Chapter 1

The Nature of Energy

In this chapter, you will learn the following to World Class standards:

- **What is Energy**
- **Potential Energy**
- **Using Energy**
- **Converting Biomasses for Energy**
- **Converting Fossil Fuels to Energy**
- **The Greenhouse Affect**
- **The Alternate Energy Picture**
- **The Nuclear Energy Option**
- **The Role of Modern Architects, Designers and Engineers**

What is Energy

Energy as described in physics is the ability of a physical system to do work, where the work done is the product of the force times the distance taken to move a mass in the direction of the work. So if we lift a 10 pound box up five feet from the ground to a shelf, the amount of work is 10 pounds times 5 feet or 50 foot – pounds. The formula for work is:

$$W = Fd$$

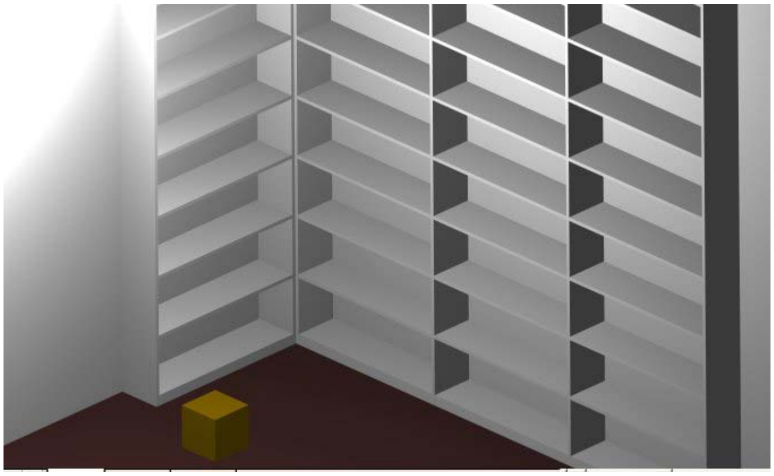

Figure 1.1 – A 10 lb Box to be Lifted to the 5th Shelf

So in this case, the work is the transfer of energy by moving the box upward against the force of gravity. If the box would fall from the shelf, the stored energy of 10 pounds above the original position is expended when the box hits the floor. The first law of Thermodynamics is the universal law of the conservation of energy. In simple terms, energy cannot be destroyed. When we observe matter, we can always compute the amount of energy that it contains in its present state.

Sometimes we work with Engineers that use the metric system, where the measurement of work is the joule. A joule is the energy to lift an object the weighs one Newton one meter distance. You could say that a joule is one Newton – meter. In the above problem, the 10 pound box is equal to 44.484 Newtons (N) and 5 feet is equivalent to 1.524 meters (m), so 44.484 N times 1.524 m equals 2.322576 N-m or 2.322576 joules of energy.

Find the amount of energy we would expend lifting the following masses. Compute your answer in Foot-pounds, Newton-meters and Joules.

	Weight of the Box	Height to be lifted	Foot-pounds (ft-lbs)	Newton – Meters (Nm)	Joules (J)
1	50 lbs	3 ft			
2	2 kg	2 m			
3	25 g	1 m			
4	25.5 lbs	18 in			
5	9 oz	36 in			
6	100 lbs	1.5 m			
7	200 lbs	12.75 in			
8	5 kg	36 in			
9	2 lbs + 50 g	45 in			
10	14 kg + 0.5 lb	3.5 m			

*** World Class CAD Challenge 12-1 * - Compute the amount of energy needed to lift mass in the air and set it on a shelf. Record the answer in foot-pounds, Newton-meters and Joules. Complete each record in 2 minutes and record the answers in the table.**

Continue this drill using some weights and distances you have determined, each time completing the drawing under 2 minutes to maintain your World Class ranking.

Potential Energy

There are two types of energy we can see and they are potential and kinetic. Potential energy is the amount of energy that is being stored in matter. Kinetic energy is the work done to accelerate a mass to a specific speed. We will first look at sources of potential energy. In our first example, we will examine an atom, which is a very small particle of matter, and we may already know that Albert Einstein found in 1905 that there is a huge amount of energy stored in atomic masses. Most of you already know the most recognized equation in science:

$$E = mc^2$$

Einstein formulated that the mass (m) of a particle contains energy computed at the product of itself times the square of the velocity of light. For instance, the mass of an hydrogen atom is $1.673 \times 10^{-27}\, kg$. The speed of light in a vacuum is 299,792.458 kilometers per second. Multiply that number by 1000 to get meters per second at 299,792,458. Now imagine the speed of light to the second power. The new value is 89,875,517,873,681,764 meters squared per second squared. Multiply the mass of a hydrogen atom times the square of the speed of light and we get the total energy stored in the hydrogen atom as shown in the calculations below.

