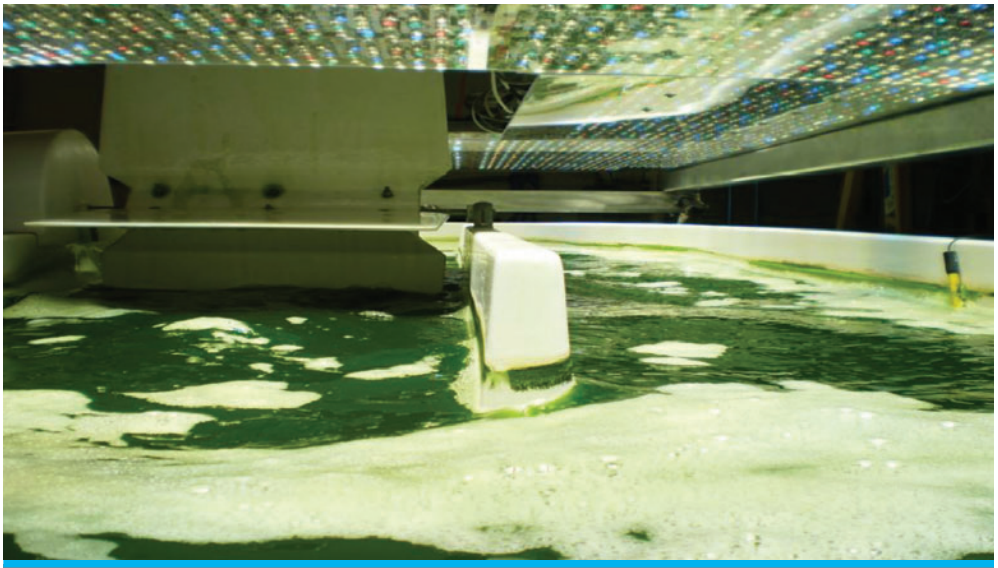
Advanced Algal Systems

Research and development (R&D) on advanced algal biofuels and bioproducts presents an opportunity to sustainably expand biomass resource potential in the United States. The Bioenergy Technologies Office's (BETO's) Advanced Algal Systems Program is carrying out a long-term, applied R&D strategy to lower the costs of algal biofuel production by working with partners to develop revolutionary technologies and conduct crosscutting analyses to better understand the potential and challenges of the algae industry.

The term "algae" refers to a great diversity of organisms—from microscopic cyanobacteria to giant kelp. Most algae convert sunlight into energy in a similar manner to plants; however, the genetic diversity of the many different kinds of algae means there are an incredible number of unique properties that can be harnessed to develop promising algal biofuels and bioproducts. Algal biomass development focuses on identifying or improving those properties, such as a fast growth rate and high oil content, which make algae attractive to convert into biofuels.

Some of algae's unique properties include the following:

- High potential yield per acre
- Ability to grow on land not suited for agriculture
- Ability to grow in saline or waste water
- Absorption of carbon dioxide (CO_2) during growth
- Relative ease of conversion into fuels and products that are fully compatible with today's vehicles, jets, and delivery systems.



PNNL's indoor, LED-lighted, and temperature-controlled climate-simulation raceway pond (Photo courtesy of Michael Huesemann, PNNL)

Sustainability and Analysis

BETO and its partners conduct rigorous techno-economic, resource, and life-cycle assessments to determine the potential for algal biofuels to help sustainably meet BETO strategic goals. The Office aims to validate an algal biofuel production system that cuts greenhouse gas emissions by 50% or greater relative to petroleum baselines, creates socioeconomic benefits, meets water conservation targets, and satisfies federal standards for wastewater and emissions. Conservative analyses support a scenario in which the United States could sustainably produce more than 5 billion gallons of renewable diesel from algae annually by 2030.

Recent algae R&D efforts include studying the use of CO_2 emissions from stationary point sources in algae cultivation designs. Recovering these waste streams could help emitters meet CO_2 reduction targets, while simultaneously serving as a source of added value for algae producers.

