Aquatic species, such as algae and seaweeds, offer potential to convert energy from the sun into transportation fuels without harming the environment or impacting the food chain. PNNL is developing tools to enable significant advances in the cost-effective, large-scale production of algae to support lowering U.S. dependence on fossil fuels and reducing greenhouse gas emissions.

**PREDICTING PERFORMANCE OF NEW ALGAE STRAINS**

PNNL uses algal biology to develop new strains and evaluate their potential for high biomass productivity under realistic conditions. We evaluate new strains in our unique climate-simulating pond system to see how they will perform anywhere in the world, at any time and during any season.

**Strain Characterization.** Using a thermal gradient incubator, we determine the strain’s maximum specific growth rate as a function of light and temperature.

**Biomass Growth Modeling.** We have developed a biomass growth model that predicts a strain’s performance in outdoor ponds using species-specific temperature and light response functions determined during strain characterization. The model is also used with PNNL’s Biomass Assessment Tool (BAT) to predict productivity of a given strain in hypothetical outdoor pond cultures at any geographic location.

**Climate-Simulated Culturing.** A strain’s superior performance is validated under climate-simulated conditions before transitioning to outdoor ponds. PNNL has designed LED-lighted, temperature-controlled indoor ponds to cultivate microalgal strains. The ponds use meteorological data and PNNL’s pond water temperature model to reproduce light and water temperature fluctuations at different times and seasons anywhere in the world.

**Testing.** After confirming the high productivity of a selected strain under climate-simulated conditions, the strain is grown in outdoor ponds.

**Converting biomass to fuels and chemicals.** PNNL uses hydrothermal liquefaction to convert concentrated algal slurries directly from the pond to biocrude. Using catalytic processes, we can upgrade the biocrude to finished fuels.

**EXPERTISE AND CAPABILITIES**

PNNL brings a multidisciplinary team of experts, who draw upon resources from across the laboratory, to the challenges of converting algae to fuels and chemicals. Our capabilities include:

**The Biomass Assessment Tool (BAT).** BAT is a unique, high resolution, spatio-temporal modeling framework used to simulate the amount of algal biomass that can be produced in ponds at specific locations. For each location, BAT estimates the biofuel production, associated resource requirements, and costs, including water, land and nutrients. The results can be

**Acceleration the transition to large-scale pond culturing**

PNNL’s integrated strategy for strain screening and testing translates into the following benefits:

- Fast, cost-effective, reliable results regarding performance of promising strains in photobioreactors and raceway ponds.
- Best match between strain and location for large-scale outdoor cultivation systems based on biomass growth models and performance of promising strains in climate-simulated conditions.
- Ability to optimize culture operations by identifying the best culture depth, dilution rate, and harvesting time.
- Fewer problems associated with pilot-scale outdoor pond culturing such as delays, capital and operating expenses, sub-optimal geographic locations, inclement weather, and invasive species.
used to identify the most promising regions for production as well as estimate their production capacity.  

**Biotechnology.** PNNL has extensive experience working with eukaryotic and prokaryotic systems for strain development.

**Conversion technologies.** PNNL can combine thermal and catalytic processes to produce biocrude along with a medium Btu gas, resulting in clean water and nutrients available for recycle.

**Economic modeling.** PNNL uses process and life-cycle analysis, and economic modeling to ensure development of economically, environmentally and technically sound processes that can be successfully transferred to industry.

### DELIVERING IMPACT

The BAT model has helped us redefine where and how much biomass can be grown and it has been used by industry to evaluate commercial applications. In addition, we’re working with industry to pilot and deploy our conversion technologies, which can produce fuel and energy applications. Our industry partners include Genifuel, Corp., and Algenol Biofuels.

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**ABOUT BSEL**  
The Bioproducts, Sciences, and Engineering Laboratory (BSEL) is a multipurpose R&D facility that includes:

- Modern laboratories for fungal strain and bioprocess development and optimization
- 2,500-square-foot high-bay biorefinery for technology scale up
- Analytical chemistry lab equipped with a wide array of analytical instruments.

**ABOUT MSL**  
The Marine Sciences Laboratory (MSL), headquartered at PNNL’s Sequim Marine Research Operations on Washington State’s Olympic Peninsula, is the Department of Energy’s only marine research laboratory. This unique facility and the capabilities of its researchers deliver science and technology that is critical to the nation’s energy, environmental and security future. To learn more about the MSL, visit http://marine.pnnl.gov/.

**COLLABORATIONS**  
PNNL collaborates with multiple industrial partners to keep its research relevant to the needs of industry and to facilitate technology transfer to the public domain. We also partner with world-class regional, national and international universities and have active collaborations with other national laboratories. We continue to leverage our work with the Joint BioEnergy Institute (JBEI), DOE’s National Advanced Biofuels Consortium (NABC) and National Alliance for Advanced Biofuels (NAABB).

**ABOUT PNNL**  
PNNL’s biomass conversion work is an important element in a wider portfolio of research and development funded by the U.S. Department of Energy, other federal agencies and the private sector. PNNL is a DOE Office of Science National Laboratory where interdisciplinary teams advance science and technology and deliver solutions to America’s most intractable problems in energy, national security and the environment. To learn more about PNNL, visit http://www.pnnl.gov/.

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