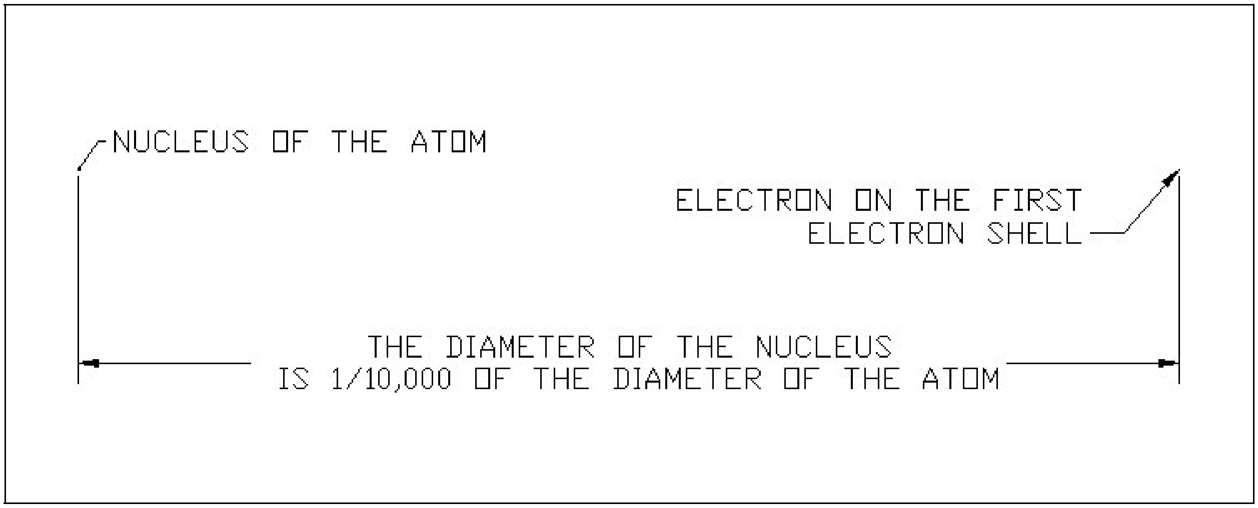

Figure 1.2 – The Size of the Nucleus of an Atom in Relationship to the Orbital Shell

$$E = mc^2$$

$$E = (1.6727 \times 10^{-27}\,kg)(299{,}792{,}458 \text{ m/s})^2$$

$$E = (1.6727 \times 10^{-27}\,kg)(89{,}875{,}517{,}873{,}681{,}764 \text{ m}^2/\text{s}^2)$$

$$E = (1.6727 \times 10^{-27}\,kg)(8.9875517873681764 \times 10^{16} \text{ m}^2/\text{s}^2) = 1.5036 \times 10^{-10} \text{ kg - m}^2/s^2$$

There are 1.265 x 10^{26} hydrogen atoms in a gallon of water so $1.5036 \times 10^{-10} \text{ kg - km}^2/s^2 \times 1.265 \times 10^{26} = 1.902 \times 10^{16}\,kg - km^2/s^2$

One $\text{kg - km}^2/s^2$ equals one joule, so the energy of hydrogen extracted from a gallon of water is $19{,}020{,}000{,}000{,}000{,}000 \text{ kg - km}^2/s^2$ (19 quadrillion) joules of energy. According to Einstein, this would be the consumption of the entire mass, converting the matter into energy. This is not likely to happen, however using existing nuclear fission or fusion, a percentage of that enormous energy is released. How do we compare this huge number to our modern experiences? Well, according to the New York City Energy Policy the 2003 peak demand was 39,672,000,000,000,000 (39.6 quadrillion) joules of energy. So the potential energy of a small amount of hydrogen atoms could produce enough electricity for an extremely large population in the future.

In the United States, we do not use joules to compute energy, we use kilowatt hour. A kilowatt hour (kWh) is equal to 3,600,000 Joules, so our small hydrogen atom could produce 4,176,715,039 kWh of energy. After understanding that a small mass contains huge amounts of energy, we will look at the levels of cosmic energy available.

