59
Refined Products Imports 1.57
Refined Products Exports 0.94
Other Liquids 0.13
Residential 0.85
Commercial and Industrial 5.10
Crude Oil Imports 8.93
Crude Oil Supply 14.77
Crude Oil Refinery Input 15.08
Refinery Input 16.30
Refinery Output 17.25
Motor Gasoline 8.36
Distillate Fuel Oil 3.70
Liquefied Petroleum Gases 2.18
Jet Fuel 1.70
Residual Fuel Oil 0.83
Other 2.69
Petroleum Consumption 19.48
Transportation 12.99
Crude Oil Production 5.83
Crude Oil Stock Change, Unaccounted for, and Losses 0.36
NGPL Refinery Input 0.37
Processing Gain 0.95
NGPL Direct Use 1.54
Fuel Ethanol and Motor Gasoline Blending Components
Refined Product Stock Change 0.01
Electric Power 0.53

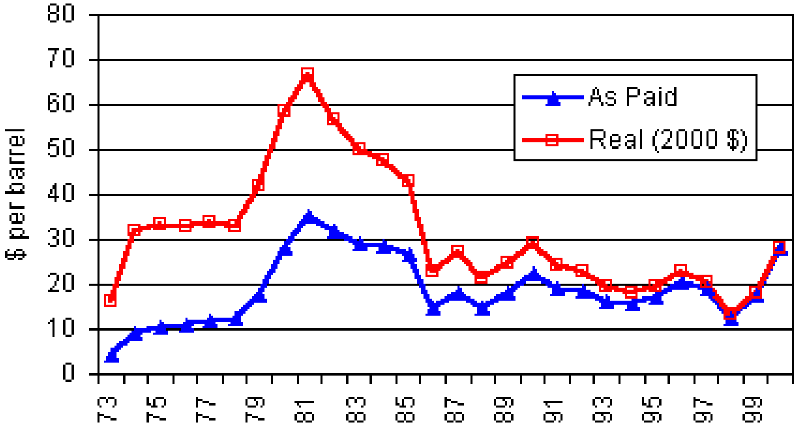


Figure 3. Recent U.S. oil prices[9].

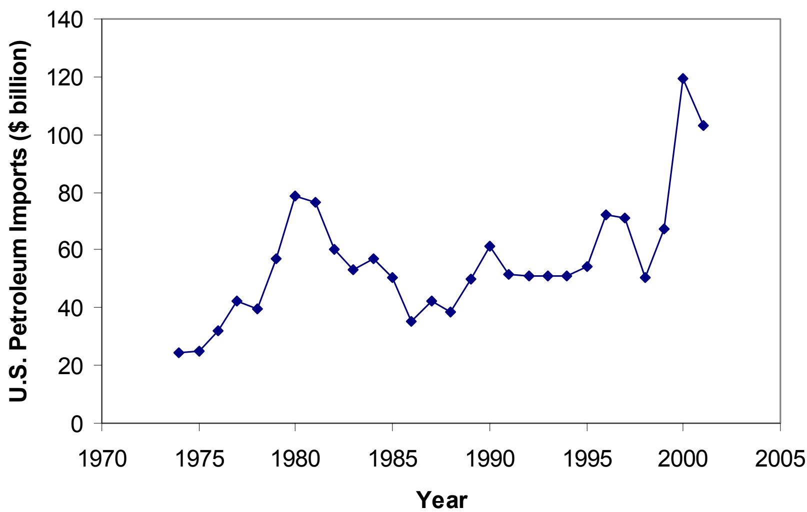


Figure 4. U.S. imports of petroleum.[10]

