BETHEL COLLEGE MENNONITE CHURCH
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Energy availability and affordability and environmental problems caused by energy use have become serious concerns. They will become more serious as world population continues to grow and per capita energy use accelerates. Growing energy use not only may increase the rate of depletion of energy resources but also may exacerbate many pollution problems, especially the emission of greenhouse gases that intensify global warming. But all of this depends upon the energy options we choose.

I will summarize below some of the energy sources that we might use to perform needed services.

Fossil fuels. These are the dominant energy sources in the industrialized world. There are finite supplies of each of them so they are depletable.

1. Coal – World-wide coal use increased by 6.9% in 2003, continuing rapid growth in coal use, especially in India and China. It is used to produce 56% of the electricity in the US. Coal has a high net useful energy yield so it is the cheapest way (unless one factors in environmental costs and government subsidies) to produce high temperature heat and electricity. The US has large supplies of coal with enough to last 300 years at current rates of use. However coal is the dirtiest fossil fuel. Since it is 70-80% carbon, it produces more carbon dioxide (the most common greenhouse gas) per unit of energy than other fossil fuels. Coal emits many pollutants as gases or in the fly ash when it is burned unless strict pollution control methods are used = including compounds of sulfur, mercury and nitrogen, much particulate matter, and some radioactive elements such as thorium and uranium. Surface mining causes severe land disturbance and underground mining is a very dangerous occupation.
2. Petroleum – World-wide oil use increased by 3.4% in 2004, the fastest rate of increase in 16 years. US domestic oil production peaked in 1970 and has been declining since. World production is projected to peak before 2020, so it is the fossil fuel in shortest supply relative to demand. Being a liquid mixture, oil is a versatile fuel and relatively easily transported. It is a good vehicle fuel and has a high net useful energy yield. However it emits large amounts of carbon dioxide when burned as well as air pollutants such as nitrogen oxides and sulfur oxides. Oil spills have also been a pollution problem. Petroleum is also a feedstock for plastics and other organic compounds and some experts would maintain that remaining stocks are more useful for that purpose than for fuel.
3. Natural gas – World-wide use of natural gas increased by 2% in 2003. Natural gas is cleanest of the fossil fuels. It produces half as much carbon dioxide as coal when burned. It also emits few other pollutants. It has a high net useful energy yield. World supplies will last 80-200 years, but this will shorten if usage rates continue to grow by 2% per year. Although it can be transported easily by pipeline over land, it must be liquefied to be shipped by tanker and this reduces the net useful energy yield by one-fourth. Methane, the major component of natural gas, is a more potent greenhouse gas than carbon dioxide but little escapes into the atmosphere from its extraction and use. Natural gas is also dangerous because it is highly explosive.

Nuclear energy. World nuclear generating capacity increased by more than 2% in 2004. World nuclear generating capacity has grown very slowly – less than 12% since 1990. In the US, no new nuclear reactor has been started since 1970. However recently, it has been promoted as a solution to the global warming threat, since nuclear power plants emit no carbon dioxide. However an analysis of power plants over their entire life cycle indicates that the average nuclear plant produces 20-40% of the carbon dioxide emitted

by a natural gas-fired plant over its life cycle. Nuclear plants also release some more potent greenhouse gases, such as sulfur hexafluoride. Proponents of nuclear energy point out that an average coal-fired plant has more radioactive emissions than the average nuclear plant. Opponents point out that this does not take into account radiation exposure over the whole fuel cycle from mining to waste disposal nor the possibility of accidental high releases from a nuclear plant. The main factor discouraging the development of nuclear power plants is the high cost, much higher per kwh of electricity than many other technologies. Nuclear energy is only used in large centralized power plants that have a long lead time of many years from planning to startup. They depend upon a limited supply of uranium. There are also problems that have not been satisfactorily solved – what to do with the 20-30 tons of radioactive spent fuel produced by each plant each year and how to maintain its security over many generations and how to restrict the proliferation of nuclear weapons. Also the public is still hesitant over the risks of a major accident at a plant or in transportation of radioactive materials.

Renewable sources. The following energy sources all depend upon the capture and use of the vast amount of energy that comes to the earth each day from the sun. Therefore the source will be there as long as the sun sends out radiant energy.