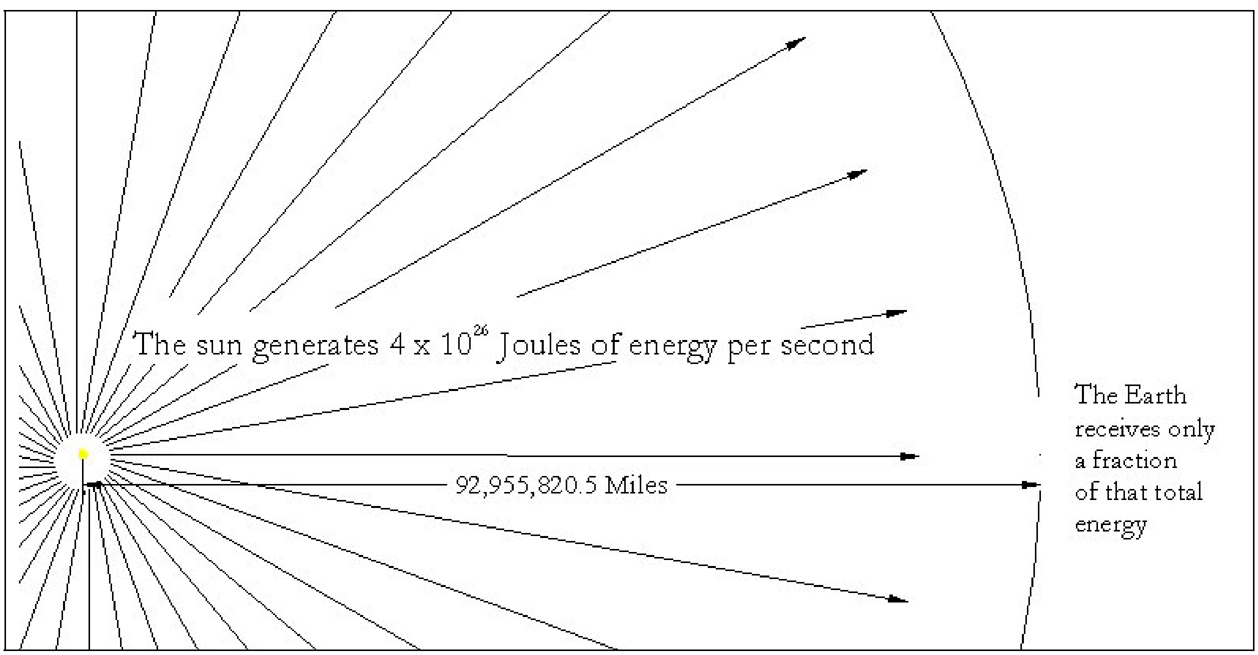

Figure 1.3 – The Sun Generates Massive Amounts of Energy in the Solar System

On an even larger scale the sun contains much more potential energy. According to the Lawrence Berkeley National Laboratory at the University of California, the sun produces 4×10^{26} Joules per second, where only a portion of the energy is received by the Earth. This makes our star, the largest source of energy now and throughout many years into the future. The problem for architects, designers and engineers is the conversion of the potential energy into kinetic energy to do the work we desire in our lives.

We can estimate the amount the sun's energy that reaches the light side of the Earth by calculating the area of the Earth surface in relationship to the surface of the imaginary sphere at our planet's orbit. That small percentage of total surface area represented by the Earth would be subject to that percentage of the energy produced by the sun. The diameter of the Earth is 7,926.41 miles making the area of the circle facing the sun at 49344980 square miles (127802911504965 square meters). The total surface area at the astronomical unit (AU) or the distance from the sun to the Earth is 92,955,820.5 miles. The surface area of the imaginary sphere is $4\pi r^2$ or 1.0858×10^{17} square miles. Divide the area receiving the sunlight by the surface area of the orbit and we estimate that we get 0.000000045444% of the sun's energy. Multiply that number by the total energy output of the sun and the Earth is subject to 1.82×10^{17} Joules of energy per second. Convert our number of Joules by dividing the total by the number of square meters in the area and we get 1422 Joules per square meter per second. NASA estimates that the Earth receives 1380 joules per square meter per second which has been verified by satellite data from 1979 to 1999.

*** World Class CAD Challenge 12-2 * - Research the amount of energy that reaches a 8 meter long by 1 meter wide solar panel on a satellite in one day while circling the Earth at 22,300 miles (geostationary) orbit. The satellite maintains a stationary track over the Earth and is in the sun what percent of the day? Compute the amount of energy the solar panel receives when pointed directly at the sun during satellite daylight hours in Joules.**