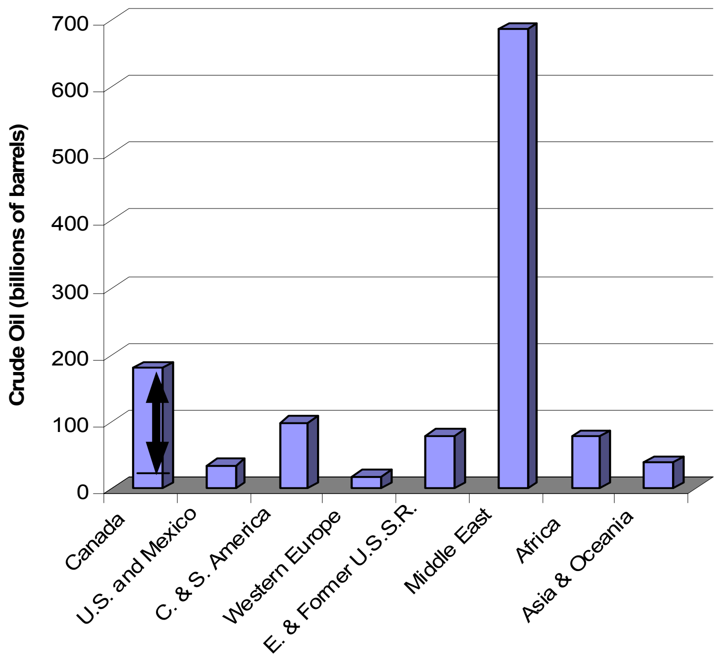


Figure 5. World oil reserves by region[11]. Estimates of Canadian reserves by Oil and Gas Journal in 2003 are much higher than previous years—they likely include easily recovered tar sands.

Energy Sources - Petroleum provides more than 90% of vehicular fuels in the U.S., but in addition petroleum represents 53% of all energy consumed in the U.S. as summarized by Figure 6. The energy stocks used in the U.S. are in sharp contrast to U.S. reserves (see Figure 7), and this will ultimately lead to energy crises.

Continuing with world energy consumption at the present rate, the world has approximately 3.6[3] years of petroleum (to supply all energy needs), 17 years of coal, 46 years of natural gas, and thousands years of uranium (assuming full use of uranium and ocean recovery)[12]. If the U.S. were the sole consumer of world energy reserves, world petroleum would last 75 years toward meeting all the U.S. energy needs, coal 500 years, natural gas 1000 years, and uranium tens of thousands of years.

In the year 2000, the U.S. imported 53% of it petroleum to satisfy a consumption of 19.7 million barrels per day. If total U.S. demand for

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[3] For world oil reserves of 5.3e18 Btu and total world total energy consumption of 1.5e18 Btu/yr.

petroleum had to be met with known reserves in the U.S., we would run out in about three years. The strategic petroleum reserve (available predominantly stored in salt caverns) would last a total of 31 days.[13]

It is where consumption exceeds availability that technology makes the difference. Can coal be converted to quality liquid fuels? Can nuclear energy be converted effectively to hydrogen or liquid fuels to power automobiles? The right combination of technologies can make the difference between security or vulnerability; between cheap energy or economic recession due to restricted oil supply.

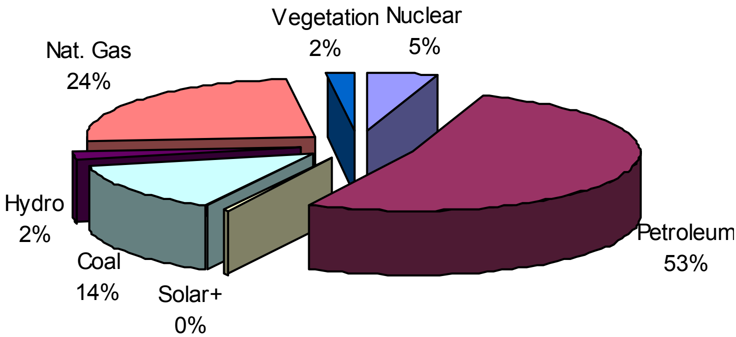

Figure 6. U.S. Energy consumption by source.

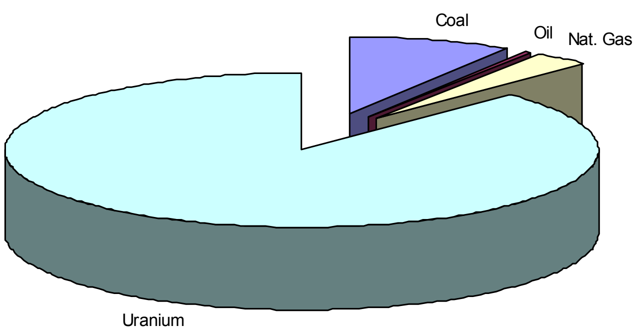

Figure 7. Estimate of U.S. energy reserves.

E. Environmental Impact

Environmentalism has a rich tradition of keeping industry under control. History bares witness to the devastation caused by deforestation. As early as 6000 BC, the collapse of communities in southern Israel were attributed to deforestation[14]. In southern Iraq deforestation and soil erosion and salt buildup devastated agriculture in 2700 BC[15]. These same people repeated their deforestation and unforgiving habits in 2100 BC, a factor in the fall of Babylonia. Some of the first laws protecting timbering were written in 2700 BC[14].

