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Renewable Good – Fossil Bad

Working Paper Series 03-01— February 2003

SUSTAINABLE ENERGY SOLUTIONS

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It is time for a reality check. The political rhetoric surrounding the combined issues of energy production economics and policy, and global warming science and policy needs to be toned down. The real issues and facts need to be focused on calmly and rationally. Therefore, I propose to provide the definitive conclusions from studying energy and pollution. Well, maybe not the definitive case because much of science looks at possibilities and ranges of outcomes, but I hope to provide a sober viewpoint.

On our so-called Third Rock from the Sun we have an incoming source of energy on a daily basis and we also have stored energy in the form of fossil fuels, nuclear fuels and geothermal heat. The question society has to answer is: how do we turn this energy into useful energy forms to power our industrial and developing economic systems with transportation of products from place to place and the production of electricity for myriad uses? I use the term "society" in the singular because of the global issues involved with energy conversion, at the same time I recognize there are many sub-societies based on national boundaries and other types of definition. It is also necessary to recall basic high school chemistry and physics, the laws of the conservation of energy and conservation of matter govern. So the question involves the processes of converting energy from one form to a useful form and the consequences as matter is modified during those processes.

Energy Sources

Fossil fuels, oil, coal and natural gas, are the result of stored incoming solar radiation from eons past. These fuels are relatively new to the human matrix of energy sources, but are currently the most important component of that matrix. There is no doubt that these fuels are in limited supply: there is a finite amount without contemplating geological time periods. However, a common counterargument to the fact that these resources are exhaustible goes something like: "For each of the last 30 years there has been an estimate that we have 30 years worth of oil left, and this year is the same." The title for this piece, as detailed below, is not based on the exhaustion of the resources.

Many believe we are in the third phase of the fossil fuel revolution as society has moved from coal to oil to natural gas. Each subsequent energy source has been typically cleaner and more efficient than the previous. Natural gas is a wonderful improvement over the other two fuels and will gain increasing market prevalence in the near future. The current economic structure is solidly founded on fossil fuels and will remain so for the next several decades.

Incoming solar energy can be used in a variety of manners, which fall into four primary categories: solar, wind, biomass, and hydro. Each of these will be discussed in turn.

Incoming solar energy can be directly converted into heat using passive solar systems such as hot water heating. Sol's rays can also be converted into electricity using photovoltaic systems, and the electricity can then be used in myriad manners. PV systems can be small enough to operate temporary roadside signage or can be arrayed in farms to produce large amounts of electricity. At present PV is rather expensive compared to other forms of energy conversion. However, costs are dropping. In our lab we have a very small 3.5 watt panel that is labeled as costing $196.95 in 1976, and $35.00 for 1982. At today's costs, a panel producing that minimal amount of electricity would costs pennies.

Incoming solar energy is naturally converted into kinetic energy. We call this phenomenon wind. The kinetic energy can be captured using wind turbine generators, which convert this energy into electricity. As with PV systems, wind systems can be both large and small. Primarily due to the geometric relationship between the radius (blade size or cost) of a circle and the area of a circle (production), the cost for wind-based electricity has been dropping and is currently competitive with some fossil fuels in some locations.

Incoming solar energy can also be converted, using the photosynthesis process, into potential energy as plant material. Either directly or indirectly the potential energy can then be converted into heat energy and finally into electricity using various forms of burning. The generic term for this is biomass, and can include agricultural residue, wood industry by-products, municipal waste, specifically grown crops and other sources. Biomass can also be used for other types of energy conversion. Some systems forgo the electricity production and are used for local and village-based heating. Biofuels such as ethanol and biodiesel can be produced for the transportation sector.

Another use of biomass is land fill gas (methane) which is then burned for electricity. The use of wood pellets for furnace and boiler heat is a major activity in the Scandinavian regions and is becoming popular as a relatively clean heat source for individual homes in the U.S. Northeast and Northwest regions. Biomass costs are variable depending on the application, but are falling as development occurs. Biomass also brings into play some issues of the carbon cycle and effluent. One interesting variation of the biomass fuel concept is that these fuels *will become* our dreaded "fossil fuel," give time. By compressing and storing this matter over millions of years, the energy content per mass increases, and the biomass becomes a fossil fuel. We consider fossil fuels "nonrenewable" because the timeframe of the conversion from biomass to fossil is several orders of magnitude greater than our lifetimes, or even the lifetime of our modern civilization.

