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## Alternative Energy Sources - Myths and Realities

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Oil fuels the modern world. It brought great changes to economies and lifestyles in less than 200 years. Nothing else to date can equal the enormous impact which the use of oil has had on so many people, so rapidly, and in so many ways around the world. But oil is a finite resource. The common question "How long will oil be produced?" is the wrong question. The critical question is "When is the date of the maximum daily amount of world oil production--the peak?" After that oil will be an irreversibly declining resource facing an increasing demand which cannot be met. The world passed its peak of rate of oil discoveries in the 1960s, but there is a lag time from discovery to full production. Although estimates differ slightly, it seems clear that the peak of world oil production will be reached at least by 2020, and possibly within the next decade (Campbell 1997; Campbell & Laherrere 1998; Ivanhoe 1995).

One statistic points up the need to think about alternative energy sources; the world now uses about 26 billion barrels of oil a year, and in new field discoveries we are finding less than 5.5 billion barrels annually. The world is going out of the oil business. With the many good things which oil now does for us, what will happen when we no longer have it? What are the possible alternatives to oil? Can any one of them or all combined really fill the gap left by the depletion of oil?

Alternative energy sources can be divided into nonrenewable and renewable.

### **Alternative Energy Sources**

<u>Nonrenewable</u>	<u>Renewable</u>
Oil sands, heavy oil	Wood/other biomass
Coal	Hydropower
Shale oil	Solar energy
Gas hydrates	Wind energy
Nuclear fission	Wave energy
Geothermal	Tidal power

Fusion  
Ocean thermal energy  
conversion

## **Need For Careful Analysis**

There is much casual popular thought that energy sources are easily interchangeable, with little examination of the facts. For example, who mentions energy density? Solar energy is a very low-density energy, whereas gasoline is a high-density energy form. There is also the need to determine how available these alternative energy sources are under varying conditions. Wind and solar energies are intermittent and undependable.

We here briefly examine these alternative energy sources as to their advantages and limitations, and their potential to individually or collectively replace oil. We consider those alternatives closest to conventional oil (from wells), and then expand our alternative energy horizons.

## **Oil Sands/Heavy Oil**

This oil exists in huge quantities (trillions of barrels) particularly in Alberta, Canada and Venezuela. This is true oil but in deposits which take special treatment to recover the oil. The oil sands must be mined, and then processed in various ways. Heavy oil deposits can be injected with hot water or steam. Because of these processes, the net energy recovery is considerably less than from conventional drilled wells. At present about 500,000 barrels a day is recovered from the Athabasca oil sands of Alberta. To increase this 10-fold to 5 million barrels a day would be a very large task, with severe environmental limitations. This must be put in the perspective of the 72 million barrels of oil the world now consumes daily. Other similar oil deposits have the same problems of scale and net energy recovery. In total, oil sands and heavy oil can replace conventional oil only to a small degree.

## **Coal**

Coal is a very large energy source, but it must be mined, it is not nearly so easy to handle and transport as is oil, and it has much less energy density. For use in producing electricity in power plants (burned under boilers), it can replace oil. But converting it to a liquid fuel that might be used in motor vehicles is expensive, and doing this on a scale that could significantly replace oil in vehicle use becomes an impossibly large

mining project. Coal can replace oil in some uses, but not in most. Although considerable progress has been made, coal production and burning still have environmental problems, which are of major concern. Adding to the greenhouse effect is one.

## **Shale Oil**

The production of oil from oil shale has been attempted at various times for nearly 100 years. So far, no venture has proved successful. One problem is that there is no oil in oil shale. It is a material called kerogen. The shale has to be mined, transported, heated to about 900 degrees F, and have hydrogen added to the kerogen to make it flow. The shale pops like popcorn when heated so the resulting volume of shale after the kerogen is taken out is larger than when it was first mined. The disposal problem is large. Net energy recovery would be low at best. It also takes several barrels of water to produce one barrel of oil. The largest shale oil deposits in the world are in the Colorado Plateau, a markedly water poor region. So far shale oil is, as the saying goes: "The fuel of the future and always will be." Fleay (1995) states: "Shale oil is like a mirage that retreats as it is approached." Shale oil will not replace oil.

## **Gas Hydrates**

These are very large deposits of natural gas which are in a solid substance composed of water molecules forming a rigid lattice of cages. Most of the cages contain a molecule of natural gas, chiefly methane. They exist as relatively thin zones interbedded with other sediments, and are known from two distinct areas--Arctic regions and at the edge of the continental shelves where there are cold bottom temperatures. So far recovery has defied Japanese and Russian engineers, and the likelihood that this energy form can be economically recovered seems remote.