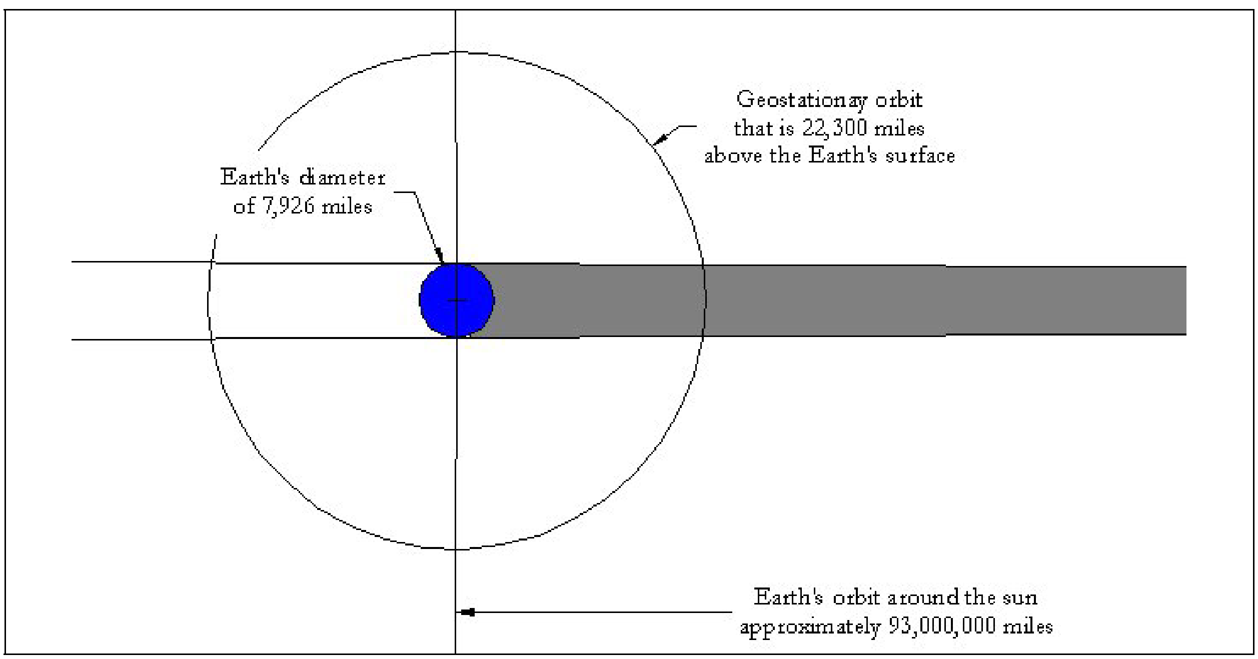

Figure 1.4 – The Geostationary Satellite Solar Problem

Using Energy

The main uses of energy in the world today are for heating, lighting and moving masses. Humans are only a part of the Earth's environment and actually can participate as a system in the transfer of energy. In other words, we can observe energy transfer in almost everything we do. Since the state of energy transfer is so prevalent in our lives, many people do not consider the ramifications of a subject that is as typical to you and I as breathing or our feeling our own heartbeat.

Our bodies work throughout the day by expending energy from the food that we eat. The foods we locate or grow on the Earth contain chemical energy derived from the sun. In each transfer from plant, to animal, to human, the amount of energy converting from one system to another decrease. There are energy losses due to heat, or the incomplete digestion or transfer of energy from the food matter. Finally, the consumer of the food will excrete waste of undigested matter and unused energy. We use the energy from the food we eat to do work as we saw in the first problem in the chapter. Humans need energy to maintain their 98.6° Fahrenheit body temperature, to maintain critical systems such as respiratory, cardiac and digestive systems. We eventually want to move around and do some work and even more energy is expended.

We find other types of potential energy stored in other materials and living entities around the Earth's surface and just below the ground and the ocean. There is stored energy in animals used by people, like using an oxen or a horse to pull a cart or carry a rider. There is energy in the wind that rotates a windmill. A fast moving river turns a water wheel and the cycling of the sea waves can generate electricity. Some systems work cleaner than another, but all systems do create affects on the environment.

When people wanted to do more without using their own power, they figured out how to domesticate other large animals to provide energy and power for them. Nomadic groups use camels, oxen and horses to transport their household goods when they traveled. At the end of the journey, the same animal could turn a grinding wheel in a mill. The term horsepower in our studies comes from the study of how much work a certain type of animal can do.

James Watt, an inventor who made improvements to the design of steam engines studied the amount of power an animal could exert accomplishing work. A pony lifting coal out of a mine could pull 22,000 foot-pounds per minute. He increased the results by 150%, which is 33,000 foot-pounds per minute (550 ft-lb/s) and called it horsepower. We also will need to know that a single horsepower is 746 watts of power. One watt is equal to a Joule per second. Today, the term horsepower is used to describe car engines and electric motors.

