The Oil Drum
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Response to Green Algae Strategy Review

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I have received a response from Mark Edwards, auther of Green Algae Strategy: End Oil Imports And Engineer Sustainable Food And Fuel. I reviewed the book here recently, and as I indicated in the conclusion of the review I would gladly post any of Mark's comments. So, here they are in full. I have added clarifications, such as to indicate when Mark is quoting me [e.g., RR quote]. I have otherwise tried to keep the formatting consistent with what Mark sent me. No further response from me.

Response to Green Algae Strategy Review

Thank you for the review and the opportunity to respond to your thoughtful comments. Your observations are right on target for someone focused on algal oil as a liquid transportation fuel.

Remember that food energy is actually more important to humans that liquid transportation fuels. We can survive without transportation assistance but we starve quickly without food energy. I see no way to produce algae economically purely for liquid transportation fuels. The only way production makes sense will be to grow massive amounts of algae biomass, harvest the lipids for transportation energy and use the protein and carbohydrates to produce additional forms of energy, including especially food and feed.

> **RR quote: "Either Mark Edwards is dead wrong, or I am dead wrong."**

On the future of any topic, especially science, the truth is probably somewhere in the middle.

Skeptics abound in the algae space and the leading skeptic, Dr. John Benemann, speaks at all the algae conferences and stands in stark contrast to many other equally experienced scientists who do not share his natural pessimism. John revels in his reputation for pessimism. Other scientists engaged in the Aquatic Species Report have a completely opposite view. Several are working for companies that are producing algae for fuel. Professor Milton Sommerfeld at ASU and a co-author on the Report, has been producing algal oil for jet fuel in the laboratory and a field setting for several years.

Speculation on cost per gallon of algal oil is useless until we see actual field production. The good news on this front is that I have seen the following:

• Cost reduction of algal oil production -- one order of magnitude in the last two years

• Cost reduction on algal extraction -- two new methods promise two orders of magnitude
• Cost reduction on energy for mixing -- one order of magnitude in the last two years

These cost reductions will be reflected in various producers' cost models. American scientists and engineers are exceptionally talented at taking costs out of production.

The real question is not the cost of algal oil per gallon but the value of the total culture. The best production models I've reviewed have only about 30% of the algal biomass value going to fuel. That means 70% of the biomass produces other coproducts from the protein and carbohydrates. Those many coproducts are examined in analyzed in Chapters 7 and 10 in Green Algae Strategy.

Green solar energy captured in algae creates a portable energy source and grows biomass with solar energy stored in forms that may be used for a variety of purposes:

• **People** – organic protein in food
• **Animals** – organic protein in fodder
• **Fowl** – natural protein for birds
• **Fish** – natural protein in fish feed
• **Land plants** – organic nitrogen fertilizer
• **Fire** – high energy algal oil for cooking and heating
• **Cars** – carbohydrates refined to gasoline for transportation
• **Trucks and tractors** – high energy clean, green diesel
• **Trains, boats, barges and ships** – high energy clean diesel
• **Planes** – high energy, clean aviation gas and jet fuel

Algae also offer low energy and low cost pollution solutions to clean waste, brine or salt water, sequester CO2 from coal fired power plant plumes and recover abandoned soils. This presentation will highlight the status of the algal industry with a focus on food and energy.

> ***RR quoting a study that I cited in the review: What about the value of sequestered carbon in algae-based biofuels? In short, there isn't any. Atmospheric carbon is only sequestered for a short time until it's burned in an engine. Under existing biofuels mandates in most industrialized countries, there will be no opportunity to sell carbon offsets unless fuel production is additional, or beyond such mandates.***

This criticism ignores the fact that algae-based biofuels recycle atmospheric carbon and every gallon displaces a gallon of fossil fuel. When algal production occurs with no fossil energy, the production is carbon neutral because the carbon dioxide is simply being recycled. In contrast, cropland-based biofuels such as ethanol emits more carbon than burning natural gas directly due to the huge amounts of fossil fuels needed to produce corn.

I recently presented a paper demonstrating our work with Desert Sweet Biofuels where we produced carbon negative algal biomass by using a gasifier and creating bio-char. The gasifier burned biomass in a oxygen starved container creating hydrogen and carbon monoxide. The hydrogen was burned for energy to create electricity while the carbon dioxide was flued into algal ponds to produce algal biomass. Our calculations showed that we sequestered only about 10% of the total carbon -- the bio char that was scratched into fields. The University of Arizona is currently conducting research to see what percentage of that bio char stays in the soil and for how

long. Other research suggests that much of the bio char stay sequestered for decades.

Several countries are financing gasifiers in the U.S. for algal oil production for carbon trade offsets.

> **RR quote: Edwards falls prey to the Vinod Khosla fallacy on cellulosic ethanol: *This is simply too important and there are too many companies working on this to fail.***

Vinod Khosla gave an excellent keynote at the 2009 Algal Summit in Seattle where he outlined his reasoning for not investing in algal production. His primary points were that he needed to see actual production before making investments and that the industry needed to do a better job at conveying the value proposition for algae.

