energy in a global world

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Historically, the primary sources of energy for agriculture, transportation, and other human endeavors were the efforts of humans and their domesticated animals. Wood and other forms of biomass were the major sources of heat for cooking and to keep homes warm. The limitations imposed by these energy forms obviously suppressed productivity and living standards. Transportation was slow, work was tedious, and productivity minimal.

Much changed with the emergence of the Industrial Revolution. The Industrial Revolution was largely a result of the growing capacity of humans to harness and utilize fossil fuels as an energy source. Fossil fuels developed from organisms that lived long ago and over time have become transformed into coal, oil, natural gas, or other products. The increased capacity of humans to efficiently use fossil fuels as an energy source has completely transformed human life.

Fossil fuels have dramatically increased transportation speed and capacity. They are used to operate farm equipment and factories and have greatly increased the work capacity of individuals. Fossil fuels also heat and cool our homes and provide electricity to keep the lights on and to operate our televisions, radios and computers, and allow us to do so with the flip of a switch.

Additionally, fossil fuel industries provide employment for large numbers of people and contribute extensively to our economy. Yet, there are major concerns with our fossil fuel-based economy. These include:

1. The inevitable depletion of a nonrenewable resource
2. U.S. dependence on foreign energy
3. Climate changing greenhouse gasses and other forms of pollution
4. Environmental consequences of fossil fuel extraction and transport

Resource Depletion

Fossil fuels are a nonrenewable resource. The fossil fuels we use today will simply not be available for our future generations. Resource depletion is amplified by ever increasing resource use. The world's population is growing and people are getting wealthier, both of which lead to increased consumption. As people around the world become wealthier, they desire to translate their higher incomes into an improved standard of living that includes the consumption of vastly greater amounts of energy. It is true that ever-improving technology makes it possible to use previously unusable resources. For example, recent developments in horizontal drilling and hydraulic fracturing (fracking) make it economically feasible to produce natural gas and "light tight" oil from previously unusable shale formations. While the implications of these developments are profound, fossil fuels are still a nonrenewable resource and supplies necessarily diminish when they are used.

Thus far, U.S. coal and natural gas production has been sufficient to meet demand. The same is not true of petroleum production. U.S. petroleum production increased until reaching a peak in 1970 and then began to decline as major oil fields became depleted. The amount of petroleum produced in the United States declined by 35 percent between 1970 and 2000 (Figure 1). In the past decade petroleum production in the U.S. stabilized as a result of fracking that made production from shale formations such as the Bakken in North Dakota and surrounding areas economically feasible. Until now, shortfalls in petroleum production have been offset by ever increasing oil imports. Figure 2 makes U.S. dependence on energy imports apparent. With finite fossil fuel resources, however, even international supplies must eventually become depleted.

U.S. Dependence on Foreign Supplies

Foreign oil dependence is problematic for several reasons. First, when the U.S. imports foreign oil, it results in the transfer of massive wealth from the United States to the major oil producing countries. Furthermore, many of the oil exporting countries use oil wealth to maintain non-democratic governments and suppress human rights. Finally, for the U.S., foreign dependence means vulnerability.

A dependence on energy imports, associated with resource depletion, has led to pressure to increase production of the more abundant U.S energy resources. The U.S. has extensive known coal deposits and the emergence of fracking has allowed the production of natural gas to increase substantially (Yergin, 2011). Additionally, oil shale is a fossil fuel with massive reserves that may be critical in the future. Oil shale can be mined and processed to generate oil similar to the oil that is pumped from conventional oil wells. While oil shale is found in many places throughout the world, by

far the largest known deposits are found in the Green River Formation in Colorado, Utah, and Wyoming. Estimates of the recoverable oil from the Green River Formation are three times greater than the proven oil reserves in Saudi Arabia. Extracting oil from oil shale is more complex as it has to be mined and then heated and is thus more expensive. Consequently, the utilization of oil shale is minimal. Should oil prices get high enough or extraction techniques more efficient, oil shale could play a significant role in meeting the energy needs of the future.

Climate Changing Greenhouse Gas Emissions and Other Pollutants

Unfortunately, any energy solution based on fossil fuels enhances climate change and other pollution concerns. Increasingly, scientists are in agreement that dangerous climate change is occurring and is a result of human activities, especially the burning of fossil fuels. As fossil fuels are burned carbon dioxide, methane, and other greenhouse gasses accumulate in the atmosphere. These greenhouse gasses allow light from the sun to enter, but then trap a portion of the outward-bound infrared radiation, which makes the air increasingly warmer (Speth, 2004). Some greenhouse gasses in the atmosphere are natural and necessary. In the 19th century and before, carbon dioxide levels in the atmosphere were about 284 ppm (Emmanuel, 2007; IPCC, 2007; Speth, 2004). Carbon dioxide levels increased from 316 ppm in 1959 to 397 ppm in 2012, an increase of 26 percent in only 53 years. Also significant is that the rate of increase has become larger as progressively larger amounts of fossil fuels are being burned each year.

Evidences of climate change proliferate throughout the world. If current trends continue, the amount of greenhouse gasses in the atmosphere will continue to grow, and the consequences could be disastrous (Stern, 2007). Obviously the best way to avoid these scenarios is to reduce fossil fuel use.

