Clean Energy

Tony Noerpel and Gina Faber, August 25, 2008

"[Nobel Laureate Wilhelm] Ostwald's energetic imperative – 'Waste no energy but value it' – is relevant as humankind makes the inevitable transition to a permanent economy based exclusively on solar radiation." *From Vaclav Smil "Energy in Nature and Society"*

"My own preference is to fill the Mojave with solar concentrating plants, and save some of this wonderful stuff [oil] for our descendants."– *Dave Rutledge, Cal Tech, personal communications*

What Should We Be Concerned About?

Joel Achenbach suggests that the largest problem facing us is not just global warming but rather the human destruction of very biosphere that we depend upon for Earth's primary productivity and the composition of our atmosphere. His perception reflects a broader view we would do well to consider.

If a few humans were plopped down in the middle of the Eocene hot house 50 million years ago, they might be fine. Life can survive a hotter climate. Having said that, the current rate at which we are changing the Earth's climate is in fact causing an extinction event. What are we doing to contribute to the magnitude of the Holocene (10,000 years ago to present) extinction event? Deforestation, overfishing the oceans, mountaintop removal mining, strip mining tar in Alberta, using fertilizer to grow corn which we will then use to convert lignite coal (really lousy stuff) into ethanol, burning fossil fuels, and overpopulating Earth are all contributing human factors to hastening mass extinctions.

All life on our planet, including Homo sapiens, a rather self-important and clever species but perhaps not altogether wise, depends on the primary productivity of autotrophs via photosynthesis. In fact, our atmosphere of nitrogen and oxygen is unstable without autotrophic photosynthesis. Global warming, effectively restoring the hothouse climate of the early Cenozoic (see chart of the geological periods below) within a few hundred years, greatly reduces primary productivity of this critical natural process.

At our current rate, we can easily increase atmospheric carbon from the current, 387 parts per million by volume (ppmV) to early Cenozoic levels, 600 to 1500 ppmV by the end of the century. Fossil fuels, deforestation, cement manufacture and permafrost melt alone can easily do it. The lowest credible estimate for remaining fossil fuel carbon is 540 Gigatonnes of carbon (David Rutledge, Cal Tech) and permafrost contains over 1000 Gigatonnes (David Lawrence NCAR). There are another couple hundred Gigatonnes in all the trees we are burning down and the potential for 50 Gigatonnes from cement manufacture over the next hundred years.

Converting GtC to ppmV

A simple rule of thumb for converting Gigatonnes of Carbon to parts per million by Volume of Carbon in the atmosphere is to

- divide by 2.1 to convert GtC to ppmV and then
- divide by 2 since at present approximately 50% of our annual carbon emissions are being reabsorbed by the oceans and land.

This "50%" is conservative since there are already many studies showing that the oceans are becoming saturated and land use changes are impacting the ability of land to absorb more of our carbon emissions.

Thus the additional 1740 GtC we will cause to be emitted into the atmosphere over the next century divided by 4.2 gives an increase of 410 ppmV. Adding this to the current 387 ppmV gives about 800 ppmV.

"Clean Coal"

What is carbon capture and sequestration (CCS)? CCS means that the carbon dioxide (CO_2) - a major contributor to global warming - is captured before it's spewed into the atmosphere, and then transferred underground for storage. The phrase "clean coal" refers to dirty coal augmented by carbon sequestration. But "clean coal" is oxymoronic. Mountaintop removal mining destroys millions of acres of once-pristine biodiverse deciduous watershed and thousands of miles of rivers and streams and emits toxic heavy metals into the biosphere, and in so doing contributes to species extinctions and reduction of primary productivity. In the figure below, note the tiny tuft of lush green forest at the bottom. This entire toxic wasteland stretching for miles and miles used to look like that.

But even if the acquisition of the coal was not problematic, is carbon sequestration feasible? There are currently four pilot plants in operation around the world. Each requires 25% more fuel in order to generate the energy required to sequester all the emitted carbon. So not only do such proposed plants cost much more to construct, they also will cost much more to operate and will destroy even more watershed per BTU generated than conventional plants. In other words, coal fired power plants using carbon sequestration are arguably dirtier than the plants they may replace because they will require more mountains to be blown up with the resultant loss of more watershed and biodiversity.