## **Nuclear Fission**

The end product of nuclear fission is electricity. How to use electricity to efficiently replace oil (gasoline, diesel, kerosene) in the more than 600 million vehicles worldwide has not yet been satisfactorily solved. There are severe limitations of the storage batteries involved. For example, a gallon of gasoline weighing about 8 pounds has the same energy as one ton of conventional lead-acid storage batteries. Fifteen gallons of gasoline in a car's tank is equal to 15 tons of storage batteries. Even if much improved storage batteries were devised, they cannot compete with gasoline or diesel fuel in energy density. Also, storage batteries become almost useless in very cold weather, storage capacity is limited,

and batteries need to be replaced after a few years use, at large cost. There is no battery pack which can effectively move heavy farm machinery over miles of Midwest fields, and no electric battery system seems even remotely able to propel a Boeing 747 14 hours nonstop at 600 miles an hour from New York to Capetown (now the longest scheduled plane flight). Just the considerable additional weight to any vehicle using batteries is a severe handicap in itself. In mobile machinery, electricity is not a good replacement for oil, which is the limitation many alternative sources have where electricity is the end product.

### **Geothermal Energy**

This is heat from the Earth. In a few places in the world there is steam or very hot water close enough to the surface so that the resource can be reached economically with a drill. The steam or hot water flashed to steam, can turn a turbine, turning a generator producing electricity. At best, because of the scarcity of such sites, geothermal energy can be only a minor contributor to world energy supplies, and the end product is electricity, the limitations of which have already been described.

### **Hydroelectric Power**

Originally thought of as a clean, non-polluting, environmentally friendly source of energy, experience is proving otherwise. Valuable lowlands, which are usually the best farmland, are flooded. Wildlife is displaced. Where anadromous fish runs are involved as in the Columbia River system with its 30 dams, the effect on fish has been disastrous. Also, hydroelectric power, if reservoirs are involved, as is the case of most such facilities, is not a renewable energy source. All reservoirs eventually fill with sediment, which means hydroelectric power is not truly renewable. Some reservoirs have already filled, and many others are filling faster than expected. We are enjoying the best part of the life of huge dams. In a few hundred years Glen Canyon Dam and Hoover Dam will be concrete waterfalls. And, again, the end product is electricity, not a good oil replacement.

### **Solar Energy**

This is a favorite source of future energy for many people, comforted by the thought that it is unlimited. But, quite the contrary is true. The Sun will exist for a long time, but at any given place on the Earth's surface the amount of sunlight received is limited--only so much is received. And at night, or with overcast skies, or in high latitudes where winter days

are short and for months there may be no daylight at all, the sunlight received is very limited at times. Direct conversion of sunlight to electricity by solar cells is a promising field, but the amount of electricity that can be generated by that method is not great compared with demand. The conversion efficiency is low, about 12 percent with present technology.

Solar energy in quantity requires huge installations. It has been estimated that an area of 60 square miles in relatively clear central Oregon would have to be covered with solar cells in order to meet the present electric needs of that State. About 10% of the cells have to be replaced each year. But the big problem is how to store significant amounts of electricity when the Sun is not available to produce it. That problem remains unsolved. The statement that "solar energy will not make next century's electricity" is probably right. And the end product is electricity--a very limited replacement for oil.

### **Wind Energy**

This energy source is similar to solar in that it is not dependable. Also, it is noisy, and the visual effects are not usually regarded as pleasing. The best inland windfarm sites tend to be where air funnels through passes in the hills that are also commonly flyways for birds. The bird kills have caused the Audubon Society to file suit in some areas to prevent wind energy installations. Wind can produce some electricity and be a small help in the total energy demand. But the end product is electricity, no significant replacement for oil.

### **Wave Energy**

All sorts of installations have been tried to obtain energy from this source, but with inconsequential results. Piston arrangements moved up and down by waves, which in turn move turbines, have been tried in The Netherlands, but the project was abandoned. Waves are not dependable, and in any event the end product is electricity, and producing it in significant quantities from waves seems a remote prospect.

### **Tidal Power**

It takes a high tide and a special configuration of the coastline, a narrow estuary that can be dammed, to be a tidal power site of value. Only about nine sites have been identified in the world. Two are in use and generate some electricity. Damming estuaries would have considerable environmental impact. The Bay of Fundy in eastern Canada has long

been considered for a tidal power site, but developing it would have a negative effect on the fisheries and other sea-related economic enterprises. It would also disturb the habits of millions of birds, which use the Bay of Fundy area as part of their migration routes. Summary: Very few sites, ecologically damaging, not a significant power source. And, the end product is electricity.

### **Ocean Thermal energy Conversion (OTEC)**

Within about 25 degrees each side of the equator the surface of the ocean is warm, and the depths are cold to the extent that there is a modest temperature differential. This can be a source of energy. Use a low boiling point fluid such as ammonia that at normal atmospheric temperature of 70 degrees Fahrenheit is a gas. Pump colder water from the deep ocean to condense the ammonia, and then let it warm up and turn to gas. The resulting gas pressure can move a turbine to turn a generator. But the plant would have to be huge and anchored in the deep open ocean subject to storms and corrosion, and the amount of water that has to be moved is enormous, as the efficiency is very low. OTEC does not appear to have much potential as a significant energy source, and the end product is electricity.

