Climate Change : Climate Solutions

Bioenergy: The Scum of the Earth

One of the simplest plants on Earth could help us out of a few complex problems. Algae may not only help us mitigate climate change, they could also become one of the few truly sustainable biofuels.

Marine algae thrive on CO2 and sunlight in the photobioreactor at Jacobs University Harvested algae can be used to produce biofuels (Photo courtesy: Laurenz Thomsen)

The unsightly, suffocating green sludge we call pond scum is an unlikely savior for the planet.Yet algae underpin all life on Earth. They use the sun's energy to convert carbon dioxide and water into 70 to 80 percent of the world's oxygen. They are also energy-rich foodstuffs that sustain the Earth's animal life.

As if that wasn't enough, scientists on both sides of the Atlantic want to take the waste gases spewed out by power plants, feed them to carbon-dioxide-hungry, fast-growing algae, harvest the resulting crop and turn it into high-octane biofuels, animal feed, or even plastics. The algae would produce bioenergy without adding more carbon dioxide (CO2) to the atmosphere.

This is not a new idea. For nearly 20 years, the U.S. Department of Energy tried to turn CO2 from coal-fired power plants into algae diesel. When the project was scrapped in 1996, algae diesel couldn't compete with cheap petroleum diesel, which only cost about 20 dollars a barrel back then. With oil prices now nearly seven times as high, the idea has come back.

U.S. company GreenFuel Technologies, only one example among many, is using plastic sacks full of algae to recycle emissions from a small power plant into biodiesel. GreenFuel is testing larger systems at coal and gas-fired power stations.

Meanwhile, the Greenhouse Gas Mitigation Project has tested a system that used marine algae to capture CO2 from a 350-Megawatt coal-fired power plant in Bremen, Germany. Emissions were pumped into a 'photobioreactor' — a greenhouse packed with vertical rows of glass tubes filled with algae sitting in salt water. Sunlight pouring into the greenhouse stimulates the algae to convert the gases into biomass. The

green sludge was harvested by flushing it out of the photobioreactor tubes with water.

The big advantage: algae grow incredibly fast. Marine algae reproduce once a day in the summer, producing up to 20 times more biomass than other plants, says Laurenz Thomsen, professor at Bremen's Jacobs University and co-ordinator of the project. But unlike most CO2-to-algae pioneers, Jacobs University and its spin-off company Phytolutions are looking to truly "fix" the carbon by converting the biomass into solid materials, such as building insulation or even bricks.

"Only then do you sequester CO2," Thomsen argues. "Otherwise it is recycled into the atmosphere."

Bioreactor Grapgic

A system for growing and harvesting algae developed by the University of Ohio use fibre optic tubes to deliver light to algae growing on vertical sheets (Diagram courtesy: David Bayless)

Thomsen says one square kilometer of greenhouse will mitigate up to 30,000 tons of CO2 a year, depending on sunlight. That means a few hectares of photobioreactors could recycle the carbon emissions from a biogas plant or other small power plant, but to mitigate all the CO2 from a 300MW plant, Thomsen says tens of square kilometers of greenhouse would be needed. The largest greenhouse in Europe is 350 square kilometers, but in most of the developed world, space is scarce.

"You need unpopulated land where no other agriculture is possible, on the coast, for example," says Thomsen. "The IPCC recommends sequestering CO2 in oil and gas reservoirs. If there are pipelines transporting CO2 towards the ocean, we can sit close to pipelines and use the CO2. And we can use any power plant next to the sea."

The only sustainable biofuel?

With growing concerns about the impact of ethanol fuel and biodiesel production on the world's forests and food prices, the search is on for a more sustainable biofuel. Since algae is not a food crop, and growing it would not necessarily require agricultural land, it could be a leading second-generation biofuel.

Algae also pack a considerably bigger energy punch than any other biofuel feedstock. Up to a quarter of the weight of algae is vegetable oil, or lipids, so algae can produce 20 to 70 times more biodiesel than other biofuel crops, such as oil palm or rapeseed. According to Thomsen, a one-hectare photobioreactor could produce 1,000 tons of biomass per year. With 1000 tons of biomass, you can make 200 to 300 tons of biofuels.

GreenFuel claims that while an acre of corn can produce 300 gallons of ethanol a year, an acre of algae could theoretically produce 5,000

gallons of biofuel.

“It’s good enough that the U.S. Department of Defense is putting a lot of money into researching algae-based biofuels,” observes David Bayless, a professor at Ohio University’s Coal Research Center. “Algae is probably the only sustainable solution for biofuels.”

Bayless grows algae on membranes in an enclosed container resting in wastewater, which are fed waste gases and sunlight via fiber optic cables. Unlike Thomsen’s algae, Bayless is using algae species that dislike intense sunlight.

His algae are about 40 percent protein by mass, a much better proportion than corn or soybeans. This suggests that algae may also be a more sustainable, protein-rich feed for the world’s ever-increasing number of livestock.

Algae’s requirements are few: CO2, sunlight, and nutrient-rich wastewater or seawater will suffice. However, while algae farms don’t need precious freshwater or fertile agricultural land, they do need space This issue, along with the start-up costs associated with a new technology competing with established industries, is daunting. But Bayless says that circumstances could change in favor of increasing use of algae biomass.

“It would really help algae if there was a significant carbon tax, perhaps 40 to 50 dollars a ton,” he says. “I would be shocked if in 10 years we don’t see large-scale algae production, at least in developing countries.”

Conditions for an algae boom could be ripe in places like Africa, India, and other emerging nations, where many new power plants are being built, population densities are generally lower, land is cheaper, and there is more sun. While flower power was all the rage in the sixties, the era of algae power might not be too far off.

editor: James Tulloch

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