Incoming solar energy can be converted into kinetic energy via the evaporative/precipitive process rain cycle. This kinetic energy can then be converted into electricity using low-impact hydro systems. However, by definition, these systems cannot be large suppliers of electricity and do not hold potential for replacing fossil fuels on a global scale. Additionally, the resource availability is nowhere near ubiquitous.

Our third rock from the sun contains two other forms of stored energy: geothermal and nuclear. Geothermal energy, like low-impact hydro, is limited by local availability and cannot become a major substitute for fossil fuels. Nuclear energy has always shown a great promise scientifically but has shown a great danger emotionally and ethically to many people in its current practice—fission. Fission energy has a high energy output with no air emission problems; however, the caretaking of the resulting, high-level radioactive waste for a hundred generations is unappealing to a modern society. Fusion energy is a promising theory of energy production without the hazards of fission; however, the transition from theory to practice has eluded humanity's brightest minds for over half a century.

On the horizon there is much talk about a hydrogen-based economy. The infancy of the research and development of fuel cells and other hydrogen systems looks very promising. However, the potential raises another question: how will the hydrogen be collected/produced? A hydrogen car that uses fossil fuel based electricity to produce the hydrogen is simply exporting the effluent from tailpipe to smokestack, so the problems of fossil fuel use are not eliminated.

Hydrogen does have the benefits of being storable and transportable. Indeed, it is easy to envision our entire transportation system using hydrogen storage and fuel cells. The real benefits will come from using renewable energy sources, primarily solar and wind, to produce the electricity to produce the hydrogen to provide the kinetic energy necessary to ship DVDs and plasma TV's around the rock.

There is no doubt that the inexpensive fossil fuels we have used for the last 150 years have allowed previously unimaginable growth and wealth in some sections of the global society. Fossil fuel prices are very low at present and will likely continue to be so for the foreseeable future. Gasoline prices were at historical lows as late as 1998 and have only slightly increased since then. Fossil fuels prices are only likely to increase in the foreseeable future due to international conflict and political turmoil. Locally, prices fluctuate due to supply chain disruptions, such as refinery fires, or weather disruptions. Otherwise, the private prices of fossil fuel-based energy conversions are and will be lower than most renewable energies. This is particularly true in the United States where fossil fuel processors receive a myriad of subsides and tax credits not available to renewable energy producers.

SOCIAL COSTS OF FOSSIL FUELS

Continuing exploration and discovery of fossil fuels will keep the *private* costs of fossil fuels relatively low, unless international events, such as war, disrupt supplies. So why worry about all this renewable energy stuff anyway? Simply put, fossil fuels are very dirty methods of converting energy into useful sources and fossil fuel use is releasing millions of years of sequestered carbon at alarmingly fast rates. The dirty effluents and the carbon dioxide production *are* having, and will continue to have serious consequences on our little rock.

Fossil fuels are not pure carbon or hydrocarbons. They are mixed amalgams of carbon and various other types of matter, so when they are burned to convert the energy, the other nasty things are also released and undergo chemical processes. I leave you, good reader, to explore the specific chemistry elsewhere. Given the burning process, many of these nasties are released into the atmosphere from tailpipes and smokestacks. The consequences of these chemicals in the atmosphere are numerous, so I will focus on three before moving onto global warming issues: health costs, visibility issues, and acid rain.

Each year there are an estimated 160,000 emergency room visits due to air quality issues and asthma. We are also seeing an increasing rate in childhood asthma. Although direct causation has not been thoroughly investigated, it is hypothesized that decreasing air quality is a primary culprit. The health care costs attached to fossil fuel energy conversion are enormous, but the dollar cost is not all. Not having asthma, I cannot empathize with sufferers, but I have had the wind knocked out of me during sporting events. The only good thing about one of life's most painful events is that you have a vague idea that in a minute or two you will be able to breathe again. An asthma attack carries no such guarantee. The human suffering of increasing asthma and air quality induced asthma attacks due to fossil fuel energy conversion is inestimateable.

