

Micro-Algae Could Play a Significant Role in Achieving Energy Independence

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I want to talk about a source of renewable energy that has enormous potential but is not currently being considered in discussions about solar, wind, and geothermal sources.

Q. Is there any source of renewable energy that actually improves the environment?

A. Lets talk about micro-algae.

Q. What are micro-algae?

A. Micro-algae are a large group of photosynthetic, heterotrophic organisms which have extraordinary potential for cultivation as energy crops. (Micro-algae are some of the most numerous organisms in nature. They grow extremely rapidly. In the oceans, they consume large quantities of CO₂ and produce oxygen.)

Q. What can micro-algae do that involves renewable energy?

A. They can produce Lipids.

Q. What are Lipids?

**A. Lipids are molecular organic compounds, composed largely of carbon, oxygen, and hydrogen, that store energy and are essential for cell growth.
The important thing here, is that these Lipids can be converted via a process called transesterification, into biodiesel fuel.**

Indeed, micro-algae produced biodiesel fuel is the renewable energy we wish to talk about.

Q. What is special about micro-algae?

A. One of the really special things about micro-algae is that in the process of producing Lipids, they consume a large amount of CO₂.

Q. Where can you find large quantities of available CO₂?

A. At any coal, oil, or natural gas burning power plant.

Thus, the same technology that might produce biodiesel fuel might also help our environment by reducing the amount of CO₂ discharged from power plants.

“Thus, Renewable Energy AND Environmental Improvement”

The Micro-Algae Dream

- 1. A micro-algae based, biodiesel plant, at every coal burning power plant in the country, that consumes, perhaps as much as 80% of the CO₂ generated. “A drastic reduction in the CO₂ released/year.”**
- 2. A significant new supply of fuel for ground, rail, & marine transportation, and for home heating, produced at these plants, that cost less than \$3/gallon. “Perhaps as much as 40~50% of the fuel we need for home heating and for transportation.”**
- 3. A significant reduction in the number of US dollars spent each year in foreign countries.**
- 4. A significant number of new jobs in the American economy associated with the production and distribution of biodiesel.**
- 5. A significant reduction in emissions from all transportation and heating applications burning biodiesel fuel. “Biodiesel actually burns cleaner than petroleum diesel.”**
- 6. A practical bridge to enable us to gradually transfer from our current commitment to coal as our main source of electricity to other, cleaner, renewable sources.**

“The environment is improved, the economy is improved, we decrease the money we spend for foreign oil, power companies actually make more money, and you & I save money filling up at the pump.”

Q. What is new here?

**A. The amazing thing is that much of this is not new.
The science involved has been understood for many years.**

Q. If nothing is new, why has the DREAM not come true?

**A. The answer is the economics of the processes that have been tried.
Specifically, no micro-algae process has yet produced biodiesel fuel at a
cost as low as \$3/gallon. It is a process economics problem.**

**Q. What are the dominant cost contributing aspects of micro-algae
processes? -or- Lets consider: "How do micro-algae produce lipids?"**

**A. Micro-algae produce lipids via a photosynthetic reaction that combines
light, CO₂, and nutrients with a micro-algae broth under controlled
conditions that include variables such as temperature, pH, and salinity.**

Q. What is the cost of the ingredients?

A1. The majority of processes attempted utilize sunlight, but artificial lighting can also be used.

When sunlight is used, algae are frequently grown in open ponds. The cost of ponds is measured in the acres of land necessary for significant production rates.

When artificial lighting is used, there is a direct relation between the amount of lipids produced and the cost of electricity needed to provide sustained lighting.

Thus, the cost of the lighting required, is measured in the cost of land or in the cost of electricity.

A2. The micro-algae broth itself is usually prepared in a culture farm operated as a pre-processing step to lipid production.

A3. The cost of recycled CO₂ from a power plant is mostly associated with the pre-processing needed for the CO₂ stream. This preprocessing involves both cooling and removal of exhaust nitrogen.

A4. It turns out that animal waste, possibly from a feed lot or dairy farm or waste from a wastewater treatment plant, can be used as the nutrient stream. Again, a large component of the cost of a nutrient stream is the cost of pre-processing.

A5. The final step in production, separation of the lipids and conversion of lipids into biodiesel, is a post-processing step.

Summary of Costs

In general, none of the ingredients are very expensive. In fact, in each case, most costs are associated with either pre- or post-processing steps.

From an engineering point of view, the important thing here is to keep your sense of perspective. Compare the cost of ingredients and the cost of pre- and post- processing just described to similar costs in the oil industry.

Micro-algae ingredients do not cost \$120 per barrel.

You may not be aware of this, but most every engineer knows that refining costs in the oil industry are among the highest processing costs in industry. It is hard to imagine that the pre- and post-processing costs described above could equal those in petroleum refining.

From an engineer's perspective, it is only a matter of time until we can design a micro-algae process that produces biodiesel fuel for under \$3/gallon. Many engineers believe that an economical micro-algae process is not here yet, but is not far away.

Historic Estimates of Cost/Gallon for Biodiesel

- Q. What has been the estimated cost per gallon of the biodiesel produced by micro-algae processes?**
- A. Scientific reports of laboratory demonstrations of micro-algae consuming CO₂ and producing lipids began to appear more than 50 years ago. No cost figures were reported in these early reports.**

The most well known research initiative to develop the process needed was initiated by the US Department of Energy. It was called the Aquatic Species Program and was operated from 1978 thru 1996.

The final set of cost estimates produced by this program showed that the cost of algal biodiesel would range from \$1.40 to \$4.40 per gallon based on projections at that time. Because crude oil was selling for less than \$20/barrel, the cost of #2 diesel was less than \$1.40/gallon.

Estimated cost of a micro-algae plant

- Q. What is the estimated cost of a micro-algae based plant for producing biodiesel fuel?**
- A. The actual cost of such a plant will depend upon the specific processes chosen. It is expected that such plants will cost in the tens of millions of dollars.**

It is clear that, based on the Kyoto Protocol, carbon credits are now a reality in every industrialized country except the United States.

Both of our presidential candidates support implementing carbon credits.

Even a small power company, whose plants utilize coal and/or natural gas, will be required to pay tens of millions of dollars per year in carbon tax.

We believe it is probable that, when carbon credits are established in the United States, the total cost of micro-algae based biodiesel production facilities will be justified by carbon taxes alone.

Status Quo

Q. What is the state of micro-algae process development?

A1. In the US alone, there are about a dozen, privately funded, startup companies each attempting to design the first economic micro-algae process.

A2. There are a small number of government funded research projects that are focused on some aspect of micro-algae or biodiesel research.

A3. There are about a dozen other university research projects, also investigating micro-algae processes, many with some level of private funding. (Including one at UNLV in cooperation with Nevada Power Company)

What can we conclude from this?

C1. There is a universal focus on developing intellectual property.

C2. There is little cooperation among the advocates and no sharing of results.

C3. We need a cooperative, national, federally funded effort to push forward improved micro-algae processes as rapidly as possible.

Summary

The authors believe that:

1. **Sooner or later, the micro-algae dream will be realized and will make a significant contribution to our energy independence.**
2. **The first successful processes that appear will appear sooner and will enable more rapid adoption, if there is a government sponsored effort, involving both academic and private efforts, that share results.**

We need a GENOME style project to advance the science of micro-algae and to determine optimal design(s) for micro-algae processes.