Advances in citywide sanitation go back to at least 2500 BC and can be attributed to people uniting in an effort to improve their environment against the byproducts of civilization. In 200 BC the Greek physician Galen observed the deleterious acid mists caused by copper smelting. Lead and mercury poisoning was observed among the miners of the 100 AD Roman empire. High levels of lead may have been a factor in the fall of the Roman Empire. The bones of aristocratic Romans reveal high levels of lead likely from their lead plates, utensils, and in some instances food[16].

Poor sanitation, including raw sewage and animal slaughter wastes dispersed throughout cities, during the dark ages contributed to both the Bubonic Plague and cholera—the insects and stench must have been horrific. In these ancient examples, the factors that allowed civilization to attain its magnificence, also presented new or reoccurring hazards. In this early history, the lives saved by the benefits of agriculture and metals typically far outweighed those lives lost or inconveniences due to adverse environmental impacts.

The dark smoke of coal burning became evident as a significant problem in the 13th century. In 1306, King Edward I forbade coal burning in London. [3] Throughout history the tally of deaths attributed to air pollution from heating and other energy-related technology accumulated. The better-documented of these cases are reported prior to government regulations that finally brought the problems under control

On October 26th and 31st, 1948, the deaths of 20 people along with 600 hospitalizations were attributed to the Donora, Pennsylvania Smog incident. A few of the other smog incidents in the next few years include 600 deaths in London from "killer fog" (1948), 22 dead and hundreds hospitalized in Poza Rica (Mexico) due to killer smog caused by gas fumes from an oil refinery (1950), 4,000 dead in London's worst killer fogs (Dec. 4-8, 1952), 1,000 dead in a related incident in London in 1956, 170-260 dead from New York's smog (November, 1953), and in October of 1954 most of the industry and schools in Los Angeles were shut down due to heavy smog conditions (a smart, proactive measure made possible by the formation of the Los Angeles Air Pollution Control District in the 1940s, the first such bureau in the U.S.). In the 1952 London incident, the smoke was so thick that busses required a guide to walk ahead of the bus with all London's transportation except subway traffic coming to a halt on December 8th, 1952.

In 1955, the U.S. congress passed the Air Pollution Research Act. California was the first state to impose automotive emission standards in 1959 including the use of piston blow-by recycle from the crankcase. The automakers united to fight the mandatory use of this modification that cost seven dollars per automobile. Subsequent federal legislation has been the dominant force on changes in U.S. energy infrastructure during the last 25 years.

The late 1960's has been characterized as an environmental awakening in the U.S. Prior to 1968, newspapers rarely published stories related to environmental problems while in 1970 these stories appeared almost daily[17]. Sweeping federal legislation was passed in 1970 with the Clean Air Act establishing pollution prevention regulations, the Environmental Policy Act (EPA) initiating requirements for federal agencies to report the environmental ramifications of their planned projects, and the establishment of the Environmental Protection Agency. The Clean Air Act was amended in 1990 specifically strengthening rules on SOx and NOx emissions from electrical power plants to reduce acid rain—this legislation ultimately led to closing some high-sulfur coal mines.

Starting with 1968-model automobiles, the Clean Air Act (CAA) required the EPA to set exhaust emission limits. Ever since, the EPA has faced the task of coordinating federal regulation with the capabilities of technology and industry to produce cleaner running vehicles. Since the pre-control era, before 1968, automotive emissions (gasoline engines) of carbon monoxide and hydrocarbons have been reduced 96% while nitrous oxide (NOx) emissions have reduced 76% (through 1995, the result of 1970 CAA).[18] The phasing out of lead additives from gasoline was a key requirement that brought these reductions.

On February 22, 1972, the EPA announced all gasoline stations were required to carry unleaded gasoline with standards following in 1973. Subsequent lawsuits--especially by Ethyl Corp., the manufacturer of lead additives for gasoline—ended with the federal court confirming that the EPA had authority to regulate leaded gasoline. Leaded automotive gasoline was banned in the U.S. in 1996. In 2000, the European Union banned leaded gasoline as a public health hazard.

The removal of lead from gasoline was initially motivated by the desire to equip automobiles with effective catalytic converters to reduce the carbon monoxide and unburned fuel in the exhaust. The lead in gasoline caused these converters to cease to function (one tank of leaded gas would wreck these converters). The influence of energy corporations were obvious when the U.S. Chamber of Commerce director warned of the potential collapse of entire industries from pollution regulation on May 18, 1971. This has been viewed as a classic example of *industrial exaggeration*.

Corporate influence was again seen in 1981 when Vice President George Bush's Task Force on Regulatory Relief proposed to relax or **eliminate US**

leaded gas phaseout, despite mounting evidence of serious health problems[19].

