Algal Biofuels

Algal biomass is a fast-growing, renewable resource and a promising feedstock for advanced biofuels.

Algal biofuels are generating considerable interest around the world. In the United States, they represent promising pathways for helping to meet the biofuel production targets set by the Energy Independence and Security Act of 2007.

Algae are a diverse group of primarily aquatic organisms that are capable of using photosynthesis to generate biomass. Some algal strains are able to double their mass several times per day. In some cases, more than half of that mass consists of lipids or triacylglycerides. These bio-oils can be used to produce drop-in replacements for diesel, gasoline, and aviation fuels. Some algae accumulate carbohydrates (including starch), which can also be used to form intermediates for processing into biofuels. Proteins from the residual biomass could provide supplemental feed for livestock and aquaculture operations.

Renewed Interest and Funding

Volatile oil prices and increased interest in energy security have stimulated new public and private investment in algal biofuels research. The Biomass Program is building upon the knowledge gained from the Aquatic Species Program (1978 to 1996) at the National Renewable Energy Laboratory (NREL) and is incorporating new technologies to drive down the cost of algal biofuel production. Today, several of the DOE National Laboratories are engaged in algal biofuels-related research and analysis along with universities, industry, and other federal agencies, such as the Environmental Protection Agency, the Defense Advanced Research Projects Agency, and the Air Force Office of Scientific Research.

NREL researchers analyzing algae samples for oil content. The Fluorescence Activated Cell Sorter (FACS) shines laser light on cell samples to fluoresce the lipid oils, revealing the types of cells.

Benefits of Algal Biofuels

Impressive Productivity:

NREL's Aquatic Species Program demonstrated algal biomass yields exceeding 10 dry tons per acre per year in an open pond system. Significant potential exists to further increase productivity.

Diverse Production Scenarios:

Algae can be cultivated in large open ponds, in enclosed photobioreactors, or in the dark using fermentors located on non-arable land in a variety of climates (including deserts).

Flexible on Water Quality:

Many species of algae thrive in seawater, water from saline aquifers, or even wastewater from treatment plants.

Beneficial Reuse of CO_2:

During photosynthesis, algae use solar energy to fix carbon dioxide (CO_2) into biomass, allowing for the productive re-use of CO_2 emissions from stationary sources.

Broad Product Portfolio:

Algal biomass can be used to make a range of biofuels, and the remaining biomass residue has a variety of useful applications:

- Combust to generate heat.
- Use in anaerobic digesters to produce methane.
- Use as a fermentation feedstock in the production of ethanol.
- Use in value-added byproducts, such as animal feed.

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NREL biotechnologist examines a flask of lipids (oils) produced by microalgae that can be converted into biofuel.

Challenges to Commercialization

Algal biofuels are not economical to produce today. Lowering the cost of production will require coordinated research across a wide range of technical sectors (see box) over the next five years or more. Although the technical challenges are significant, the public benefits of successfully commercializing algal biofuels warrant investment in research and development (R&D). Particular attention must be paid to the engineering of sustainable algae systems and to the regulatory and environmental requirements.

Overcoming Key Barriers

To identify and prioritize R&D needs on the critical path to commercializing algal biofuels, DOE held the National Algal Biofuels Technology Workshop in December 2008. Participants included a balanced group of experts in relevant disciplines. Workshop results are being used to inform development of the National Algal Biofuels Technology Roadmap, which will be available to the broader scientific community in 2010.

Through the American Recovery and Reinvestment Act (ARRA) of 2009, DOE made strategic investments in algal biofuels to address critical barriers to commercialization. In December 2009, DOE awarded cost-shared funding to Algenol Biofuels Inc., Solazyme Inc., and Sapphire Energy Inc. to build and operate biorefineries at either the pilot or demonstration scale. These facilities will integrate promising algal biofuels technologies and provide the data necessary for scaling up production.

In January 2010, DOE announced ARRA funding for an algal biofuels consortium, the National Alliance for Advanced Biofuels and Bioproducts (NAABB). NAABB brings together leading experts from industry, academia, and government to break down critical barriers to the commercialization of sustainable, algae-based biofuels. For more information on the roadmap, integrated biorefinery projects, and the consortium, please watch for news on our website: **www.biomass.energy.gov**

Photo courtesy of Seambiotic

Algae can be grown intensively in raceway-type ponds.

R&D Focus Areas for Algal Biofuels

Basic Algal Biology

- Algae strain isolation and screening
- Genetics, genomics, strain improvement tools
- Photosynthesis and solar conversion efficiency
- Algae productivity and regulation of the production of fuel intermediates

Cultivation Research

- Algae mass cultivation
- Control of competitors, grazers, and pathogens
- System design and engineering
- Algae for wastewater treatment

Production and Integrated Process Scale Up

- Long-term maintenance of desired strain in culture
- Hydrodynamics of mixing
- Evaluation of local water supply for algal cultivation
- CO_2 supply
- Harvesting technology
- Extraction and separation technologies
- Optimization of specific fuel production processes
- Distribution and infrastructure

Economic Analysis

- Detailed process analysis
- Potential for value-added co-products
- Resource and siting analysis
- Environmental impact of large-scale algae farms
- Water requirements and recyling
- Regulatory concerns
- Public awareness and acceptance

For additional information visit: www.biomass.energy.gov **March 2010**

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