DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Advancing Commercialization of Algal Biofuels through Increased Biomass Productivity and Technical Integration

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Algae Platform Review

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Goal Statement

BETO's Multi-Year Program Plan Goal

- 2018 demonstrating algal 'biofuel intermediate' productivity of 2,500 gallons per acre per year, on a trajectory to demonstrating 5,000 gallons per acre per year by 2022

Cellana DOE ABY Grant Goal

- Achieve a fully-integrated, high-yield Algae Feedstock Logistic operation system, using the most advanced strain improvement, cultivation, and processing technologies in the proven algae cultivation operations at Cellana's Kona Demonstration Facility (KDF).

Relevance

- Project aligns with BETO MYPP and FOA-DE-811 Priority Area 1-3

Quad Chart Overview

Timeline

- Award Start Date: 09/01/14
- Validation & Go Decision: 12/05/14
- 10% complete
- Project End Date: 9/30/16

Budget (in $ millions)

	FY 10 - 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
DOE Funded	$0	$0	$2,706,000
Project Cost Share (Comp.)*	$0	$0	$1,383,000

Barriers Addressed

- Aft-A Biomass Availability and Cost
- Aft-B. Sustainable Algae Production
- Aft-C. Biomass Genetics and Development
- Aft-D. Sustainable Algae Harvesting
- Aft-H. Overall Integration and Scale-up
- Aft-I. Algae Feedstock Preprocessing

Partners

- Los Alamos National Lab
- Sandia National Lab

Project Overview (1 of 3)

- Cellana is a for-profit entity which operates a 6-acre demonstration level facility located in Kailua Kona, HI, herein referred to as KDF.
- KDF has been operational for 6 years and has produced over 10 tons of algae of various strains using its patented ALDUO™ system.
- Cellana has participated in many DOE and USDA funded algal research projects, most of which are presenting at this review today, including: NAABB, Cornell's Marine Algal Biofuels Consortium, ATP3.
- Participation in these important DOE projects led Cellana to form research collaborations with Los Alamos National Labs (LANL) and Sandia National Labs (Sandia), both of whom are partners on this project.

Project Overview (2 of 3)

Project Objectives

- Priority Area 1: Improve algal biomass productivity
- Priority Area 2: Improve pre-processing technologies
- Priority Area 3: Integration of algal biomass unit operations
    - We intend to leverage Cellana's experience producing at a demonstration scale to identify two strains with potential to reach the goals of the ABY FOA. Strains selected will be suitable for feeding Cellana's commercial product streams:

Biofuels, Animal Feeds, and Nutraceuticals

Project Overview (3 of 3)

Approach

- Novel strains will be identified using a variety of techniques and tested and cultivated at lab-, mid-, and demonstration-scale for their potential to increase biomass and lipid productivity, as well as to lower operational costs.

- Novel strains and the integrated process at demonstration scale will lead the industry toward meeting the 2500 gallon/acre/year biofuel intermediate goal.

Approach (Technical)

DATA Quality Approach

- Quantify all key variables in the manufacturing process, not only the specific lipid and biomass productivity experimental parameters.
- Correlating manufacturing variables with test variables will help to assure test data is meaningful and reproducible.
- The goal is to develop yield increases, and also identify the manufacturing specifications and tolerances required to turn promising experimental data into a robust manufacturing process that can reliably be scaled.
- Templates are being used to create uniform, detailed protocols to guide each phase of the study.

Uniformity in methods, data collection, and reporting will help to ensure that data inputs to TEA models are reliable and provide output recommendations that are valid and reproducible at production scale.

Approach (Technical-Priority Area 1)

Improve Algal Biomass Productivity)

Tasks

- Identify & Improve Algal Strains (Cellana/Sandia)
- Microbial Management/Contamination Protection & Control (Cellana/Sandia)
- CO_2 Utilization (Cellana/Sandia)
    - Novel carbon dioxide introduction method
    - Flue Gas Utilization
- Increase Light Utilization (Cellana/Sandia)

Goals

- Increase in lipid and biomass productivity
- Increase in biomass productivity and culture stability
- Improved transfer of carbon dioxide into growth media-
- Improved CO_2 dissolution
- Increase efficiency of CO_2 usage to reduce cost

Approach (Technical-Priority Area 2)

Improve pre-processing technologies

Tasks

- Low-Shear Centrifugation (Cellana)
- Ultrasonic Harvesting (LANL/Cellana)
- Bacterial Flocculation (Sandia/Cellana)
- Supercritical CO_2 Fluid Extraction (Cellana)

Goals

- Harvest Efficiency and Biomass Quality
- Reduction in Capital Cost and Energy Use

Approach (Technical-Priority Area 3)

Integration of algal biomass unit operations

Tasks

- Process Integration
  - Initial Process integration will be developed at lab scale as a guide for scale up.
  - All technologies will be integrated at demonstration scale for verification of an improvement in lipid and biomass productivity and further validation of production cost.