Carbon sequestration on a sufficient scale to make a dent in carbon emissions is arguably not possible and not going to happen. Just this past Feb 2008, the heavily government subsidized FutureGen carbon sequestration demonstration plant supported by President Bush was cancelled for fiscal reasons. This plant was projected to cost $1.8 billion for only 275 MWatts of power, about the same cost as Governor Tim Kaine's Wise County "clean coal" plant in Virginia, which will produce twice as much power. Neither plant ever had a chance of meeting their price targets but the reason the Wise county plant is so much less expensive is that it does not have CCS technology. Though sold to the public as Virginia City Hybrid Energy Center, the Wise County plant does not sequester carbon and cannot ever do this trick and its mercury, uranium and thorium emissions are as bad as any other coal fired power plant.

BioFuels – Corn Ethanol

Pimentel and Patzek wrote their first paper on the inefficiency of corn ethanol in the 1980's and followed this up with other studies (see attached references below) which demonstrate that corn ethanol has a negative energy balance. That is, it takes more energy to create this fuel than the fuel can provide! Pimental and Patzek are not the only experts who have pointed this out. For example, Paul Weisz wrote [1] "ethanol production from biomass, which involves a complex agricultural and industrial processing system that requires large and diverse external energy inputs, easily results in a negative [energy output], yet government subsidies can make the production profitable to producers."

Pimentel and Patzek are two of the most highly regarded energy ecologists in the world. They have published extensively. Their papers are cited often and their research is superb. Nevertheless, their research and conclusions have been relentlessly attacked in an amateurish campaign funded by Archer-Daniels Midland (ADM) [2], a company who stands to profit immensely from corn ethanol. The reason why ADM's dirty tricks campaign has not succeeded is because Pimental and Patzek's reputations as scientists are well known and verifiable. Every single study (none published in the peer-reviewed literature) which purports to contradict Pimentel and Patzek leaves obvious costs out and even then can only manage a very slight marginal gain in energy produced over that consumed. The argument, between Pimentel and Patzek on the one hand and Shapouri of the USDA and Wang on the other, boils down to whether or not to include workers lunches and the energy required to repair farm equipment. Pimentel and Patzek include these energy costs and Shapouri and Wang do not. Thus the arguments in favor of corn ethanol are exposed as downright ludicrous if we can only get a positive return by not repairing our tractors.

But assuming the absolutely best possible numbers for corn ethanol's efficiency (even ADM's imaginative numbers) and the best all-time harvest, what benefit can we expect? If converted to ethanol in its entirety, this harvest would still only replace at most 3% of our gasoline consumption. We can make a bigger improvement in carbon emissions just by keeping our tires inflated and that has the advantage that nobody in the world has to starve to death as a result [3].
As Eaves and Eaves point out, the most optimistic gains from ethanol production and consumption are so marginal that they disappear as a result of a bad flood or drought.

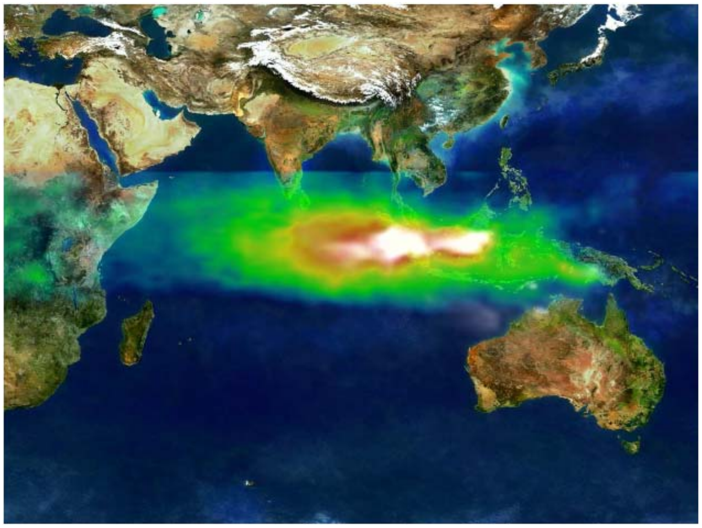
All studies of corn ethanol inefficiency, even Pimentels and Patzeks, do not account for the energy costs associated with cleaning up the Gulf of Mexico dead zone and the financial loss of fisheries (see figure, right). Dead zones are typically created when massive amounts of synthetic fertilizer from conventional farms are carried via rivers to the ocean. The fertilizers cause algae blooms which suffocate fish. As reported in a recent issue of the journal Science, the number of Dead Zones has risen from 162 to 405 in the last twenty years. This year's Dead Zone in the Gulf of Mexico, created by chemical farm fertilizer runoff, factory farm pollution, and municipal sewage contamination in the Mississippi Basin, is a record 8,000 square miles.