Since the banning of lead in gasoline, scientific communities are essentially in unanimous agreement that the phasing of lead out of gasoline was the right decision. In addition to paving the way for cleaner automobiles, these regulations have ended a potentially greater environmental disaster. All the lead that went into automobiles did not simply disappear—it settled in the soils next to our highways. Toxic levels of lead in the ground along highways continue to poison children and result in to mental retardation even today (See Insert).

In perspective, the air quality in our cities is good and generally improving. While the federal government monitors emissions and works to reform emission standards, the public and media tend to follow other issues more closely. Issues such as oil spills and global warming make the news.

Lead (Pb) and Its Impact, As Summarized by the EPA

http://www.epa.gov/oar/aqtrnd97/brochure/pb.html

Health and Environmental Effects: Exposure to Pb occurs mainly through inhalation of air and ingestion of Pb in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues. Lead can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to Pb may cause neurological impairments, such as seizures, mental retardation, and behavioral disorders. Even at low doses, Pb exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ. Recent studies also show that Pb may be a factor in high blood pressure and subsequent heart disease. Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals.

Trends in Pb Levels: Between 1988 and 1997, ambient Pb concentrations decreased 67 percent, and total Pb emissions decreased 44 percent. Since 1988, Pb emissions from highway vehicles have decreased 99 percent due to the phase-out of leaded gasoline. The large reduction in Pb emissions from transportation sources has changed the nature of the pollution problem in the United States. While there are still violations of the Pb air quality standard, they tend to occur near large industrial sources such as lead smelters. Between 1996 and 1997, Pb concentrations and emissions remained unchanged.

The Exxon Valdez oil tanker spill (March, 1989) is one of the infamous oil spill incidents. This oil tanker ran aground in Price William Sound, Alaska, spilling 11 million gallons of petroleum. It is the more infamous because of the costly remediation/penalties (over $1 billion in fines with Exxon claiming $3.5 billion in total expenditures)[20] that Exxon was required to perform as a result of this incident. Five billion in punitive damages was also awarded against Exxon, but his remains to be collected after almost a decade.[21] In 1992, the supertanker Braer spilled 26 million gallons of crude oil in the Hebrides islands. Both of these incidents are dwarfed by the Amoco Cadiz wreck off the coast of France in 1978 with the loss of 68 million gallons.

In view of the Amoco Cadiz incident and the cumulative tens of thousands who died in London's killer fogs, it is easy to understand the increased environmental consciousness in Europe. For example, the European governments are aggressively addressing potential global warming issues while the U.S. government tends to withdraw from international cooperation on the issue. Neither the U.S. nor European governments dispute the fact that carbon dioxide levels are increasing in the atmosphere. They do have varying opinions on the implications of these increasing carbon dioxide emissions.

On June 23, 1988, NASA scientists warned Congress about possible consequences from global warming with potential effects of drought, expansion of deserts, rising sea levels, and increasing storm severity. On December 11, 1997, the Kyoto Protocol was adopted by the US President Clinton (a democrat) and 121 leaders of other nations. The republican dominated U.S. Congress refused to ratify the protocol. More recent comments by President Bush concerning the Kyoto Protocol sound like the comments and actions of the U.S. Chamber of Commerce director and former Vice President George H. W. Bush on the phase out of lead from motor gasoline.

What the Future Holds – The complexity of U.S. politics that forced the breakup of Standard Oil in 1911 is now dwarfed by the manner in which energy and international politics are coupled. Operation Desert Storm and the Gulf War in 1991 put all doubt aside. The U.S. government is willing to protect oil supplies with direct military action.

Our transportation systems, fuel oil and propane heating, and plastic materials have unquestionably saved more lives than have been lost in the conflicts fought to keep oil flowing. But can crude oil be replaced with alternatives while maintaining the benefits of cheap transit, heating fuels, and plastics? Canada and South Africa have certainly demonstrated that crude oil can be cost-effectively replaced with alternatives. Why does the U.S. not follow suit? It is certain that large energy corporations will try to maintain their status in this multi-trillion dollar industry.

Today's politics and government policies inhibit technology. They can also inhibit national prosperity. To understand this requires learning about energy science, conversion technology, and economic/profitability analysis. It requires evaluating the facts and resisting the temptation to look for simple answers. Vested corporate and political interests are ready to capitalize on ignorance providing their simple answers. This book is written to provide individuals and legislators information to make informed decisions without the influence of those who stand to profit from the continuation of current policies.