Environmental Consequences of Fossil Fuel Extraction and Transport

By its very nature, the extraction of fossil fuels is environmentally disruptive beyond simply the emissions generated. Fossil fuels are underground, and soil and rocks must be removed, tunnels dug, or wells drilled to reach them. The process of extracting fossil fuels by mining requires that the sought after resources be mixed with impurities and other unwanted materials that have to be removed. Disposing of these unwanted materials is a significant problem. Another consequence of mining for fossil fuels is oil spills. In April 2010, a massive oil spill occurred in the Gulf of Mexico following an explosion at a BP well. Estimates are that 19,000 barrels of oil per day gushed into the Gulf. Before the flow could be stopped several months later, more than 120 million gallons of oil had been spewed into the Gulf, making it the worst oil spill in world history. In 1989, the wreck of the supertanker Exxon Valdez in Alaska's Prince William Sound resulted in 260,000 barrels of oil being spilled. The implications of oil spills for wildlife and biodiversity are extensive and last for years.

Reducing Fossil Fuel Dependence

As a consequence of these problems, there is extensive interest in decreasing our dependence on fossil fuels. Two major approaches for reducing fossil fuel dependence include increased alternative energy use and conservation.

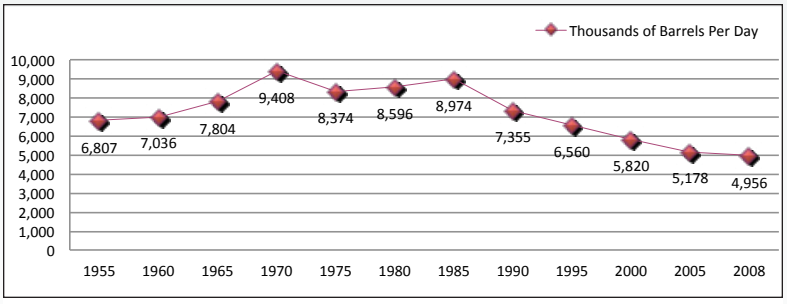

Figure 1. Crude Oil Production in the U.S. between 1955-2008.

Alternative Energy

Two major sources of non-fossil fuel energy include nuclear power and renewable energy. Nuclear power has always been surrounded by controversy as opponents contend that it poses significant threats because of nuclear wastes which can remain dangerous for millennia; the risk that technology

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and materials can be used to build nuclear weapons; and concern that nuclear power plants pose the risk of major nuclear accidents. Proponents of nuclear energy argue that nuclear power is sustainable, emits no climate changing greenhouse gasses, and can decrease U.S. dependence on foreign energy.

A variety of renewable energy sources represent another form of alternative energy. As opposed to the nonrenewable fossil fuels, renewable energy is generated from naturally replenishing resources such as the sun, wind, plants, and flowing water (IPCC, 2011). While the potential benefits of renewable energy are great, significant problems remain. Most fundamentally, the cost of producing renewable energy is generally more expensive than producing fossil fuel energy – unless externalities are considered. For example, producing electricity from coal is simply more cost efficient than producing energy from wind or solar – especially if the costs of greenhouse gas emissions are not considered. Also troubling are the problems of consistency and predictability. The wind doesn't always blow and cloudy and rainy days reduce the capacity of solar energy.

Conservation and Efficiency

An absolute necessity to assure a reasonable energy future is improved conservation. Vast amounts of energy could be saved if cars achieved better gas mileage and were driven fewer miles, if public transportation was more widely used, if we all walked more, and if homes were smaller and better insulated. While significant progress has been made, there is vast room for improvement.

Conclusions

The utilization of fossil fuel energy has completely transformed the world in which we live. A fossil fuel economy, however, at given consumption levels is unsustainable in the long run. Thus, efforts to enhance the production of alternative and renewable energy are vital and time is of the essence. Improved energy conservation is also essential. Educational programs and policy alternatives to make reduced dependence on fossil fuels should be a top priority. By acting now, the U.S. has the potential to be on the forefront of renewable energy production, with the resulting expansion of employment opportunities and other economic benefits. The sun and wind that are so pervasive can become major economic assets. An advantage of the sun and wind, compared to fossil fuels, is that these energy sources are truly infinite.

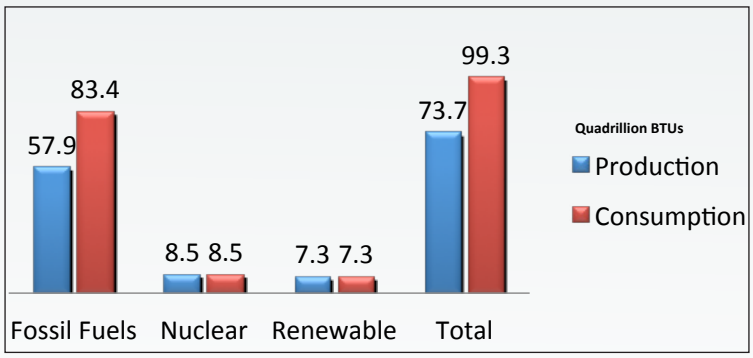

Figure 2. Energy Production and Consumption in the U.S. in 2008.