The same nasties that make it difficult for some people to breathe also cause visibility impairment or haze. I live in Flagstaff, Arizona, which is one of the prettiest places on our little rock. Flag, as we call it, is the largest city on the roughly 50 million-acre Colorado Plateau, which in my mind is the prettiest place on our little rock. I am a transplant from several places elsewhere in North America. People travel from all over the world to visit my home and my backyard: the Grand Canyon National Park. Yet there are days when people get to the rim of the Grand Canyon and have difficulty even seeing the grandeur of its magnificence. After thorough study, it has been shown that much of the visibility impairment or haze is caused by fossil fuel energy conversion.

I have my favorite hiking trails and spots to relax and enjoy the marvelous vistas typically available at elevations above 7,000 feet. The West, and particularly the Colorado Plateau is known for the wide-open skies and the viewscapes where one can see far into the distance. Taking photographs, with an electricity-based digital camera, of buttes in the Painted Desert from 80 miles away provides spectacular e-mails. But many days the visibility impairment is so severe that the hike up the mountain only provides exercise benefits.

It would be bad enough if it was our own local energy conversion that created the visibility impairment. In that case we would be paying the cost of fossil fuel conversion. But Flagstaff is a small town of roughly 60,000 and we do not consume enough fossil fuels to cause impairment throughout the sparsely populated magnificence of the Colorado Plateau. Instead, the plateau is home to 12 large coal-fired electricity generating plants for distant cities like Los Angeles and Phoenix. Other sources of the impairing nasties are other fossil fuel conversion from automobiles in Los Angeles, San Francisco and Las Vegas. So we, and tourists to the plateau, pay additional social costs due to the fossil fuel conversion for those distant cities.

Air pollution is not simply a local problem; it is a regional and international problem. Some of the nasties produced from fossil fuel conversion impair visibility in the gaseous form and then precipitate out of the atmosphere as acid when it rains. These acids fall into lakes and onto forests and accumulate. The PH levels of soils and water decrease over time. Anyone who has ever had a fish tank knows that the PH level of the water is very important. A seemingly small increase or decrease in the PH level can put some species in distress and even kill them. Having learned the lesson, you either get different fish or maintain the PH level.

But acid rain doesn't just change the PH level in a 55-gallon aquarium or simply kill off a $1.50 fish. Ecosystems, either water or land based, evolved within certain small ranges of the PH spectrum over eons. Vast acreage down wind from fossil fuel conversion units are affected by the increasing acidification process in a very short evolutionary time frame. From the last ice age to the fossil fuel age, the ecosystems had 10,000 years to adjust to minute PH level changes. Then in 50-100, or less, years the PH level changed and the ecosystems deteriorated. In some locations the process has been slowed and in some cases is reversing itself due to international agreements. But the consequences of fossil fuel conversion are clearly evident.

The social costs, ignoring the tree hugging argument, in regards to resource loss have been enormous. Timber loss and sport fishing reductions are two examples of lost resources. So once again, fossil fuel conversion produces nasties that have definitive social costs that are not borne by the producers or consumers of the converted energy.

So fossil fuel energy conversion does not simply produce additional social costs on a local level. But neither are the negative consequences simply regional. In addition to the nasties, fossil fuel energy conversion also has global consequences. The geological processes necessary to produce, by definition, fossil fuels took eons to sequester carbon. Quite frankly, the modern industrial age of fossil fuel based economies is releasing that carbon at alarming rates.

Good reader, take a big breath and hold it until you finish reading this sentence. Now release it. What did you exhale? More carbon dioxide than you took in. So we can't really call carbon dioxide a pollutant in the usual sense. Otherwise, if it was outlawed, then… (This is a fun lesson to give to middle school children at summer energy camp.) Good reader, take another big breath. Hold it. Hold it a little longer. Now exhale. What was the difference in the weight of carbon dioxide you inhaled versus the amount you exhaled? How many decimals places are necessary?

