

Algal Biofuels R&D at NREL

NREL is involved in several algal biofuels projects in 2009 and 2010, including a series of special projects funded through NREL's Laboratory Directed Research and Development program.

Algal Biofuels Projects and Partnerships

- **Development of Algal Strains**
NREL and Chevron Corp. are collaborating to develop techniques to improve the production of liquid transportation fuels using microalgae. The researchers are identifying and developing microalgal strains that can be economically harvested and processed into finished transportation fuels. Partner: Chevron Corp.
- **Establishment of a Bioenergy-Focused Microalgae Strain Collection Using Rapid, High-Throughput Methodologies**
A seed grant from the Colorado Center for Biorefining and Biofuels is being used to discover new novel microalgae strains that can be used for biofuels and bioproducts applications. Partner: Colorado School of Mines.
- **Development of Algal-Based Jet Fuel**
NREL is working with the U.S. Air Force Office of Scientific Research (AFOSR) to perform a proteomics analysis of an oil accumulating green algae. This basic research will answer fundamental algal biology questions regarding oil production that could lead to the development of cost-effective, algal-based jet fuel. Partner: U.S. Air Force Office of Scientific Research. For more on algal-based jet fuel, see the proceedings and presentations from the February 2008 NREL/AFOSR Workshop on Algal Oil for Jet Fuel Production: www.nrel.gov/biomass/algal_oil_workshop.html.
- **Development of a High-Performance Computational Framework for Combinatorial Systems Biology**
NREL is constructing chemically detailed metabolic models and parallel software to sample, fit, and optimize network behaviors of algae in the space of model parameters such as enzyme concentrations and kinetic constants. The modeling is focused on biofuel production in the green alga *Chlamydomonas reinhardtii*. Partners: Colorado School of Mines, Carnegie Institute (Stanford), with support from the DOE Office of Advanced Scientific Computing Research and Office of Biological and Environmental Research.
- **Collaboration with Israeli and U.S. Partners to Develop Cost-Effective Algal Biofuels**
This project is designed to:

- Develop cost-effective methods for extracting oil from algal biomass
- Determine the feasibility of using proven thermochemical conversion technologies, such as gasification and pyrolysis, to transform algal residues into fuels and fuel-related intermediates
- Quantify the economic feasibility for algal biofuels scale-up
- Develop cost-effective processes for producing and harvesting algal biomass using open raceway ponds.

Partners: Sandia National Laboratories, Israeli and U.S. industrial partners.

- **Isolation, Characterization, and Preliminary Assessment of Scale-Up Potential of Photosynthetic Microalgae for the Production of Biofuels in the United States and Canada**
NREL is using high-throughput fluorescence activated cell sorting capabilities to isolate algal strains from water samples taken from a variety of northern marine and freshwater habitats. Partners: Sandia National Laboratories, National Research Council of Canada.
- **Development of Methods for High Frequency Transformation of Green Algae**
NREL is developing robust methods for transforming green algal species with exogenous DNA. Partner: Agency for Science, Technology, and Research, Singapore.
- **Technoeconomic Assessment of Algal Biofuels**
This project studies the viability of algae as a biofuels feedstock in the context of resource availability and technoeconomic barriers and opportunities. Partners: DOE, Sandia National Laboratories, Solix, New Mexico State University.
- **Identification of R&D Activities to Accelerate Commercialization of Algal Biofuels**
NREL and Sandia National Laboratories are working with DOE to identify and prioritize R&D needs for commercialization of algal biofuels. The labs and DOE hosted the Algal Biofuels Workshop in December 2008 and invited experts in biology, systems and process engineering, modeling and analysis, algae cultivation, algal oil extraction and conversion, algal-based co-products, water and land use, and policy and regulatory issues. Participants helped draft the roadmap by identifying activities needed to work toward commercial-scale algal biofuel production.

Algae-Based Laboratory Directed Research and Development Projects

Each year, following a competitive process, NREL awards Laboratory Directed Research and Development (LDRD) funding to in-house projects designed to advance NREL's technical competencies. Among the recent LDRD projects are several focused on algal biofuels development.

- **Development of a Comprehensive High-Throughput Technique for Assessing Lipid Production in Algae**
NREL researchers are combining a high-throughput, robotics-based platform with two advanced chemical characterization techniques—pyrolysis-molecular beam mass spectroscopy (py-MBMS)

and near-infrared (NIR) spectroscopy—to characterize lipid production by algal species. The goal is to provide spectroscopic data for multivariate analysis.

- **Use of Digital Gene Expression: Tag Profiling for High-Throughput Transcriptomics in Microbial Strains Involved in Advanced Biofuel Production**

NREL is evaluating the utility of high-throughput transcriptomics analysis of microbial strains relevant to advanced biofuel production using the Illumina Genome Analyzer, a novel gene sequencing technology. Transcriptomics is the study of gene expression patterns that vary with external environmental conditions. This technology will provide NREL with information that can be used for the identification of genes and pathways involved in biofuel production.

- **Development of a Genetic Model for Producing Biodiesel from Cyanobacteria**

NREL is working to establish a genetic model in a cyanobacterium for solar biodiesel production. Cyanobacteria are not currently considered to be good candidates for high density biofuel production because they typically produce carbohydrates as storage products rather than lipids. The goal of this project is to redirect carbon fixed in photosynthesis toward lipid accumulation. This approach involves blocking glycogen synthesis and other non-essential carbon utilization pathways to focus metabolism primarily for triacylglycerol synthesis.

- **Evaluation of Regulated Enzymatic Disruption of Algal Cell Walls as an Oil Extraction Technology**

This project evaluates cell-wall degrading enzymes that can disrupt algal cell walls sufficiently to allow internal oil bodies to escape and be easily harvested. This technology could be a simple and economic option for recovery of lipids from algal biomass, currently a major economic hurdle.

- **Identification of Novel Promoters in Green Algal Species**

NREL is working to identify promoter gene sequences isolated from a green algal species, and is taking advantage of the sequencing information of the chloroplast genome to increase lipid production. This work will expand the genetic tool box for green algal systems.

- **Development of Novel Cyanobacterial Biofuels**

NREL researchers are studying metabolic pathways in a model unicellular photosynthetic microbe to establish strategies to enhance the synthesis of next-generation renewable biofuels. This project is designed to develop a comprehensive understanding of carbon pathways and their regulation in photosynthetic organisms.