Goals

- Rapid feedback of the effect of experimental results on techno-economics to guide decisions and direct research.
- The TEA model will verify cost reduction and process economics in light of the 2,500 gallon/acre/year goal.

Approach (Management)

Communication Plan/Project Management

- All partners will attend monthly teleconferences with the DOE Program Office, as well as on an as-needed basis via email, teleconference or Skype, partners will have annual review meetings, and will share data via a web-based program and document management systems.
- Decisions: changes in the research plan or statement of project objectives (SOPO) or shifts in milestones or go/no go decisions will be discussed with the DOE Program Office.

Project Management Accomplishments

DOE Activities

- Official Start Date of 9/1/2014
- Budget Reduction/Work scope Exercise Complete

Partner Activities

- Kickoff Meeting Cellana, LANL, Sandia in Kona, HI 9/9/14 - 9/10/14
- DOE affirmed a GO Decision on 12/05/2014
- Executed Material Transfer Agreement with Sandia and LANL 12/30/14
- Protocol development and approval process is in place
- Communication Plan in Place

Technical Accomplishments

Priority Area 1: Improve algal biomass productivity (Cellana/Sandia)

- Mutation and Selection protocols are being finalized, and experiments will begin this month
- Developed a set of stringent nucleic acid extraction protocols to support the complex microbial community analysis needed for developing "probiotic" cultivation communities
- Light utilization experiments initiated in late January 2015

Priority Area 2: Improve pre-processing technologies

- Low-Shear Centrifugation
  - Equipment has been procured and installed to continuously monitor turbidity, flowrate, and power consumption
  - Pond harvest batch record has been modified to accommodate additional operator steps to execute study
  - Analytical plan in place to process samples in a timely manner

Technical Accomplishments

Priority Area 2: Improve pre-processing technologies

- Ultrasonic Harvesting
  - Build upon field test of scaled-up harvester as part of NAABB
  - FY13-14 BETO funding facilitated the development of a new model to guide ultrasonic harvester scale-up, based on combined measurement of algae physical properties and harvester device characteristics.
  - Developed a method to measure the physical properties of algae relevant to ultrasonic harvester and centrifuge performance (e.g., buoyant density, acoustic contrast, size, etc.)
  - Purchased long lead time components (e.g., 1 kW power amplifier) for a scaled-up harvester currently being designed.

Technical Accomplishments

Priority Area 2: Improve pre-processing technologies

- Supercritical Fluid Extraction
  - Experimental protocol has been initiated – served as the basis for the equipment specifications
  - Quotes for equipment have been received and currently in the final stages of selecting vendor
  - Experimental protocol development ongoing and will be based on the equipment purchased

Priority Area 3 Integration of algal biomass unit operations

- A Techno Economic Model is established and being validated

Relevance

BETO MYPP

- All aspects of this project are designed to help the algae industry move forward and achieve its goal: 2018 demonstrating algal 'biofuel intermediate' productivity of 2,500 gallons per acre per year, on a trajectory to demonstrating 5,000 gallons per acre per year by 2022.

Global/USA Impact

- Reduce reliance on fossil based fuels through the commercialization and worldwide expansion of algal-based biofuels.

Cellana/LANL/Sandia

- DOE's funding for algal projects is essential for the industry.
- Cellana and its partners are grateful for the DOE's support.

Summary

Technical Accomplishments/Progress/Results

- Project was initiated on December 5, 2014, and progress is already being made toward goals in all three priority areas.

Relevance

- Achievement of objectives will help BETO achieve its MYPP goal of 2,500 gallons per acre per year by 2018 and will demonstrate that algae products are viable in a bio-based economy.

Future work

- Successful completion of the grant objectives will lead to further development of the technology with DOE and our partners.

Summary

Overview

- Achieve a fully-integrated, high-yield Algae Feedstock Logistic operation system, using the most advanced strain improvement, cultivation, and processing technologies in the proven algae cultivation operations at Cellana's Kona Demonstration Facility (KDF).

Approach

- The approach Cellana is taking is to develop a commercially viable algae production process using a combination of research and techno-economic analysis with the ultimate goal of building profitable algae production facilities.

Additional Slides

Partner Sites

- Cellana's Kona Demonstration Facility
- Los Alamos National Laboratory
- Sandia National Laboratory

Cellana's Kona, HI Demonstration Facility (KDF)

Aerial View of KDF

- 2.5 hectare site in Kona, Hawaii; >25 employees
- ~$20MM facility
- ~1MM liter large-scale cultivation capacity
- Produced ~15 tons of algae biomass since 2010 for testing / biz dev purposes

Los Alamos Acoustic Harvesting Lab Facilities

Program Area: Algae

Unique Facilities and Expertise:

- New Mexico Consortium, Bio-Lab and greenhouse
- Fully equipped molecular biology lab space
- Environmental photobioreactor (ePBR) array
- Mid-scale algae ponds in greenhouse

Sandia

Sandia National Lab Molecular Biology Facilities

Sandia