Yet the fossil fuel era of carbon dioxide release (net from all sources) is measured in the *billions of tons per year.* 6.3 billion metric tons is a recent and reliable estimate. There are over 130 million registered automobiles in the United States. Averaging the weight of a small economy car, a mid-sized family car, and a modern SUV, a typical car weighs 3,300 pounds. Obviously a weighted average would be a better measurement, but the conclusion would be similar. The net global release of carbon dioxide into the atmosphere during the fossil fuel era is roughly *31.7 times the weight of the entire fleet of cars in the United States.* Good reader, contemplate that. 130 million cars piled on top of one another multiplied by 32. Then think of the difference between steel and aluminum and glass and rubber, don't forget the leather, and platinum and all the other solids. Then contemplate 32 times that amount of a gas: carbon dioxide! We are not discussing an insignificant number of those breaths you took.

The atmosphere of our little rock can be equated to the skin of an apple. That is a reasonable comparison and we humans live one molecule below that skin. All of us have tried to eat an apple with a damaged skin. It is bruised underneath, or worse. And the ecosystem in which we live is that first level of molecules. Just the other day a colleague gave up on her apple after three attempted bites. Shall we do that with our rock?

The politics and economics of global warming are full of rhetoric and vested interests, but I mentioned that I have the definitive explanations. Ok, maybe I overstated that, but there are 3 incontrovertible results of the anthropogenic production of carbon dioxide due to fossil fuel energy conversion. Fossil fuel energy conversion releases huge amounts of previously sequestered carbon into the atmosphere in the form of carbon dioxide. The vast majority of the carbon dioxide, a fairly stable molecule, remains and will remain in the atmosphere for the foreseeable future. And increased concentrations of this non-polluting gas in the skin of our rock causes increased warming of our rock. This cannot be argued. The magnitude and range of the consequences of these three conclusions can be argued, but the conclusions cannot. Again, science lives in the realm of ranges and probabilities based on conclusions, and most reasonable people agree upon these conclusions.

The time frame for PH level changes between the last ice age and the fossil fuel age is roughly 10,000 years. The changes in PH levels over a relatively short time period were so obvious that actions were taken fairly quickly given the politics of international agreements. The time frame for the changes in non-anthropogenic carbon dioxide levels is eons versus the same 50-100 years. The multitudinous ecosystems of our little rock are undergoing eons of change in far too short a time period for us to be assured that the anthropogenic consequences are not going to be catastrophic, as some of the rhetoric claims, or at least substantial. Myriad studies show that the timing of temperature based seasonal changes is evident in ecosystems. Which raises the questions concerning the timing of events as certain plants bloom earlier, but the pollinating insects do not hatch earlier, or vice versa.

Richard Norgaard argues that human society should avoid large experiments. Jane Jacobs argues that we should only conduct experiments at life-friendly temperatures and toxicity. Global warming potentials break at least the first rule. Fossil fuel energy conversion breaks both rules. Fossil fuels are too expensive and have a potential of being even more expensive in the future. Alternatives must be employed. And those alternatives can exist and should be developed.

ALTERNATIVE SOLUTIONS TO FOSSIL FUEL ENERGY CONVERSION

Although it has become clear that fossil fuels have serious consequences, finding efficient ways to convert incoming solar radiation into useful forms of energy in the current market system has proven difficult for society. Non-renewable energy is the cause of an ever-growing variety of serious health, visibility impairment and other problems for the current generation and future generations. On the other hand, renewable energy is clean, sustainable and fairly inexpensive, *after* a sizeable initial investment. The problem is that even with current incentive programs, there are still various barriers hindering the general public's acceptance of renewable energy. As a result, society still has a long way to go until renewable energy is successfully and efficiently implemented as an important source of electricity.

