New wave in energy: Turning algae into oil

By Erica Gies
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SAN FRANCISCO — Algae, those simple, aquatic plants, are composed of carbohydrates, proteins and plant oil. The algal oil can be processed into biodiesel or nonpetroleum gasoline, the carbohydrates into ethanol, and the protein into animal feed or human nutritional supplements.

The whole biomass can generate methane, which can be combusted to produce electricity. Processors can extract chemicals to replace petrochemicals. As algae grows, it absorbs carbon dioxide. And it can be used to clean sewage or agricultural or industrial runoff.

Microalgae, the simplest and most primitive plants, are generally more efficient converters of solar energy than terrestrial plants and have a much higher energy potential. This possibility has lured entrepreneurs and venture capitalists into the research fray.

Still, challenges loom large. Companies must grow algal biomass at a low enough cost to make it worth processing, find a cost-effective way to separate the algae from water, extract something of value from the algae and stabilize that product to make it market-ready, said Lissa Morgenthaler-Jones, chief executive of LiveFuels, an algae company based in Menlo Park, California.

Start-ups in the United States and elsewhere are investigating myriad processes and products derived from two basic models: closed or open systems.

Closed systems use photobioreactors, clear containers that allow growers to carefully control the species and the environment. They have been expensive to build and can suffer from "self-shading" if the algae grows to the point that it blocks out the sunlight that it needs to proliferate.

Open systems grow algae in ponds, raceways, or even in the wild. While less expensive to build, they are susceptible to invasion by other species and vulnerable to environmental changes.

LiveFuels uses open ponds to grow algae that are indigenous to the local environment, hoping that this will avoid the invasion problem. Since algae need nutrients to grow, including nitrogen and phosphorous, the company plans to feed agricultural runoff water - polluted with nitrogen and phosphorous fertilizers - into its ponds, combining energy production with water treatment.

Another company, Bionavitas, of Redmond, Washington, also grows native algae, but in deep, narrow canals, with a special optical system to bring light to the algae beneath the surface. It too hopes to harness nutrients from polluted wastewater; and because intense carbon dioxide inputs can speed growth, it envisages setting up sites next to a factory that could funnel smokestack emissions directly into its canals. Michael Weaver, the chief executive, said that Bionavitas aimed to use "the whole algae" to produce biodiesel, ethanol, nutriceuticals and products currently derived from petroleum.

Vertigro, a U.S. company based in Vancouver, Canada, is testing single varieties of algae, grown in bioreactors that resemble hanging plastic bags, to see which grows best in a

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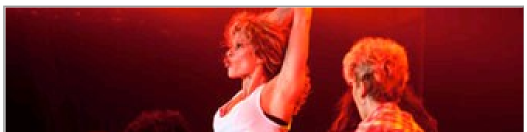

closed environment and produces the most oil. Its business plan is to sell its system to companies that would use it for commercial biofuel production, said Glen Kertz, chief executive of Valcent Products, a partner in Vertigro with Global Green Solutions, a sustainable energy development business.

In Seattle, Blue Marble Energy is putting algal biomass in anaerobic digesters to produce industrial chemicals and methane. The latter is combusted in a turbine to generate electricity and could also be used in fuel cells, said the chief executive, Kelly Ogilvie. Saleable byproducts include ammonia, anhydrous ammonia, and other industrial chemicals currently made with petroleum.

Water cleanup is an important part of Blue Marble's business model. Its first demonstration, starting this year, will harvest nutrients from a Thai beer factory's effluent pond using native algae. In the future it hopes to work with sewage treatment plants, mine sites or even the toxic marine algal blooms caused by agricultural runoff pollution. Harvesting these blooms, if possible, would help to repair the damaged ocean ecology.

All of these models will probably require inputs to adjust the balance of nutrients and carbon dioxide. "You're going to be adding something," Morgenthaler-Jones said. "The only question is, what do you have to add and how much is it going to cost?"

Large-scale commercial production is at least five years away, according to most estimates, and it is still too early to say which methods, if any, will be economically viable, how much energy they may produce and what their effects on the environment might be.

"They're so different that one really has to look at them one at a time to make sense of what they're promising," said Jeremy Martin, a senior analyst with the Union of Concerned Scientists, an independent scientific policy organization.

Although the industry is still taking shape, the concept is not completely new. The U.S. National Renewable Energy Laboratory researched algae from 1978 to 1996, before halting its work because of dwindling budgets. At that time researchers decided to focus on ethanol derived from cellulose, deemed to be more economically feasible at a time when oil cost about $20 a barrel, said Al Darzins, group manager of the laboratory's National Bioenergy Center.

The laboratory recently restarted its algae program, thanks in part to interest from oil companies including Shell and Conoco Phillips and financing from Chevron.

Darzins said he remained unsure which production route held the most promise.

"It all comes down to how much is it going to cost to get a gallon of that oil," he said, noting that costs currently range from $6 to $100 a gallon, depending on the method.

To reduce that cost the laboratory is focusing on the development of commercial co-products, like ethanol or animal feed, which could help to improve profitability.

The Union of Concerned Scientists is interested in algae innovation but cautious about hype. Like anything that is promoted as a green energy source, algae will have to prove its credentials. "You have to add up all the pieces that it takes to make this into a fuel and do lifecycle accounting," Martin said.

He dismissed, for example, the notion that harvesting carbon dioxide from smokestacks would offer an additional environmental benefit. "Any plant used to make fuel uses recycled carbon dioxide," he said. "Whether you recycle it on its way out of a smokestack or straight from the atmosphere, like a plant growing in a field somewhere, it's still the same carbon recycling."

Martin also questioned whether companies could find the ingredients they would need - water, sunlight, nutrients, carbon dioxide - in close proximity and in quantities large enough to generate a meaningful amount of fuel.

But Darzins, of the National Renewable Energy Laboratory, said, "whenever you try to harness biology, it's never an easy thing." He added that the laboratory was "bullish" on algae.

So, too, was Morgenthaler-Jones of LiveFuels. "Our team looked at hydrogen, solar power, wind power, ethanol, biodiesel, cellulosic ethanol," she said. "It's only when we got to algae that we said, 'this one is going to be really hard, but it could work. And if it works, it has the potential to change the world.'"

The Union of Concerned Scientists counsels balance. It says no single material is likely to meet global fuel needs without having an effect on the environment. And reducing pollution from transportation fuels is only part of the puzzle, which also includes improving energy efficiency and reducing the number of miles that people drive.

"As exciting as these developments are," Martin said, "we don't see any likelihood that there'll be so much algae that it will reduce the need to do these other things."

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