*** World Class CAD Challenge 12-3 * - A senior engineer wants you to convert the data in the table to horsepower, watts, Joules per second and foot-pounds from the value given.**

	Horsepower (hp)	Watts (W)	Joules per Second (J/s)	Foot-pounds (ft-lbs)
1	200 hp			
2	75 hp			
3		1500 W		
4		300 W		
5			4000 J/s	
6			90 J/s	
7				25 ft-lbs
8				80 ft-lbs

During the industrial revolution in the 18^{th} century, machines began to replace people and animal power. The steam engine used biomasses such as wood or fossil fuel like coal to bring water to a boil and create steam. The steam would move a piston and the shaft attached to the piston could do mechanical work. Today, coal burning and nuclear power plants create steam to turn a rotor that generates 3 phase electrical power that we use in our homes and businesses. Again, both coal power and nuclear power plants have large affects on our surroundings, not just from the electrical product they make, but from the amount of air pollution from the burning of fossil fuels and from the problem of burying the spent radioactive material which is dangerous to life forms for thousands of years.

How much do we rely on energy in our lives? Using the same system that the power company provides to compute our monthly bill, we can track our how much energy we use. We can also use this information to develop a number for ourselves, which is presently known as the Energy Footprint. An Energy Footprint is a number that represents the area of land required to absorb the Carbon Dioxide (CO2) that we are emitting into the environment.

You can take a quiz to help you determine your Energy Footprint on numerous websites. We took the quiz at http://www.myfootprint.org/en/ by Kinga Dow Productions, Inc. After taking the quiz, we found that we were using more energy than the average person on the planet. The Energy Footprint number is an interesting communication technique that allows individuals and groups to take responsibility for the affects they have on their surroundings. Remember, everything we do and each machine we use takes energy, so understanding the personal and environmental cost to utilizing the source allows one to make better decisions.

Determine your electric usage during each week of the ten week course.

Find the electric meter for your house or apartment. On the evening or morning after your first class, record your meter reading. Exactly seven day (168 hours) later, record the final reading. The final reading for week 1 is the beginning reading for week 2. Everyday, also record the high and low temperatures. Average them for the week by totaling the highs and dividing by seven. Do the same for the average low temperatures. Have your instructor explain how to read the electric meter in your area. The object of the exercise is to be precise. Make a graph of the electric usage and plot the week's average high and low temperatures on the same graph. Look for comparisons between temperature and electric usage.

Week	Initial Reading	Final Reading	Kwh (Final – Initial)	Average High Temperature	Average Low Temperature
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

*** World Class CAD Challenge 12-4 * - Compute the amount of energy needed for a home prior to making energy saving recommendations. Record the answer in kilowatts –hours. Complete each record in 5 minutes and record the answers in the table.**

Continue this drill using some weights and distances you have determined, each time completing the drawing under 2 minutes to maintain your World Class ranking.

More than half or the energy we use in our homes go for heating and cooling. Then comes the generation of hot water and lighting. Electrical appliances use the smallest percentage of electricity in our homes, however as we continue to use more devices this percentage continues to increase. We will now look at the different types of biomasses that are presently used to make energy for our homes.

Converting Biomasses for Energy

Our next look into potential energy used by human is the use of biomasses. That is burning wood or dried plants with fire to transfer heat energy to warm their food. Around any forest or collection of trees, one can find dead limbs setting around decomposing on the ground. Anyone with the experience of camping knows that we can collect dry wood off the ground or break dead limbs from lower levels of the tree on wet or snowy days to make a fire. A properly managed fire can remain lit for many days. Coals from the fire can remain hot and are capable of restarting a new fire in seconds or minutes if we require another cooking area.

Fires using biomass, which is wood, twigs and leaves generate enough heat for cooking. Campfires were eventually replaced with fireplaces in homes and they are still used for cooking and to provide heat. Early home designs either had a cooking area outdoors next to the house or in a room of the house. The hot coals from the fire stay extremely hot for hours and the plant or animal flesh can cook continually for a serve up meal at the beginning or ending of the day. During sleep hours, devices were invented to bring hot stones, coals or water to the bed to counter the coldness of the night. The invention of the cast iron stove brought better control of centralized heat into the home.

The use of biomass fuels to supply energy to people is common even today but this form of potential energy does not supply the largest amount of Energy for homes, towns and cities in the United States. However, the Stevens Croft Biomass Power Station at Lockerbie, Scotland is presently the largest biomass power station in the world producing up to 70,000 homes with an output of 44 megawatts of energy. Remember that 3,600,000 joules equals one megawatt-hour (mWh) so the plant is producing 158,400,000,000,000 (158.4 trillion) joules of energy.