The summary of energy reserves in Chapter 3 show that there is no energy shortage. Spikes in gasoline prices, electricity prices (California), and natural gas prices (throughout the U.S.) that occurred during the first two years of the 21st century cannot be justified based on a shortage of energy resources. Essentially all recent historical spikes in oil prices can be attributed to a lack of competition. It appears that in some cases the consumer was a victim of corporate strategies that created the appearance of shortages.

Two mechanisms induce shortages: government regulations that effectively prevent new capacity from coming on line (or define a fuel that limits potential suppliers) and a lack of diversity in energy feed stocks. Both mechanisms prevent the free market from establishing the price. In electrical power generation, increased use of natural gas presents the opportunity for gas suppliers to limit electrical power diversity and this increases prices. For vehicular transit, an over-dependence on petroleum fuels has already created national and consumer vulnerability.

A number of technologies are available to address today's greatest energy problems, but they challenge the current status quo of the energy industry. On electrical power generation, 100% nuclear fission (reprocessing of spent nuclear fuel) will address problems with both nuclear waste and electrical power diversity. On petroleum, U.S. tax strategies actually give foreign producers a $7-$15 per barrel competitive advantage (See Chapter 8 for detailed discussion). The Canadian tar sand industry and U.S. synthetic petroleum (infant) industry are capable of meeting U.S. oil consumption needs at current prices ($25 per barrel). More importantly, if given an equitable tax strategy compared to imported crude oil, these industries could create new-source competition that would tend to stabilize fuel prices at levels lower than current prices fluctuating between $30 and $40 per barrel. Finally, an increasing overlap of electrical power and vehicular fuel energy networks would provide additional diversity to stabilize gasoline prices.

The concept of market overlap is quite simple. When consumers have the ability to select between powering their vehicles with electrical power or gasoline, the price of gasoline will stabilize. If the fuel cell researchers deliver what they promise, rechargeable fuel cell systems could leapfrog rechargeable batteries for electric cars in commuting applications. Rechargeable fuel cells also have distinct advantages when used in hybrid cars.

In principle, electric power grid recharging could be used with hybrid vehicles to great advantage for commutes less than 20 miles. In such commuting applications the backup liquid fuels would not be used, reducing emissions and reducing petroleum consumption. This plug-in hybrid vehicle technology appears to be less costly than petroleum when considering the cash flow of both the consumer and electrical provider.

Plug-in hybrid vehicles would both stabilize fuel prices and reduce pollution in cities. In a similar way, a hydrogen fuel infrastructure could also partially replace liquid fuels with the diversity of fuel sources behind electrical power. The use of hybrid vehicles that use hydrogen to store electrical power (rather than batteries) could provide a demand for a hydrogen fuel infrastructure—the technologies are related.

F. Energy in Today's Industrial and Political Arena

History has documented reoccurring conflicts between corporations and societies. While corporations and societies share many common interests, the less-frequent conflicts can be significant. These conflicts should not be a surprise; corporations have not volunteered to be the "keepers of society" nor have they been asked to serve as keepers of society.

If political lobbyists cost less than implementing new technology to achieve a business objective, then a business has every right to pursue the political solution. The alternative of not pursuing this route leaves a business vulnerable to competition that could pursue the less-costly/more-profitable approach.

When faced with importing oil as usual versus investing large sums for an alternative fuel industry, industry has consistently chosen the conservative route. The conservative route does not require change and by definition maintains the corporate status quo.

Current conflicts become more complicated by an international economy where nine out of the top ten Global 500 companies are in energy or automotive businesses and the revenues of any one of these companies dwarfs the revenues of most countries. These corporations would prefer not to change business strategies that have been very profitable for decades. So how do necessary changes occur in energy mega-corporations if these corporations are not likely to change on their own?

Was it the pressure from environmental groups that prompted needed changes in the 20th century? Was it the news media that prompted needed changes by reporting these stories? Or, was it the shear magnitude of the problem that brought on regulations that required change? Yes, yes, and yes.

The greatest factor to force change was probably the media through the dissemination of information to the public and citizen legislators. Environmentally motivated actions have made our world a better place. Ever improving technology has allowed us to continue to reap benefits while reducing undesirable byproducts.

As we look forward into the 21st century, issues of global warming, energy security, the adverse political and economic effects of importing crude oil, and the ramifications of distributing wealth to terrorist-supporting countries are emerging as issues that will have the great impact on our future. History tells us that technology will provide solutions. History tells us that public education on these issues is absolutely necessary to bring about change, especially where these changes mandate that corporations change the way they do business.

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