> **RR quote: He is sufficiently skeptical about the near term prospects for cellulosic ethanol, and is harsh in his assessment of corn ethanol (even more so than I have been).**

My prior book, Biowar I: Why Battles over Food and Fuel Lead to World Hunger examines the entire ethanol fiasco including energy and cost models. BioWar I is available for free PDF download with color speaker notes at http://greenindependence.org/. Every claim made for ethanol has turned out to be false. Consider that 2009 production of ethanol produce about 9 billion gallons of ethanol (the DOE Target) and will consume:

- 40 million acres of prime American cropland
- 2 trillion gallons of fresh water for irrigation
- 5 billion gallons of diesel fuel for corn production

The 2009 ethanol production will create severe pollution of air, water and soils while reducing imported oil by about 3%. Algal production, when commercially viable, could produce far more ethanol or other higher energy fuels using no or minimal cropland, fresh water or fossil fuels.

BioWar I covers the research on cellulosic ethanol which, for litany of reasons including that it takes too much fresh water and energy, makes no sense for biofuel production. Cellulosic products may turn out to be an excellent source of carbon for the production of algal oil. BioWar I concludes that our best policy is to end subsidies for ecologically destructive production such as ethanol and big oil and to shift subsidies to ecologically friendly production such as algal biomass. Subsidies played a key role in the review.

> **RR quote: He blames the lack of progress for algae on lack of funding, which is blamed on corn ethanol. This, he argues, was the politically favorable biofuel that sucked up all the R&D funding (and subsidies). He later writes "If corn ethanol makes sense, the market will reward it without taxpayer monies or protectionist tariffs." Can't we say the same about algal**

fuel?

Making corn whiskey, ethanol, is a 200-year-old technology. Subsidies are useful for changing consumer behavior and supporting new technologies. Subsidizing corn and the many inputs for growing corn for ethanol make no sense and are ecologically destructive. Algal production does not need protectionist tariffs but does need public monies to develop the knowledge base to grow massive amounts of biomass. The two top threats I see to the algal industry are subsidy-based. Lack of government subsidies, which began in the 1990's at the end of the Aquatic Species Program led to: (Subsidies were shifted to corn ethanol.)

a. **No support for academic, institute or government algal research**. As a consequence, the US has few algae labs, nearly no American algal professors and very few students trained in algal production. Lack of trained scientists and graduate students put the U.S. at severe disadvantage in algal production.

b. **An algal industry constrained by vertical markets**. Each algal company jealously protect its intellectual property and does not share bubble research or breakthroughs. Even the scientific meetings are full of statements that the scientist cannot share real numbers because they have signed on disclosure agreements with their employers or grantors.

The R&D necessary for successful algal production will take more money than is available from private investors. Who wants to invest $500 million on R&D. Investors want a fast return and are not willing to fund sufficient R&D. Failing government subsidies, the industry will sputter for decades. Then, when humanity desperately needs sustainable food and energy solutions, we will discover that the intellectual property for production is locked up by a very few producers who monopolize production to the detriment of all humanity.

RR paraphrase: To commercially grow them in the Midwest –pipedream.

Watch. Within 10 years, most the farms in the Midwest will use algal production to:

a. Recover and recycle energy in agricultural waste streams, especially manure
b. Recover and recycle nutrients in agricultural waste streams
c. Reduce the ecological damage and carbon footprint for agricultural production

Yes, many producers may use greenhouses and geothermal energy for algal production. However, cold tolerant algal species may flourish in the Midwest especially during the normal growing season.

RR paraphrase: Energy return not covered.

Correct. No one can credibly address energy return until production specifications and costs are determined. However, the production of algal biomass using solar, wind and geothermal energy avoid the issue of fossil fuel use. Two new extraction technologies promise significant reduction in energy requirements. One method uses simple air flocculation and another uses ultrasonic waves to break up the algal cells and separate the oil from the other biomass. The ultrasonic solution

allows the oil to flow to the top where it can be skimmed off at very low cost.

> **RR paraphrase: Casually dismiss technical challenges**

The technical challenges are treated with seriousness and focus. True, most are not solved in the book. An entire chapter examines each technical challenge and what needs to be done to successfully produce algal oil. In addition, the table in the last chapter provides a summary of the technical challenges and the R&D needed.

> **RR quote: Page 13: As a criticism of using food crops for fuel, he states that massive planting of corn leads to high humidity because the leaves transpire water. This leads to thunderstorms and potentially tornadoes. That large areas planted in corn can increase the risk of tornadoes is something I have never heard before.**

Neither had I before doing the research for BioWar I and Green Algae Strategy.

> **RR quote: Page 150: When writing that algal fuel mimics fossil fuels without fossilization, he writes "Skipping the fossilization step not only saves 200 million years of pressure and heat, but lowers production costs significantly." I can't really comprehend this one.**

Consider the true cost of production for fossil fuels. Failing government subsidies, fossil fuels would cost around $15 a gallon and that's ignoring their ecological cost. Oil fields must be found and developed at huge cost. Extraction and transportation add significant additional costs.

Imagine growing algae locally for fuel production when the inputs are only sunshine, carbon dioxide and wastewater.

> **RR quote: Page 179: He cites a claim by Aurora Biofuels that their process creates biodiesel with yields 125 times higher and 50% cheaper than current methods. I am going to presume that this was supposed to read 125% higher and not 125 times higher.**

You are correct.

> **RR quoting from the book: Page 204: "When someone invents a carbon capture filter for vehicle exhaust pipes, there will be a nearly limitless supply of low-cost CO_2 for growing algae."**

I think this is a great idea. A Brit has developed the vehicle exhaust filter. This is only one of many new and some recycled ideas presented to spur algal production.