Converting Fossil Fuels to Energy

Early man found that certain types of rock would burn in the fire and they would produce more energy. Coal is a fossil fuel that is available in over half of the countries in the world. The fuel has been in use prior to heating oil or gasoline and will probably be in abundance for hundreds of years after the reduction of oil as the world's primary energy source. Remnants of coal can be found in cooking areas at excavations site of early villages. Mining of coal has been happening in countries for thousands of years.

World coal consumption is presently over 6 billion tons a year and there is an estimated 150 year supply from known coal reserves based upon usage at the present rate. Coal surpasses Nuclear power, hydro and wind as the number one method for making electricity. In the United States alone, over three quarters of the electricity manufactured is with coal fired plants.

In the western United States, where Nuclear power plants are fewer since of the risk of earthquakes, the natural gas plants produce electricity. Natural gas is found

Fossil Fuel	**Joules of Energy**
1 barrel (42 gallons) of crude oil	6,119,320,000
1 gallon of gasoline	130,880,000
1 gallon of heating oil or diesel fuel	146,330,000
1 cubic foot of natural gas	1,080,000
1 gallon of propane	96,000,000
1 short ton of coal (2000 pounds)	21,896,630,000

Figure 1.5 – Energy in Various Forms (Energy Information Administration)

In the 19th century, sea vessels spent multiple years hunting whales to bring their oil to a thriving market. Whale oil is more like a wax and was used for oil lamps. As the whale population on the Earth became sparse, the price of whale oil as our present petroleum products increased. Oil that found a way to the surface of the Earth was made into kerosene and would replace whale oil in lamps.

Oil drilling began in earnest in 1859, when Edwin Drake hit oil at 60 feet depth in Titusville, Pennsylvania. Initially used as a commodity to light homes, businesses and streets, eventually with the invention of the electric light bulb, kerosene lamps become obsolete. However, the transportation industry in the 20th century becomes dependent on oil. Ships no longer use coal but run on oil. The evolving automotive industry settles on the combustion engine to power cars and buses. Eventually, trains also convert to diesel fuel. Aviation only knew one type of fuel form, oil. Oil, now turned into diesel or gasoline, powers the majority of all transportation vehicles on the planet, and without the product, designers and engineers would have to reinvent their products.

Today, most scientist believe that we are presently at the peak of oil production and that like whale oil, production of petroleum product will be negligible by 2080. Other fossil fuels are close behind oil in their lack of abundance and they too will diminish to pre twentieth century production levels. The technologies that support conversion of potential energy from other matter will replace the burning of fossil fuels. We see them emerging today as geothermal, wind, hydro and nuclear. As the burning of fossil fuels diminish not from our care of the environment but from the lack of fossilized resources, the amount of greenhouse gases in the Earth's atmosphere will peak in the 21st century.

*** World Class CAD Challenge 12-5 * - Compute the amount of energy that would match the resource amount listed. Record the answer in the units of that column. Complete each record in 5 minutes and record the answers in the table.**

Continue this drill using some weights and distances you have determined, each time completing the drawing under 2 minutes to maintain your World Class ranking.

Wood (pounds)	**Coal** (tons)	**Natural Gas** (cubic feet)	**Oil** (42 gal barrels)	**Gasoline** (gallons)
2000				
	2			
		500		
			10,000	
100				
				12

The Greenhouse Affect

Other than air pollution, which is harmful to people and animals on the Earth, fossil fuels contribute to the greenhouse affect on Earth. The greenhouse particles that are in the Earth's atmosphere allow the energy from the sun to pass through to the surface and they retain energy by capturing long wave radiation coming from the Earth and thus warm the air. Greenhouse gases are an essential part of our ecosystem; otherwise the temperature on the planet will fall below tolerable limits. Likewise, on Venus, where the greenhouse gasses are in abundance, the planet temperature is extremely high and the present forms of life on the Earth would not tolerate those high levels of heat. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane, nitrous oxides and chlorofluorocarbons (CFCs). While levels of water vapor are dependent upon the region of our planet, and have the largest affect on the planet's ability to retain heat, the amount of all of the others have risen dramatically in the 20th century mainly due to burning fossil fuels.

We previously studied the amount of solar energy that reaches the outer atmosphere of the Earth, by doing a geometric calculation. Now, we will discuss what percentages of that solar energy actually penetrate the layers of atmosphere and heat the Earth. About one third of the energy from the sun is reflected by the Earth's magnetic field, water vapor, ice and land back into space. Half of the energy is absorbed into the land and water and 20% is absorbed in the atmosphere. The surface and atmosphere of the planet continually radiates energy back into space.