New policies and new policymaking will allow renewable technology to be incorporated into all facets of the energy market. Through research and development, costs of production can be reduced and efficiency of the equipment can be advanced. The market for renewable energy is rapidly growing. As is true with many new industries, economies of scale and economies of scope offer potentials for further reducing per unit costs. The year 2000 saw a 37% increase in solar production in the OECD countries. In developing countries, growth is expected to be even higher in the future. As the industry grows, economies of scale can be expected to continue. This is true in the production of all renewable energy technologies. In addition to economies of scale, economies of scope are also likely to develop as new and different uses of renewable energy are found. For example, water pumping, highway-sign lighting and low-wattage fencing (for herd animals) can all use renewable energy sources.

Through education, interest in renewable energy can be expanded by informing society of the negative externalities associated with non-renewable energy production and the benefits of renewable energy. Moreover, education will lead to awareness of pollution problems and allow each person to rationally quantify the marginal social and private costs imposed by non-renewable energy production. By offering these newly enlightened citizens tax credits, tax breaks, rebates and subsidies, the investment burden of adopting renewable energy can be relieved. With these steps, new technology can be implemented and employed in a way that will produce clean, sustainable and inexpensive energy, in addition to increasing the standard of living and the quality of life.

The ongoing energy revolution will create jobs and income as the industry grows and costs fall. As one colleague indicates, “being in the renewable energy market now is what it must have been like being in computers in 1980. It is an exciting time.”

But then most of human history has been based on renewable energy as various forms of biomass were used to create heat for a variety of uses. Then coal became the energy source of choice. Coal was followed by oil, which allowed for massive increases in production in terms of both quantity and quality. The petroleum revolution led to the current emphasis on natural gas. For example, the deepwater drilling in the Gulf of Mexico would have been impossible without the technological advances provided by petroleum.

These fossil fuels are now allowing the completion of the cycle back to a renewable energy based economy. At each step in the process, the technological developments and profits from energy conversion have allowed the investment in the next. The same is true now regarding renewable energy.

The benefits of a renewable energy based economy will be far more than the reduction of air pollution and global warming. Each previous energy revolution resulted in economic growth, increased jobs and lower costs. The same will be true with the current revolution. These benefits will not only be available to the developed world, but also to the developing countries in Africa, Asia and South America.

Unlike fossil fuel energy conversion, renewable energy conversion sites can be relatively small in scale and therefore decentralized. Decentralizing the production of electricity from mammoth generating plants serving many millions of customers to small village scale systems reduces the investment in infrastructure. Electrification programs need not require miles of grid connections, so the total costs can be reduced. Village scale systems offer huge potentials for improving the quality of life for many millions of people in the developing world.

Electrification can provide methods for pumping and purifying water. Water borne disease is rampant in many areas of our little rock. Increased water can be combined with efficient irrigation systems to provide increased local agriculture; therefore, reducing the need for imports. Electrification also offers improved health benefits from refrigeration. Improved food storage and the resulting increase in nutritional variety, combined with local production, lead to a healthier population. Electrification also allows for improved communications. The telecommunications revolution is offering huge potentials from telemedicine to improved education. The closing of the worldwide digital divide can only occur with concurrent electrification programs. As the developing populations are no longer concentrating their efforts on simple survival, indigenous cultures and social structures can be rejuvenated. The renewal of indigenous cultures combined with improved education, health and employment opportunities will allow the development of stable political structures.

Policy and market-based innovations will increase the rate at which renewable energy conversion systems are incorporated into the global production system. The production of electricity can lead to a hydrogen revolution for transportation. Small village based production can provide electrification in the developing portions of the global population. Large-scale wind and solar farms can eventually replace large-scale fossil fuel conversion units. Increasing profits lead to competitive advantage, economic opportunity and innovation.

Currently, the global production system is based on fossil fuel energy production. The importance of these fuels will continue at least for several decades, but the social costs inherent with burning previously stored solar radiation are large and need to be mitigated. The potential growth of renewable energy conversion systems holds the key to that mitigation. These technologies need to be taken advantage of in policy and market based forums.

So dear reader, those are the facts and just the facts. Returning our little rock, third from the sun, to a sustainable energy base converting incoming solar radiation is within the realm of our capabilities. The only remaining question is: do we have the imagination to realize that potential? Or will the wonderful viewscapes of the Colorado Plateau, and elsewhere, continue to deteriorate?