Currently we lose a pound and a half of topsoil for every pound of corn we grow in the United States. The corn is of transitory value as a fuel but the soil loss is permanent [4].

Conceding the marginal numbers regarding corn ethanol's minimal efficiency, why is this technology still being pursued? Proponents hope that the 2 to 3 billion dollars a year of tax payer money invested in this technology will convince car manufacturers to build ethanol-ready cars. Is this financial incentive worth the cost of limiting food production causing starvation among the world's poorest? There are right now 6.7 billion humans on board planet Earth of which 800 million are starving to death. All current biofuel schemes convert needed food into fuel for unneeded SUVs. The Bush administration claims biofuels increase the cost of food by only 3% and the World Bank claims 75%.

I propose that we think more about the long-term solution of weaning ourselves from our cars rather than finding artificial ways to encourage manufacturers to equip them with useless contrivances. WWII Admiral Hyman Rickover said in a speech in 1957: "Today the automobile is the most uneconomical user of energy. Its efficiency is 5% compared with 23% for the Diesel-electric railway. It is the most ravenous devourer of fossil fuels, accounting for over half of the total oil consumption in this country."

The misguided argument that farmland is not being used for biofuels agriculture has some truth as a lot of the land is former rain forest. The carbon emissions from deforestation are 1.4 Gigatonnes of carbon per year or about 14% of current CO_2 emissions. The following figure is a NASA photo of rain forests being burned to make way for Palm oil plantations. In the fall of 1997, an orgy of 176 fires in Indonesia burned 12 million ha of virgin forest and generated as much greenhouse gases as the US in one year. 133 of these illegal fires were started by oil palm plantation/logging companies to steal old-growth trees and burn the rest for new plantations. The smoke and ozone plume had global extent. Sources: NASA's Earth Probe Total Ozone Mapping, Spectrometer (TOMS), October 22, 1997.



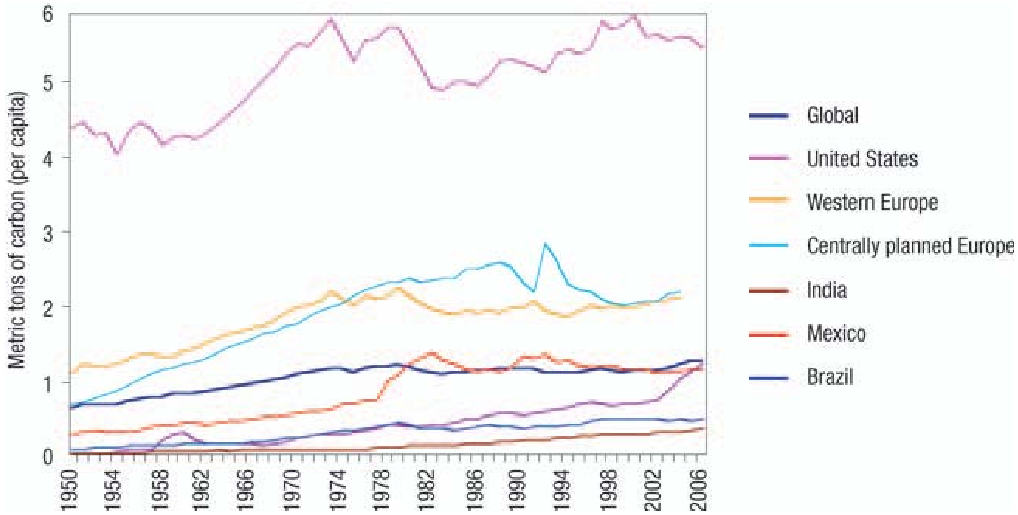
Biofuels - Switch Grass

Can switch grass and other cellulose sources be used to create biofuels in such a way as to be harmless to the biosphere? The answer is almost certainly no. At this time, the technology does not exist outside the lab. Cellulose sources have to be grown somewhere, on destroyed prairieland, on deforested land, on marginal easily eroded land or on land now being used to grow food, and they require fertilizer and pesticide inputs.