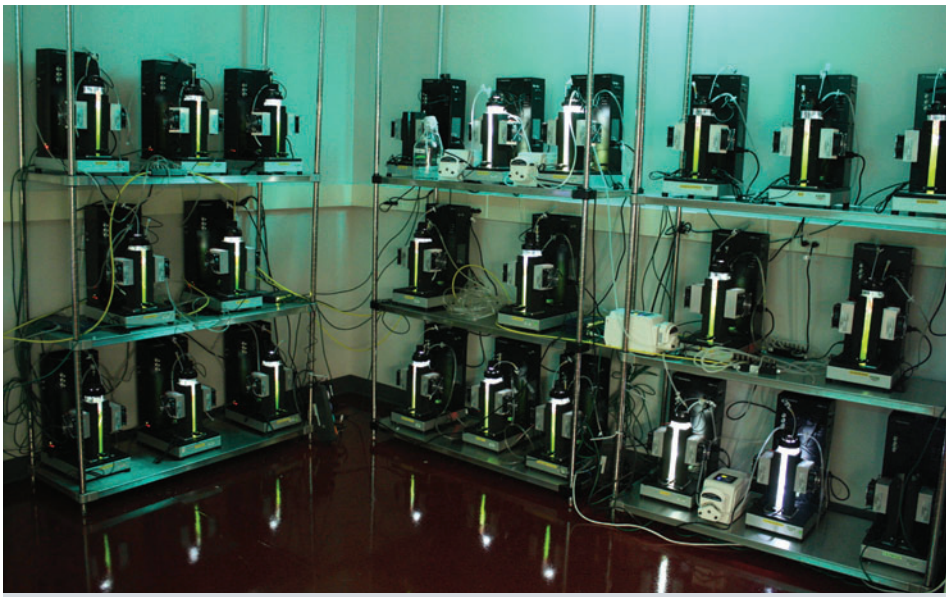
Many developers are also targeting nutrient-rich wastewater to minimize fresh water demand, while supplying necessary cultivation inputs. These approaches could reduce water and nutrient needs, assist in wastewater remediation, and add value to otherwise nonproductive lands.

New biological and engineering approaches are enabling the productive use of an increasing share of algal biomass—boosting process efficiency. In addition to using the stored fats (lipids) in microalgae, researchers are exploring ways to use additional components (such as proteins and starches), secreted compounds (without destroying the cells), or the whole algae biomass of some strains to produce biofuels and bioproducts.

Strategic R&D Planning and Implementation

A significant amount of R&D is still needed for algal biofuels to be cost competitive at a commercial scale. BETO

funds R&D to strategically address challenges along the supply chain—from the application of advanced biological tools, to the extraction and conversion of algal components into biofuels and bioproducts. Working with partners at national laboratories and competitively selected organizations through cooperative agreements, BETO addresses technical barriers, prioritized through stakeholder outreach and engagement, strategic planning and out-year goal setting, and efforts to harmonize technoeconomic, resource assessment, and life-cycle analyses. BETO continually engages with stakeholders through workshops, webinars, meetings, peer reviews, conference participation, and formal requests for information.



The Los Alamos National Laboratory/New Mexico Consortium ePBR matrix

While algae production remains a key challenge in the development of affordable algal biofuels, BETO is demonstrating promising cultivation techniques in open ponds, photobioreactors, and hybrid systems. BETO provided cost-shared funding to study the potential of production systems through pilot and demonstration-scale integrated biorefineries, as well as large R&D consortia to catalyze a new generation of algae scientists and a foundation for R&D programs across the country. Results from this early work made it clear that resource demands are a major consideration in scaling efforts, and the Advanced Algal Systems Program focused funding on semi-integrated technologies for recycling water and external nutrients during algae cultivation. BETO also focused competitive funding on the development of user-facility testbeds for the R&D community. Collaborative open testbeds established a network of facilities for the algal research community and increased stakeholder access to real-world conditions for algal biomass production. Through hands-on learning opportunities, workshops, and seminars held at partner sites and selected public events, the testbeds offer formal and informal education and training in the use of microalgae as feedstock for biofuels and coproducts. These facilities also designed a unified experimental program across different regional, seasonal, environmental, and operational conditions to compare promising production strains at meaningful scales. In 2013 and 2015, BETO announced cost-shared funding aimed at improving cultivation and yield productivities at semi-integrated processes. Funded partners also conduct R&D on improving yield through CO_2 use and crop protection strategies. BETO has acknowledged the important role bioproducts have to play in enabling the biofuels industry, and the Advanced Algal Systems Program recently incorporated product development into its R&D portfolio and technoeconomic modeling.

Algal biofuels R&D has achieved technological advancements that can bring about transformational changes, including the ability to predict, breed, and select the best-performing algal strains; monitor and control system inputs in a dynamic and integrated fashion; harvest algae at high throughputs; and extract and convert more algal biomass components into fuels. The Advanced Algal Systems Program released the *2016 National Algal Biofuels Technology Review* to summarize recent successes and breakthroughs in this field and to document the feasibility and technoeconomic challenges associated with commercial scaling.

Visit bioenergy.energy.gov to find out how to become involved with upcoming algae activities and to learn more about the program.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

For more information, visit:
bioenergy.energy.gov

DOE/EE-1424 • June 2016