The Oil Drum
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Cost Viability and Algae

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Robert Rapier recently drew attention to the demise of GreenFuel Technologies, the company founded on ideas from MIT and Harvard and supported by millions of dollars in venture capital funding. One of the creative ideas that the company has was to located their plant at existing power stations so that the carbon dioxide generated in the flue gas could be fed into the bio-reactors holding the algae, with the gas also keeping the algae at an optimal growing temperature. It was a company that was in the vanguard of promoting the use of algae in both carbon dioxide collection and liquid fuels production.

The company, however, ran into problems in raising more money in the current climate, and with the technology. According to to a recent news report:

> Getting the whole thing to run smoothly, though, was tougher than expected. GreenFuel could grow algae. The problem was controlling it. In 2007, a project to grow algae in an Arizona greenhouse went awry when the algae grew faster than they could be harvested and died off. The company also found its system would cost more than twice its target.

It is that latter part of the paragraph that is the more telling. When folk first consider using algae as a future fuel source, it is often because, when tabulated, algae can produce more fuel per acre per year, than any other crop.

- Corn - 18 gallons per acre - biodiesel - 300 gallons ethanol
- Soybean - 48 gallons biodiesel per acre
- Sunflower - 102 gallons biodiesel per acre
- Peanuts - 113 gallons biodiesel per acre
- Rapeseed/Canola - 127 gallons biodiesel per acre
- Jatropha - 202 gallons biodiesel per acre
- Coconut 287 gallons biodiesel per acre
- Oil Palm - 635 gallons biodiesel per acre.
- Sugar Cane - 662 gallons ethanol per acre
- Sugar beets - 700 gallons ethanol per acre
- Switchgrass - 1,000 gallons cellulosic ethanol per acre
- Miscanthus - 1,500 gallons cellulosic ethanol per acre
- Surface Algae - 3,654 gallons biodiesel per acre
- (Bear in mind that the energy content of ethanol is 84,000 Btu/gal; gasoline is 124,000 Btu/gal; and biodiesel is 139,000 Btu/gal. (DoE))

Source Biodiesel - Growing a New Energy Economy - Greg Paul, Chelsea Green Publishing Company, 2005, 281 pages

However, getting what has been achieved in the short term into a production mode that sustains the same yield for year after year is not that easy. Nor is simply finding the best algae the only solution required for the problem.

Given the collapse of GreenFuel, it is perhaps useful to look at some of the things that need to be considered, if you are going to have a shot at a viable algae operation.

First you need to select an algal species. This is not as simple as it sounds, because the initial thought might be to screen all the thousands of algae types that exist around the world to find the ones that (a) hold the most oil and (b) grow fastest. Algae grow by multiplication and so the common metric for the latter is the time it takes to double the volume of algae in a container, with less than a day being a good place to start. And a species that has 50% lipid content (the oil component) is also the sort of ballpark we are looking for. There are a number of candidates that meet (or come close to meeting) these criteria. One of the benefits of the program that the NREL review of algae produced was a filter of the thousands of candidates, that gave data from which to select some of the more productive.

Let us, for the sake of discussion, call one candidate AA, another BB, and a third CC. One of the early things you discover is that some of the better ones grow in salt water (seawater) rather than in river/lake conditions. That makes a little difference, particularly if you are interested in putting your algae operation (we'll call it a farm) out in the middle of the country many miles from an ocean. So that if you need that water you can either make it or import it, neither cheap.

And speaking of cheap, one of the first steps is to decide how you're going to contain your algae and growing medium (nutrient). GreenFuels used plastic tubes, but as Fireangel pointed out in 2007, these are very expensive and he concluded:

> That leaves gross profit of $3.00. That means at current prices it would take 50 years to just cut even on their investment. That is clearly not feasible. For one thing these polycarbonate sheets take a lot of UV damage and their useful life is almost always less than 15 years (usually 10 years).

It seems that at a recent algal biofuels meetings, it was concluded that the large flat race-track type of layout is the only one that stands a chance of financial viability.

But that selection brings its own concerns. For the light to reach the algae throughout the water column in adequate quantity, the water can only be around 6-inches deep. This means that the ponds have to be large, (bringing in construction and other land costs). It also limits the species that can be grown, since the conditions are more tempered by local conditions and survivability. This almost mandates, for open systems, that the local conditions select the algae, rather than picking the best. (Which helps explain why we chose a confinement strategy based on facilities constructed for other purposes and already paid for, but that is another story).

So having selected the algae and the farm, the next cost is for the nutrient that the algae needs, and to supply the carbon dioxide. Here the potential for beneficial selections should be considered; some algae for example can use sewage as the nutrient, and if cap and trade comes along, then some of the income can come from the carbon captured and used by the algae. (Proper distribution of the gas, and keeping the right quality and concentration also costs, as may the supply and its transport.)

Having grown the algae, the next step is to harvest it and separate out the algae. There are some interesting new concepts (bearing in mind that the algae are a very small percentage of the pond volume).

One way of reducing the costs of separation is by using an algae, such as botryoccocus, that weeps oil rather than creating it internally. According to one report:

> Another, Phycal, is trying to harvest oil from algae without killing the algae. Instead, Phycal bathes the algae in solvents which can suck out the oil. Some strains of algae can go through the process four times or more.

There seem to be two snags to the process, the first being that the algal productivity seems to decline with cycle number, and the other is that the biomass itself, once the oil is removed, may have value.

Costs from Solix for example:

> Algae biofuel startup Solix, for instance, can produce biofuel from algae right now, but it costs about $32.81 a gallon, said Bryan Wilson, a co-founder of the company and a professor at Colorado State University. The production cost is high because of the energy required to circulate gases and other materials inside the photo bioreactors where the algae grow. It also takes energy to dry out the biomass, and Solix uses far less water than other companies.
>
> By exploiting waste heat at adjacent utilities (one of our favorite forms of energy around here), the price can probably be brought down to $5.50 a gallon (see Will Waste Heat Be Bigger Than Solar?). By selling the proteins and other byproducts from the algae for pet food, the price can be brought to $3.50 a gallon in the near term.

OriginOil notes that

> “The energy cost of extracting algae is 10 times the energy cost ofextracting soybean oil,” Riggs Eckelberry, CEO said.

OriginOil also has a video on their site showing a cheaper way of getting the oil out.

The process also generates glycerin and oxygen as byproducts that could be collected and become part of the saleable product.

Alternately the algae can be used to generate natural gas as suggested by Genifuel:

> It works like this. Algae is grown in ponds and, while it is still wet, is it placed in gasifiers with a chemical catalyst that allows it to cook at relatively low pressures and temperatures, said president Jim Oyler. It cooks at 350 Celsius versus 700 Celsius.

> The cooking produces a synthetic gas that is 65 percent methane, or CH_4, and 35 percent carbon dioxide along with some other trace materials. The carbon dioxide is then pumped into algae ponds as food. It will be more expensive than natural gas pulled from the earth, but it will require lower subsidies than liquid algae fuel to be competitive with its fossil fuel equivalent. It yields 0.55 liters of gas per gram of dry material, Oyler claimed.

There are thus a lot of considerations (I really did not get into efficient light use, correct fluid temperatures, and secondary processing) which led to the conclusion some time ago that this has to be addressed as a system problem, and set of solutions, rather than piecemeal. Profits and income streams from as many sources as possible have to be included, since without them, as with GreenFuels, the concept is not enough to be sustainable. And to develop the systems approach needs a lot of different inputs.