ALGAE POWER, NEW GREEN REVOLUTION

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INTRODUCTION

The biofuel industry was launched decades ago when French-fry grease was used to fuel modest agricultural machines. Today, hundreds of thousands of cars run on ethanol derived from grain. In the USA, more than 40 percent of gasoline contains ethanol as an additive. The fuel is produced in huge fermenters the size of blimps, by fermenting a mash of corn or rye with yeast.

Ethanol as a biofuel has disadvantages. One hectare or 2.47 acres of corn produces less than 4,000 liters of ethanol per year, and 8,000 liters of water are required to produce a liter of ethanol. Crops grown for ethanol take away valuable farmland for food production. Farmers harvested more corn for ethanol production than for use as animal feed in 2010. An adverse consequence of the biofuel boom is that it is driving up food prices.

TECHNOLOGY DEVELOPMENT

Many environmentalists believe that growing energy plants is the wrong approach and favor algae instead. Algae do not require any farmland. Solar radiation, saltwater, a little fertilizer and carbon dioxide are all the undemanding little organisms need to thrive. And because they consume about as much CO_2 during photosynthesis as is later released when the oil they produce is burned, algae-based fuels are also carbon neutral.

Algae are astonishingly productive. A hectare of sunny desert covered with algae vats can yield almost eight times as much biofuel per unit of biomass in a year than corn grown for energy purposes. Desert areas can be turned into fertile, energy-producing land. Algae could be grown in large quantities at competitive prices like rice, in shallow patties of water on thousands of hectares. One barrel of this green petroleum is expected to cost $70-100 in the future. As with grain production, this requires the use of high-performance varieties with optimized yield, resistance to disease and harvest capability.

Figure 1. Botryococcus Braunii algae.

A type of algae: Botrycoccus Braunii contributed to the generation of hydrocarbons as coal and petroleum over the last 200 million years. This stored energy is basis of the current industrial revolution. An effort exists at sequencing the DNA of the organism in view of developing synthetic methods to synthesize oil based on the approach reached by nature.

Algae are only a beginning, because they merely enrich the oil internally. To obtain the oil, the algae must be harvested and the oil extracted in a costly and complex process. To overcome this obstacle, scientists are developing algae that do not even have to be harvested. Instead, they essentially ooze the fuel of the future. Evolution has not yielded anything that produces biofuel from CO_2 on a large scale.

The first of these miracle organisms can already be admired in the Joule laboratory. The bioengineers' tools include culture mediums, incubators and, most importantly, databases containing the DNA sequences of thousands of microorganisms. Robertson and his team search the databases for promising gene fragments, which they then isolate and inject into the genetic material of blue algae.

Using genetic engineering and sophisticated breeding and selection methods, biochemists, a new green revolution is taking shape by transforming blue and green algae into tiny factories for oil, ethanol and diesel fuel. Dozens of varieties of the microorganisms, also known as cyanobacteria, bob up and as a green brew in photobioreactors. Blue algae strains that pump so-called alkanes outward through their membranes have been identified. Alkanes are energy-rich hydrocarbons contained in diesel fuel. The cell must be induced to stop growing and make the product of interest and do it continuously. In contrast to ethanol, the end product is not a low-quality fuel, but a highly pure product that contains no sulfur or benzene.

Laboratory algae are grown in high-tech bioreactors, where carbon dioxide is constantly bubbling through shimmering green panels that look like solar collectors. The ultimate goal is to derive about 140,000 liters of biofuel a year from one hectare of land; a yield 40 times as high as with corn grown for ethanol.

A question arises about whether the laboratory creations really work as well in open fields as they do in the lab. Calculations show that some algae plants will likely consume more fertilizer and energy per hectare than grain crops. And the carbon dioxide in the air would not be enough to feed the microalgae. Scientists estimate that a commercial algae fuel plant would require about 10,000 m^3 of CO_2 per day. Large amounts of the gas could be derived from the exhaust gases of large coal power plants and then brought to the algae farms.

The farms could also require large tracts of land. In an article in the journal Science, researchers at Wageningen University in the Netherlands calculated that, in theory, an area the size of Portugal would have to be filled with algae pools to satisfy Europe's current fuel needs. A leap in microalgae technology is needed to at least triple the productivity. There is enough non-arable land with enough solar radiation and enough CO_2 and water sourcing in the world. Another important advantage is that algae-based fuel could easily be pumped into the oil industry's existing pipelines and refineries, and that cars and aircraft would not have to be modified to accommodate the biofuel.

The switch to algae-based fuel will likely take a while longer to surmount mundane problems. The algae face competition from other creatures. Other contaminant algae as well as shrimp can feed on the grown algae turning the algae farm into a shrimp farm.

REFERENCE

Von Philip Betge, “Algae could solve World’s Fuel Crisis,” der Spiegel, July 28, 2011.