Vaclav Smil ties these two ill-conceived reactions to our current energy predicament together: "There is no rational excuse for deliberately overproducing food while stressing some key biospheric services. Low-income developing countries need higher crop outputs and higher food intakes, but for affluent nations the best way ahead is not to produce more food more efficiently but to live within rational confines. Such wealthy nations should apply this strategy to all other resource demands as well, rather than pursuing costly, complicated, energy-intensive, arcane and environmentally questionable "solutions" aimed at keeping or expanding high rates of output. Current infatuation of this irrational kind range from carbon sequestration to grain-derived ethanol." [5]

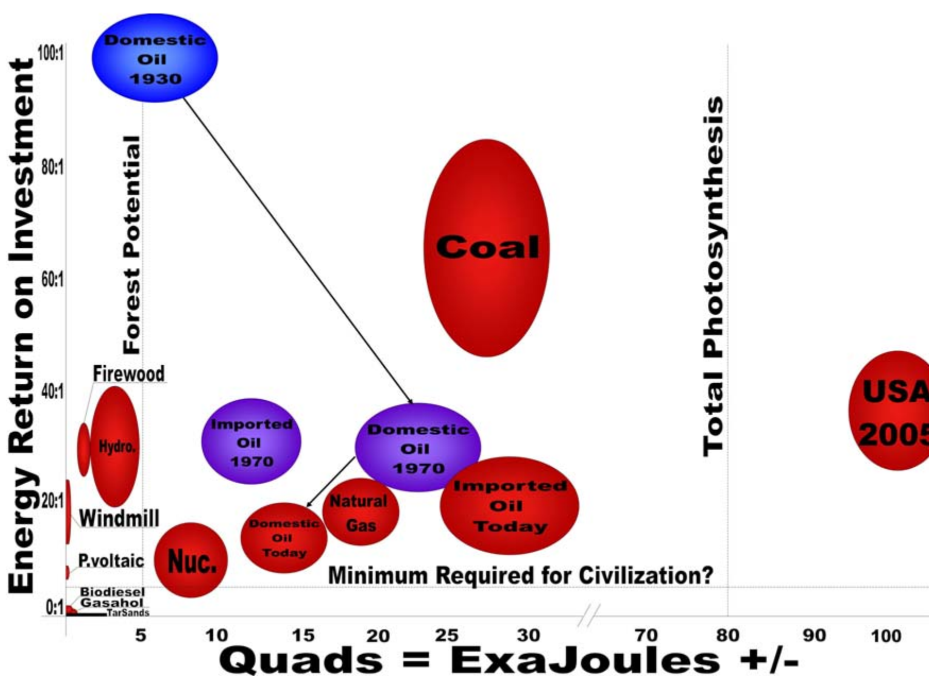
Conservation

The lesson we should take from Brazil is not sugar cane ethanol but conservation. Brazil is not energy independent because they derive about 10% of their energy needs from sugar cane ethanol but because the average Brazilian uses 14% of the energy used by the average American (7.8 tonnes of oil vs 1.1 tonnes of oil equivalent per year). In fact, if we could produce as much ethanol as Brazil, it would represent about 1% of our total energy consumption.. The average European uses only half of the energy we each use (See for example BP's annual statistical review). And Europeans have a higher quality of life as measured by health, education and freedom (see for example the CIA factbook)



We don't want to leave you just with a list of what we should not be doing and where we should not be investing our money, but also with some idea of where we **should** be making investments towards national energy security. The chart below, showing per capita carbon emissions for several countries and the world, easily makes the case that we waste considerable energy at the expense of the environment and other people. Conservation is not just the obvious near term answer to our energy predicament but is also necessary from a moral perspective anyway.

