Algal Biofuels

Biofuels made from microalgae hold the potential to solve many of the sustainability challenges facing other biofuels today.

Growing America's Energy Future

Algal biofuels are generating considerable interest around the world. They may represent a sustainable pathway for helping to meet the U.S. biofuel production targets set by the Energy Independence and Security Act of 2007.

Microalgae are single-cell, photosynthetic organisms known for their rapid growth and high energy content. Some algal strains are capable of doubling their mass several times per day. In some cases, more than half of that mass consists of lipids or triacylglycerides—the same material found in vegetable oils. These bio-oils can be used to produce such advanced biofuels as biodiesel, green diesel, green gasoline, and green jet fuel.

Renewed Interest and Funding

Higher oil prices and increased interest in energy security have stimulated new public and private investment in algal biofuels research. The Biomass Program is reviving its Aquatic Species Program at the National Renewable Energy Laboratory (NREL) to build on past successes and drive down the cost of large-scale algal biofuel production. NREL, Sandia, and other laboratories are also launching research into algal biofuels for private investors and programs within the Defense Advanced Research Projects Agency (DARPA) and Air Force Office of Scientific Research (AFOSR).

Benefits of Algal Biofuels

Impressive Productivity:
Microalgae, as distinct from seaweed or macroalgae, can potentially produce 100 times more oil per acre than soybeans—or any other terrestrial oil-producing crop.

Non-Competitive with Agriculture:
Algae can be cultivated in large open ponds or in closed photobioreactors 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.

Mitigation of CO_2:
During photosynthesis, algae use solar energy to fix carbon dioxide (CO_2) into biomass, so the water used to cultivate algae must be enriched with CO_2. This requirement offers an opportunity to make productive use of the CO_2 from power plants, biofuel facilities, and other sources.

Broad Product Portfolio:
The lipids produced by algae can be used to produce 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

Challenges to Commercialization

Algal biofuels are not economical to produce using the technology available today. Based on conservative estimates, algal biofuels produced in large volumes with current technology would cost more than $8 per gallon (in contrast to $4 per gallon for soybean oil today). Lowering this cost will require coordinated R&D across a wide range of technical sectors (listed at right) over the next 5 to 10 years. Although the technical challenges are significant, the broad public benefit of successfully commercializing algal biofuels warrants placing a high priority on the needed research. Particular attention must be paid to the engineering of sustainable microalgal systems and to the regulatory and environmental landscape.

Next Steps

To identify and prioritize R&D needs along the critical path to commercialization, DOE is holding an Algal Biofuels Workshop in Washington, D.C., in December 2008.

NREL and Sandia National Laboratories are working with DOE to plan and conduct this workshop, which will provide input for development of an Algal Biofuels Roadmap.

The roadmap will draw upon the expertise of a carefully balanced group of invited scientists and other experts in the various required disciplines (e.g., biology, systems and process engineering, modeling and analysis, algae cultivation, algal oil extraction and conversion, algal-based co-products, water and land use, policy and regulatory issues, etc.). Input from workshop participants will help define activities needed to resolve uncertainties associated with commercial-scale algal biofuel production. Upon completion of review and concurrence cycles, the resulting roadmap will be made available to the general scientific community in 2009. For updates as this process unfolds, please watch for news on our website: www.biofuels.energy.gov

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 lipid productivity; biochemistry, and regulation of lipid accumulation

Process 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
- Oil extraction technology
- Optimization of specific fuel production processes
- Analysis of algal biofuels for compliance with ASTM standards.

Economic Analysis

- Detailed process analysis
- Potential for value-added co-products
- Resource and siting analysis
- Environmental and social issues
- Environmental impact of large-scale algae farms
- Water usage and process water disposal
- Regulatory issues, especially cultivation of genetically modified algae
- Public awareness and acceptance

For additional information, please contact:

The EERE Information Center
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Visit our website at
www.biofuels.energy.gov

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