The Alternate Energy Picture

The use of water, wind and warm springs as energy sources is not new in many cultures around the Earth; however their use requires that the architect, designer and engineer study and understand the surrounding environment and have an understanding of nature. As with many sciences, there are standard principles that apply. Water falls from higher elevations to lower elevations from the affects of gravity, just like our box in the first pages of this chapter fell from the shelf. The kinetic energy from that drop converts into mechanical energy which must often turns a wheel to generate electricity. Wind or the moving of the Earth's atmosphere is a product of many variables including the rotation of the Earth, and its energy can turn a wheel that again produces electricity. Just feet below the Earth, the temperature of the ground is heated by the total mass of the Earth. This geothermal region can heat either liquid or air, which can maintain a comfortable temperature in our homes and offices. Will the borrowing of these energies have an affect on the environment? The answer is yes. What is that affect, no one scientist can tell us, but over a long enough period of time, all conversion of energy have both positive and negative outcomes.

In some cases, a designer can place a mechanical device in running water, which will turn the device mechanically and create electricity. In more instances, a dam is built which creates a reservoir of potential energy that when drops a distance, the force of the water will cause the mechanism to rotate and again generate power. Although dams make useful energy for people and their communities, as an obstacle to natural flow of water, the system does change the surrounding ecosystem. According to the Energy Information Administration, hydropower accounted for 7% of the electricity generated for the United States and we can observe in Figure 1-6, that consumption of energy generated by conventional hydroelectric is hardly improving.

The Energy Consumption Table reports the utilization of energy in British Thermal Units (BTUs). A BTU is defined as the amount of heat required to raise the temperature of one pound of liquid water one degree Fahrenheit. One BTU is equivalent to 1055 Joules of energy.

Electricity created by wind power is growing in the United States, nonetheless the technology does not even account for 1% of the energy consumed. In certain areas of the world, constant wind can generate continuous levels of electricity. Although constant wind is a consideration, the ability for individual windmill owners to place electrical current on the existing power grid is a positive incentive for an owner, where they can sell the electricity to power companies.

Table 1.1. U.S. Energy Consumption by Energy Source, 2002-2006 (Quadrillion Btu)					
Energy Source	**2002**	**2003**	**2004**	**2005**	**2006**
Total[a]	97.684	97.971	100.051	100.161	99.398
Fossil Fuels	83.994	84.386	86.191	86.451	85.307
Coal	21.904	22.321	22.466	22.795	22.452
Coal Coke Net Imports	0.061	0.051	0.138	0.044	0.061
Natural Gas[b]	23.558	22.897	22.931	22.583	22.190
Petroleum[c]	38.227	38.809	40.294	40.393	39.958
Electricity Net Imports	0.072	0.022	0.039	0.084	0.063
Nuclear Electric Power	8.143	7.959	8.222	8.160	8.214
Renewable Energy	5.893	6.150	6.261	6.444	6.922
Biomass[d]	2.706	2.817	3.023	3.154	3.374
Biofuels	0.309	0.414	0.513	0.595	0.795
Waste	0.402	0.401	0.389	0.403	0.407
Wood Derived Fuels	1.995	2.002	2.121	2.156	2.172
Geothermal Energy	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV Energy	0.064	0.064	0.065	0.066	0.072
Wind Energy	0.105	0.115	0.142	0.178	0.264

[a] Ethanol blended into motor gasoline is included in both "Petroleum" and "Biomass," but is counted only once in total consumption.

[b] Includes supplemental gaseous fuels.

[c] Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.

[d] Biomass includes: biofuels, waste (landfill gas, MSW biogenic, and other biomass), wood and wood derived fuels.

Figure 1.6 – Table from the Energy Information Administration website

Geothermal is probably the easiest system to incorporate in placing energy savings into our designs. The ground temperature a few feet below the Earth's surface ranges from 45°F in northern regions of the United States to 70°F in southern states. Either an open or closed loop system can circulate liquid through the large ground mass and either heat or cool a home or business efficiently. On heating days in the winter, the closed system's fluid is sent through the ground and then to the heat pump where when compressed, the heat is transferred to the dwelling. In the summer months, the warm temperature in the home is exchanged with the cooler ground temperature. These systems return cost savings for individuals that stay in a single dwelling for the period to collect on the energy savings.

