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Pros and Cons of Energy Alternatives

One of our nation's most significant challenges continues to be finding inexpensive, clean and reliable sources of energy. Currently, our fuel supply comes from five major sources: petroleum (comprises 39.8% of the total fuel supply), natural gas (23%), coal (22.5%), renewable energy such as wind and solar (6.1%), and nuclear power (8.2%). All five sources are used to manufacture electricity, which accounts for 38.9% of the total energy use in the United States. Transportation is the next biggest use of fuel (27.7%) and uses four of the five energy sources (not nuclear power).

The percentage of net imports of petroleum is expected to rise from 52% in 2000 to 64% in 2020. Our reliance on foreign oil brings with it cost and supply vulnerability issues. In addition, there are environmental concerns with fossil fuel that cause alarm. These problems prompted President Bush to announce his Advanced Energy Initiative in his 2007 State of the Union address. The Initiative "provides a 22% increase in research funding for cleaner, cheaper, more reliable energy: solar, wind, nuclear, zero-emission coal, batteries for hybrid and electric cars, hydrogen and biomass – with the goal of replacing 75% of oil imports from the Middle East by 2025."

Each source of energy mentioned by the President has advantages and disadvantages. There is no clear-cut winner in the race to find a better fuel. And what works to fuel manufacturing and residential equipment may not fuel cars and trucks. That depends on how transportable, storable, and efficient each "alternative fuel" source is. A discussion of each fuel, as well as its pros and cons, follows.

Solar

There are two types of solar fuel conversion. One type, photovoltaic, uses semiconductor materials (solar panels) to convert sunlight into electricity. Scientists estimate that this method is capable of supplying 5,000 times what the world currently consumes in energy. The main problem attached to photovoltaic solar energy is that the material used to make the solar panels, poly-crystalline silicon, is in short supply because of demand by the semi-conductor industry. According to the Financial Times, global production of solar batteries grew by 47% in volume during 2005. There is an alternative material in use, called amorphous silicon, but it is half as efficient, though much lower in cost.

The other type of solar fuel conversion is the solar-thermal system which captures the sun's heat, not the sunlight. A solar-thermal system consists of thousands of mirrors attached to a Stirling engine; a plant is under construction in the Mojave Desert, which will situate 20,000 mirrors on 4,500 acres. The mirrors heat water used to push a piston that in turn drives an engine. Obviously, the size of this system and the availability of sunlight are issues. Despite these obstacles, Stirling Energy Systems of Phoenix is building two plants in California and has signed

20-year power purchasing agreements with Southern California Edison and San Diego Gas and Electric.

Wind

Wind power is growing at about the same rate as solar power. Most of this growth is in Europe. In the U.S., wind power capacity was up 36% in 2005, but still only generates about 0.5% of our nation's electricity. It is estimated that if we could capture the wind's capacity we could generate 3 times the total amount produced from all energy sources in the U.S. last year. The problem is that most people do not want wind turbines in their backyard.

Nuclear

Nuclear power currently accounts for one-sixth of the world's electricity. 20,000 megawatts of nuclear capacity have come online globally since 2000, mostly in the Far East. But in the U.S., sociopolitical concerns about nuclear waste, proliferation, and safety (remember Chernobyl and Three Mile Island) have caused output from nuclear facilities to decline in recent years. Still, there are at least 11 new nuclear plants in the design process (though no firm commitments) and it is being touted as carbon-free. Nuclear power carries with it high capital costs and uncertainty how to handle nuclear waste. Also, as Iran has recently demonstrated, there is a fine line between enriching uranium for nuclear power and nuclear weapons. Nuclear proliferation is certainly an issue.

Zero-emission Coal

Coal prices are relatively low and stable, especially compared to petroleum, and the U.S. supply is abundant. However, coal power plants burn twice as much carbon per unit of electricity as natural gas, making coal a major contributor of greenhouse gases. (Currently, power plants account for one-third of U.S. and global carbon emissions according to the U.S. Dept. of Energy Office of Fossil Energy, Carbon Sequestration Fact sheet). "Zero-emission" coal can be accomplished by "carbon sequestration" (returning the carbon to the earth) which requires pipelines to transport the carbon dioxide to either a saline aquifer deep in the ocean, or to an un-mineable coal bed. CO_2 is already injected into oil fields to extract more oil, so the sale of carbon dioxide to oil producers could make this an economically feasible option. Or, zero-emission coal could be accomplished by capturing the CO_2 before or during the combustion process. However, this process requires pure oxygen instead of air to combust high-carbon fuels, and the production of oxygen is expensive in capital and energy consumption. Of course, there is the natural process of carbon sequestration; if we reforested non-forested lands, such as agricultural lands and wetlands, we could offset an additional 26% of U.S. carbon emissions. It is estimated that 13% of worldwide carbon emissions are currently sequestered by forests.