### **Wood And Other Biomass**

Wood has long been used as a fuel, now to the extent that large areas are being deforested resulting in massive erosion in such places as the foothills of the Himalayas, and the mountains of Haiti. Wood can be converted to a liquid fuel but the net energy recovery is low, and there is not enough wood available to be able to convert it to a liquid fuel in any significant quantities.

Other biomass fuel sources have been tried. Crops such as corn are converted to alcohol. In the case of corn to ethanol, it is energy negative. It takes 71% more energy to produce ethanol than is obtained from the ethanol. Also, using grain such as corn for fuel precludes it from being used as food for humans or livestock. It is also hard on the land. In United States corn production, soil erodes some 20-times faster than soil is formed. Ethanol has less energy per volume than does gasoline, so more gasoline has to be purchased to make up the difference. Also, ethanol is not environmentally friendly, as advocates would like to believe. Pimentel (1998) states: "Ethanol produces less carbon monoxide than gasoline, but it produces just as much nitrous oxides as gasoline. In addition, ethanol adds aldehydes and alcohol to the atmosphere, all of which are carcinogenic. When all air pollutants

associated with the entire ethanol system are measured, ethanol production is found to contribute to major air pollution problems." With a lower energy density than gasoline, and adding the petroleum energy used to plow, plant, cultivate, and transport the corn for ethanol production, ethanol does not save gasoline nor does its use reduce atmospheric pollution.

A comprehensive study of converting biomass to liquid fuels by Giampietro and others (1997) concludes: "Large-scale biofuel production is not an alternative to the current use of oil, and is not even an advisable option to cover a significant fraction of it."

## **Fusion**

Fusion involves the fusion of either of two hydrogen isotopes, deuterium or tritium. Deuterium exists in great quantities in ordinary water, and from that perspective fusion is theoretically an almost infinitely renewable energy resource. This is the holy grail of ultimate energy. Fusion is the energy that powers the Sun, and that is the problem. The temperature of the Sun ranges from about 10,000 degrees Celsius on its surface to an estimated 15 to 18 million degrees in the interior where fusion takes place. Containing such a temperature on Earth in a sustainable way and harnessing the heat to somehow produce power has so far escaped the very best scientific talent. However, even if commercial fusion were accomplished, the end product again is likely to be electricity, and not a replacement for oil.

## **Hydrogen And Fuel Cells**

Questions are sometimes raised as to using these for fuel sources. Neither is a primary energy source. Hydrogen must be obtained by using some other energy source. Usually it is obtained by the electrolysis of water, or by breaking down natural gas (methane  $\text{CH}_4$ ). Hydrogen is highly explosive, and to be contained and carried in significantly usable amounts it has to be compressed to hundreds of pounds per square inch. Hydrogen is not easy to handle, and it is not a replacement for pouring 10 gallons of gasoline into an automobile tank.

Fuel cells have to be fueled, most use hydrogen or some derivative of oil. Fuel cells are not a source of energy in themselves.

## **Summary**

Oil is a unique energy source that has no complete replacement in all its



varied end uses. The British scientist Sir Crispin Tickell concludes, "...we have done remarkably little to reduce our dependence on a fuel [oil] which is a limited resource, and for which there is *no comprehensive substitute in prospect.*" [Italics mine]

Coming to realize that oil is finite, any and all suggestions of means to replace oil are welcomed. Cheerful myths are enthusiastically embraced. These include: that there are two trillion barrels of economically recoverable oil in the Colorado Plateau oil shales; that dams and their reservoirs are a source of indefinitely renewable energy and that they are environmentally benign; that solar, wind, geothermal, and hydro-electric power can supply the electrical needs, from the Arctic to the tropics, of the Earth's nearly six billion people (likely to become at least 10 billion in the next fifty years); that coal, oil from oil sands, and biofuels can replace the 72 million barrels of oil the world now uses daily; and that somehow electricity produced from various alternative energy sources can readily provide the great mobility which oil now gives to the more than 600 million vehicles worldwide. Regrettably, none of these cheerful myths appear to be valid.

The mega-myth is the popular public placebo that "The scientists will think of something." The energy spectrum from burning wood to fusion that fuels the Sun is now well known. If there is some major exotic energy source beyond what has been listed, we have no evidence of it. What we know now is apparently what we have.

The reality appears to be that the world is rapidly running out of a resource that in many ways is irreplaceable. The result will be a great change in economies, social structures, and lifestyles. We have been living on a great fossil fuel inheritance accumulated during more than 500 million years. We will soon exhaust this capital, and we will have to go to work to try to live on current energy income. It will not be a simple easy transition.

In a remarkably perceptive book written in 1952, The Next Million Years, Charles Galton Darwin described historic changes in the human condition, calling them "revolutions." He wrote that there is one more revolution clearly in sight:

"The fifth revolution will come when we have spent the stores of coal and oil that have been accumulating in the earth during hundreds of millions of years...it is obvious that there will be a very great difference in ways of life..."

Life will go on, but in a different paradigm. Oil will be sorely missed.

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