The Nuclear Energy Option

After Einstein's revolution in both quantum and cosmic science starting in 1905, some scientist believed that atomic power could be a significant option in producing large amounts of energy. One of the two types of atomic power we will discuss is nuclear fission. Nuclear fission is splitting an atom into two parts, releasing free neutrons and gamma rays. The bombarding neutrons can trigger more events, thus releasing more free neutrons and more gamma rays. The release of photons cause heat in water in a nuclear reactor, and the water is turned into steam to turn generators that make electricity. The greatest harm and danger in working with nuclear fission is the creation of radioactive material. The spent nuclear fuel will be harmful to the environment for days or thousands of years based upon the type of material used. A nation using nuclear fission is responsible for storing and monitoring the spent nuclear fuel for thousands of years. The storage sites are far away from human contact and are built to shield the environment from the continual radioactive decay. Eventually, radioactive material will stabilize.

A nuclear power plant uses fuel rods with uranium 235 or plutonium 239. When a neutron collides into the uranium 235 atom, the larger element becomes an unstable uranium 236 element. The new mass splits in two lighter particles along with addition free neutrons and released energy. In a typical nuclear power plant, a pressurized water reactor, the nuclear fuel rods are in a reactor chamber where they release energy to pressurized water which will not turn to steam. The heated water is piped in a closed system to the steam generator transferring heat to another reservoir of water that generates steam to turn a turbine. The two closed systems, the pressurized water that flows through the nuclear reaction and the steam generator are not mixed, but only transfer the energy.

*** World Class CAD Challenge 12-6 * - Using information released by the United States Nuclear Regulatory Commission, draw an engineering drawing of pressurized water nuclear power plant. Add notes to describe each process.**

Complete this drawing in less than 120 minutes to maintain your World Class ranking.

The other type of atomic reaction to create energy is nuclear fusion, where in the sun Deuterium and Tritium are fused together under the enormous forces from the gravity of the star and the product is Helium, a neutron and energy. We can receive energy through nuclear fusion which is created by large gravitational forces and temperatures that are present in stars; however the Earth does not have the mass or core temperatures to produce fusion of atoms. Scientists are studying how to use inertial confinement and magnetic confinement fusion to fuse atoms together.

Two atoms have very strong positive fields keeping them from fusing. By comparison, the attraction between the nucleus of an atom and a free electron is one millionth than the energy to fuse two nuclei together. To overcome the resistance of hydrogen atoms to fuse together on Earth, scientist can use temperatures in excess of 100 million Kelvin, which is six times the temperature of the sun's core. We could also use magnetic field to squeeze the atoms together. There are various other methods that scientists are experimenting with to accomplish nuclear fusion, but the most popular involves increasing temperature and pressure.

A method to create nuclear fusion being experimented with in France uses a toroidal shaped confinement chamber with large super conducting magnets. A stream of hydrogen gas is injected into the donut shaped vacuum and the magnetic field pressurizes the plasma stream fusing the Deuterium atoms together. The energy produced in the core will heat a fluid circulating around the core and as in other system we have studied that will turn turbines and generate electricity. The advantage of the fusion reactor is that the spent material remains radioactive for only a fraction of the period that nuclear fission matter does.

The process to make energy from fusion is important to replace nuclear fission, where people will have to manage radioactive waste, or substitute for fossil fuels which resources are deteriorating and are nearly spent. Experimental fusion plants are planning to go online in the next decade.

The Role of Modern Architects, Designers and Engineers

Even with newer technologies emerging, architects, designers and engineers will need to know how to manage energy in this transitional century. Even with new ways to produce electricity being implemented in communities, designers will need to work with customers to assist them in converting their habitats into efficient energy consumers. When an engineer is working with a client that does not have reliable power or natural resources such as water, then they will have to pay close attention to designing systems into a building that use their surrounding assets efficiently and economically.

Some industries such as aviation will be exploring different ways to make synthetic fuels, so when easily found fossil fuels diminish, the systems that run on older types of fuel can be replaced. This transitional period will pave way for innovative professionals who research various forms of new technologies and gain the experience to simulate them in the computer model, account for them in the assembly drawing and understand how to assist the technicians in placing them in the actual product. Not having a complete understanding of a new subsystem to any design very often result in overall product failure, mainly from incorrect installation or poor maintenance of the misunderstood system. Do not expect a customer to comprehend the intricacies of a newer technology unless the architect, designer or engineer initially trains them on the system and makes periodic inspections or visits to verify the energy saving system is working properly.

Where many technical experts in the past just plugged into an energy rich environment, today we have the opportunity to prepare for an interesting future.

*** World Class CAD Challenge 12-00 * - Complete this textbook in 40 hours of classroom training. Pass your Mechanical Design Levels 1, 2 and 3 certifications to be ranked among the best in the world.**