Debate on the methods of manufacturing zero-emission coal does not address safety issues of coal mining. In 2005, 6,000 people in China died in mining accidents and another 60,000 suffer from black lung disease. Tainted streams and destroyed ecosystems can also be byproducts of coal mining.

Hydrogen

Although hydrogen is the most abundant element in the universe, it does not exist alone. So unlike coal that can be mined, or solar and wind energy that can be captured, hydrogen must be processed from another source such as natural gas, oil, coal or water. Currently, 95% of hydrogen produced in the U.S. uses natural gas as feedstock and releases significant quantities of

greenhouse gases. Again, we run into the sequestration problem. Two other methods of producing hydrogen are less efficient but avoid greenhouse gases. One is the electrolysis of water using nuclear power, wind or other non-carbon generating sources. Another is called "bio gasification," which according to Joan Ogden in the September, 2006, issue of Scientific American, is "heating organic materials such as wood and crop wastes so that they release hydrogen and carbon monoxide." She contends that this technique "does not add greenhouse gases to the atmosphere, because the carbon emissions are offset by the carbon dioxide absorbed by the plants when they were growing." Problems that arise with hydrogen as a fuel are that it is light, tends to leak from containers, and it is also highly combustible.

Biomass

In his testimony before the House Subcommittee on Energy and Water Development, Alexander Karsner, Assistant Secretary of the Office of Energy Efficiency and Renewable Energy, called Biomass, "the most viable renewable option for producing liquid transportation fuels in the near term, with the potential to help reduce our dependence on imported oil. The focus of the program is to make cellulosic ethanol cost-competitive by 2012." Cellulosic ethanol uses lignin, an unfermentable part of organic matter, to heat plant sugars. The heat is used to boil water in the boiler, and the energy in the steam is used to turn turbines and generators. (Corn-based ethanol uses fossil fuel to provide the heat for fermentation so it is questionable whether or not greenhouse gases are actually reduced through corn-based ethanol).

Geothermal Energy

One source of energy President Bush did not mention is geothermal energy. A January 2007 MIT study found that mining the huge amounts of heat stored in the earth's rock crust could be a competitively-priced, environmentally-sound source of energy. Although drilling has to reach depths of 5,000 feet or more in the west, and deeper than that in the eastern U.S., no fuel is required for its manufacture, and it is available almost anywhere. Also, unlike other renewable resources, geothermal methods do not rely on the sun shining or the wind blowing. The MIT study shows, "that drilling several wells to reach hot rock and connecting them to a fractured rock region that has been stimulated to let water flow through it creates heat-exchangers that can produce large amounts of hot water or steam to run electric generators at the surface." Sites in California, Hawaii, Utah and Nevada already successfully produce geothermal energy.

Energy Costs

A discussion of the pros and cons of different energy sources would not be complete without comparing their costs to the consumer. Here, coal, solar (using mirrors), and wind, all cost around 4.5 cents per kilowatt-hour and are the winners. Natural gas costs 5.8 cents and biomass costs between 6 and 9 cents per kilowatt-hour.

Transportation

In the list of "cleaner, cheaper and more-reliable energy" President Bush gave in his State of the Union Address, he mentioned batteries for hybrid and electric cars. He also called on the U.S. to produce 35 billion gallons of "alternative fuel" by 2017, and a cut in gasoline consumption by 20% in the next 10 years. But what is that "alternative fuel" and how are we to cut gasoline consumption?

Since 97% of transportation fuel currently comes from crude oil, the switch to alternative fuel will require great effort and technological advances. We have discussed the transportation and

storage issues of hydrogen fuel, and the waste storage, greenhouse, and security issues of nuclear and coal-derived electricity. But cellulosic ethanol, E85 ethanol (which contains only 15% gasoline), hydrogen and clean diesel (low-sulfur-emitting diesel) are good options. Again, there are pros and cons of each. But basically, it boils down to the "chicken and the egg" problem. Car manufacturers are waiting to see what "gas" stations will offer before they design engines. "Gas" stations are waiting to see what kind of cars and trucks they will be fueling. It seems that if we are to meet the President's goal of reducing foreign reliance by 2025 and achieve a 20% cut in gasoline consumption in the next 10 years, there needs to be more governmental direction to break this stalemate. Unfortunately, political agenda sometimes eclipse sound economics. Perhaps high gas prices will motivate industry and energy consumers to coalesce around economically viable solutions.

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