Maintaining our glutinous fossil fuels appetite discounts the future deeply. We need to begin to treat the future as something that is actually going to happen.



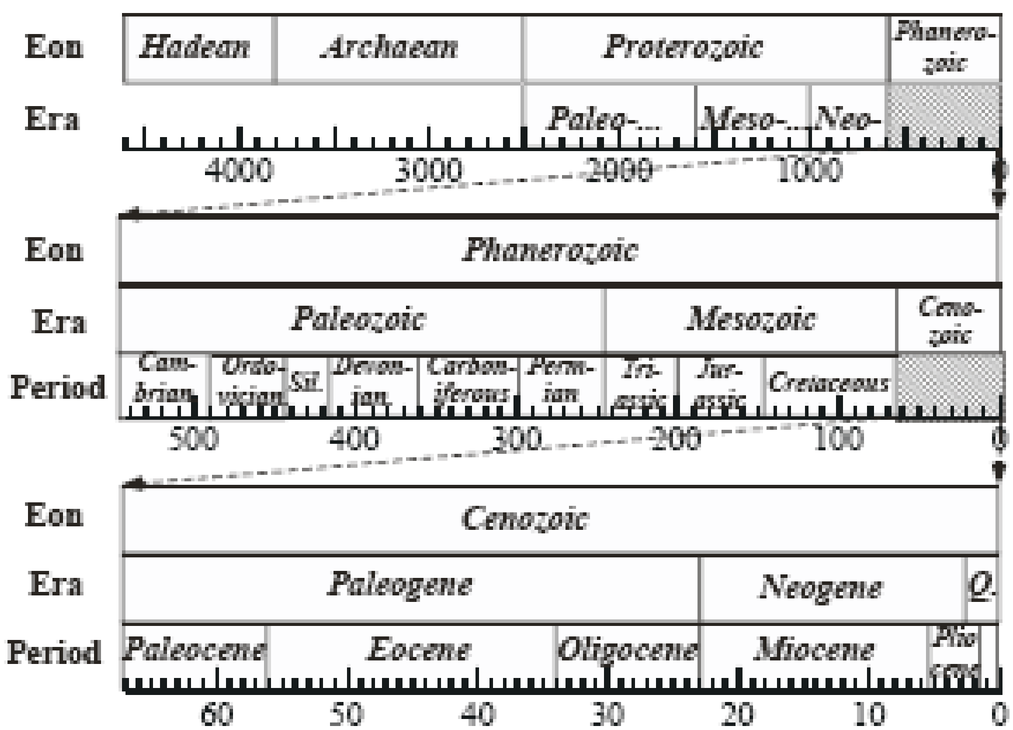
We need to invest for the long haul in conservation and renewables: solar, wind and geothermal along with population control. The chart above from Charles Hall shows Energy quality verses Energy quantity in the

US today. Note that Biodiesel and Gasahol and Canadian Tar all have low quality and quantity. Conservation can reduce our energy consumption from about 100 ExaJoules to 30 or 40 ExaJoules. This puts us in the ballpark where solar wind and geothermal can do the trick.

Paul Weisz concludes: “Population growth and energy demand are exhausting the world's fossil energy supplies, some on the timescale of a single human lifespan. Increasingly, sharing natural resources will require close international cooperation, peace, and security.”

References

[1] Weisz, P., ‘Basic Choices and Constraints on Long-term Energy Supplies,” Physics Today, July, 2004.
[2] ADM’s slander of Pimentel and Patzek pales in comparison to General Motor’s 20 year attack on Clair Petersen because he raised our awareness to the dangers of tetra-ethyl-lead as a gasoline additive. Or consider ExxonMobil’s vicious assault on the good names of Al Gore and James Hansen.
[3] Eaves, J. and S. Eaves, “Renewable corn-ethanol and energy security”, Climate Policy
[4] Spink, A., R. Sparks, M. Van Oorschot, and J. Verhoeven, “Nutrient Dynamics of Large River Floodplains,” Regulated Rivers Research and Management, 14, 203-216 (1998)
[5] Smil, V., “Water News: Bad, Good and Virtual,” American Scientist, Sept-Oct, 2008.



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