1. Solar – World-wide electrical generating capacity by photovoltaic (PV) cells, although still small, has been increasing at an average annual rate of 32% since 2000. Japan is the world leader in PV installation. At least 160,000 Japanese homes are PV-powered and the government aims to have 10% of electricity generated by PV cells by 2030. Although the cost has been reduced by about 90%, it is still higher than many other technologies and government incentives are necessary to encourage development. Energy efficiency is high. It takes 4-6 years of operation of a PV system to produce the energy used in its manufacture and it has a projected lifetime of 30 years. Coop America has started the Solar Catalyst Group, a consortium of business, government, labor, environmental and community groups to accelerate the development of a mass market for PV cells and thereby bring their price down to where they are competitive with other technologies.
2. Wind - World-wide wind generating capacity grew by 21% in 2004 and has been growing by about 20% annually for the last 10 years. Energy efficiency of wind generation is high and today wind generated electricity is cheaper than electricity generated by natural gas burning. In 1990 Germany had almost no renewable energy industry with a fraction of the wind capacity of US. Today they have twice the wind capacity of the US and this meets 6.6% of their electricity needs. Germany is also second to Japan in installed PV capacity. In 10 years they built a multibillion dollar industry. Spain exceeded Germany in the installation of wind capacity in 2004 and meets 6% of its electricity needs with wind power.
3. Biofuels - Biofuels such as ethanol and biodiesel burn cleaner than fossil fuels, are renewable and can be domestically produced in many countries. However the energy efficiency is low to fairly high depending upon the feedstock and the process. They are generally more expensive than fossil fuels although less expensive processes are being developed. World-wide fuel ethanol production grew by 14% in 2004. Ethanol developed from sugarcane accounts for 30% of auto fuel in Brazil.

Hydrogen. Hydrogen is an abundant element. When it burns, the only product is water so it is a nonpolluting fuel. However it is not a readily available energy source since most hydrogen is not free as a gas but the atoms are combined in chemical compounds with other atoms and it takes energy to free them from these molecules. The cheapest way to produce hydrogen today is

from natural gas but this is a nonrenewable resource and a product of the process is carbon dioxide. It is also possible to get hydrogen from the electrolysis of water but electricity is expensive and more energy would need to be used than would be produced by burning the hydrogen, a losing proposition if you are using electricity from power plants that burn nonrenewable resources. However hydrogen could be used as an energy currency in the future, produced by solar cells or wind-generated electricity. It could be used as a vehicle fuel or to store electricity generated by wind or solar cells. It is flammable but less explosive than gasoline or natural gas. However it cannot be compressed as easily as natural gas. In automobiles it could be used to power fuel cells which would be an efficient means of releasing the energy and would only produce water. Much work is being done to develop a hydrogen energy economy. Governor Arnold Schwarzenegger, by executive order, recently inaugurated the California Hydrogen Highway Initiative to build 200 hydrogen filling stations along major freeways in California.

We consumers do not want energy per se but rather we want the services that energy can provide – mobility, comfort, lighting, entertainment, communication, etc. Therefore getting these services with less energy expenditure in a more efficient system satisfies our needs as well as increasing the supply of energy in an inefficient system. It is often cheaper to increase the efficiency of energy use than to increase the amount of energy supplied. Therefore as individuals and as a society we should first look at ways to increase efficiency before we look at ways to increase supply. Less than 20% of commercially produced energy in the US economy performs useful services. Of the 80% that winds up as waste heat without performing useful work, about half is unavoidable waste that always occurs with energy transformations but half is unnecessary. So increasing energy efficiency is a large source of new useful energy.

We use energy for many different tasks. Different forms of energy have different qualities and are therefore well suited for certain tasks but not efficient in accomplishing others. Gasoline can run your automobile but is not well suited to lighting your home, powering your TV or running your vacuum cleaner. Electricity is a high quality energy that is well suited to the latter tasks but it takes a large input of energy to produce a much smaller output of electrical energy. Therefore electricity is not very efficient in heating a building because that does not require such high quality energy.

Another important consideration is the pattern of supply. Large centralized sources (such as large power plants) are more subject to mass breakdowns and terrorist attacks than smaller dispersed sources (such as PV cells on the roofs of buildings). In a new publication of the Rocky Mountain Institute ("Small is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size"), Amory Lovins and his six coauthors also describe how the small size of distributed resources – those devices that make store or save electricity near to where it will be used – contribute to their economic value

There are many energy technologies and each has its own positive and negative points. In determining our energy strategy, we probably will want a mix of energy sources and forms of energy. There will be tradeoffs to be made but we should optimize the energy system in terms of efficiency, environmental effect and satisfaction of human needs. We should also consider these three factors in our individual purchases of energy services.