

2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Industry Partnerships: Mechanisms,
Opportunities, and Success Stories
March 5, 2019

Liz Moore
Technology Manager
Advanced Development &
Optimization

Variety of Funding Programs

- BETO Funding Opportunity Announcement
 - Posted on EERE-Exchange (<https://eere-exchange.energy.gov/>)
 - Grants, Cooperative Agreements
 - Cost Share requirement
 - May be informed by BETO workshops, RFIs
- Direct Funding Opportunities (DFO)
 - Supplementary to consortia
 - AOP between BETO/Lab
 - CRADA or other between Industry/Lab
- Biomass Research and Development Initiative (BRDI)
 - USDA/DOE Joint FOA
 - Technical areas: Feedstocks development, Biofuels and biobased products development, and Biofuels development analysis
 - Cost Share requirement
 - Award may be issued by either agency

Variety of Funding Programs

- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)
 - Managed by Office of Science
 - Potential for follow-on phases
 - Topics complementary to BETO portfolio
 - <https://science.energy.gov/sbir/>
- Technology Commercialization Fund (TCF)
 - Congressionally mandated (EPAAct 2005, Section 1001e)
 - Run by the Department of Energy Office of Technology Transitions
 - TCF Goal: Perform technology maturation with the intent of attracting a private partner that is willing to support the (national lab) technology's commercialization
 - <https://www.energy.gov/technologytransitions/services/technology-commercialization-fund>

Variety of Funding Mechanisms - Other

- DPA Title III Advanced Drop-in Biofuels Production Project
 - Defense Production Act (DPA)
 - MOU between **Department of the Navy**, USDA, DOE
 - Fulcrum Bioenergy, Red Rocks Biofuels
- Small Business Voucher (SBV – program on hold)
 - Target population: small businesses (SB)
 - Provide SBs access to DOE national laboratories (staff & facility resources)

Keep In Touch

- <https://www.energy.gov/eere/bioenergy>

The screenshot shows the top navigation bar of the Energy.gov website. On the left, there is a green bar with "ENERGY.GOV" in white. To the right, there are links for "Energy.gov Offices" and "National Labs", and a search bar labeled "Search Energy.gov". Below this, the "Office of ENERGY EFFICIENCY & RENEWABLE ENERGY" logo and name are displayed, along with "About Us" and "Initiatives" links. A secondary navigation bar contains "SERVICES", "EFFICIENCY", "RENEWABLES", and "TRANSPORTATION". A dropdown menu is open under "BIOENERGY", showing a downward arrow.

The Bioenergy Technologies Office: Advancing a Thriving and Sustainable Bioeconomy Fueled by Innovative Technologies

Bioenergy Technologies Office

SUBSCRIBE TO NEWS

Sign up to receive updates and events from the Bioenergy Technologies Office.

Email:

Panel Members

- Jim Dooley, PhD, PE
Chief Technology Officer
Forest Concepts, LLC
- Andrew Conley, PhD
Director of Metabolic Engineering
Lygos
- Laurel Harmon, PhD
Vice President, Government Affairs
LanzaTech

forestconcepts™

Jim Dooley

jdooley@forestconcepts.com

Forestconcepts.com

3320 W Valley Hwy N. D110, Auburn, WA 98001

Precision feedstock supplier to the emerging bioeconomy

Upstream technology provider for advanced bioprocessing industry

Inventor and developer of innovative bio-based products and materials

Doing business since 1998...

forestconcepts™

PACIFIC NORTHWEST NATIONAL LABORATORY

Fast Pyrolysis Conversion Tests of Forest Concepts' Crumbles™ Final Report

PNNL-21256

Daniel Santosa, Alan Zacher, David Eakin
March 30, 2012

Techno-Economic Analysis of Forest Concepts, LLC Crumbler® Operated Proton Power to Process Crumbles from Hardwood Chips

Neal A. Yancey¹, Damon S. Hartley¹, David James Dooley²

¹ Idaho National Laboratory, Idaho Falls, ID
² Forest Concepts, Auburn, WA

February, 2019



INL is a U.S. Department of Energy operated by Battelle Energy Alliance

Bioenergy Scientists Collaborate with Industry to Convey Feedstock Value, Improve Biomass Conversion Processes

December 10, 2018

Recognizing the importance of enhancing biomass conversion processes for industry, a team of NREL scientists partnered with Forest Concepts to perform detailed thermochemical conversion simulations for biomass feedstocks. The simulations relate feedstock attributes to expected product yields and necessary pyrolysis conversion process conditions. The work by NREL will allow Forest Concepts to better convey the value of their feedstocks to biorefinery customers.



NREL researchers review mesoscale simulations of biomass conversion at NREL's Biomass Surface Characterization Lab. The model combines computational methods and image data to capture the complex behavior of real feedstocks. Photo by Steve Bhowmik/NREL.

Working with Industry to Quantify Impact of Feedstock Characteristics

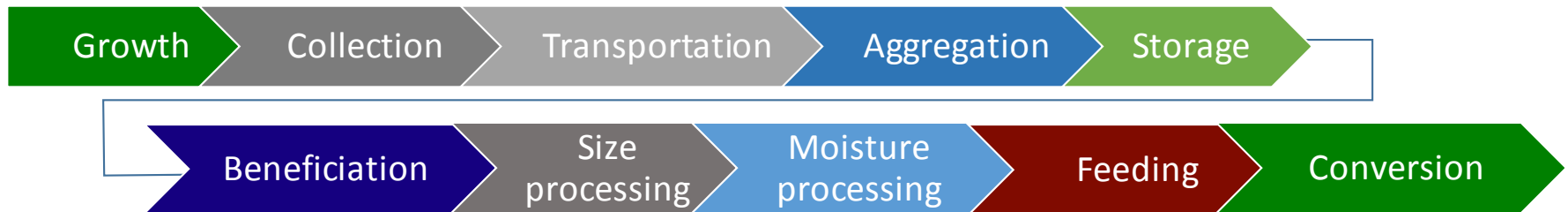
Forest Concepts, a leading manufacturer of precision woody and herbaceous feedstocks for bioenergy and bioproduct applications, leveraged NREL's capabilities in biomass conversion modeling to help them quantify the impact of their feedstock characteristics based on

What are Crumbles[®] Feedstocks?

- Physical properties are optimizable for specific conversion processes
 - Length/ Aspect Ratio
 - Thickness
 - Moisture
 - Uniformity of size
 - Flowability
 - Miscibility with catalysts, ...
- Sheared rather than pulverized



The Biomass Supply Chain



Related Forest Concepts' technologies:

Baling Biomass



Beneficiation



Crumbles® Particles



Advanced Drying



Reactor-Ready Feedstocks



Panel Member Presentations – Forest Concepts

- *Low-Energy Rotary Shear for Sub-millimeter Particle Production (SBIR, Monday Poster)*
- Investigating and Addressing the Wear Issue of the Rotary Shear Biomass Comminution System (FCIC, Tuesday Poster)
- Improved Biomass Feedstock Materials Handling and Feeding Engineering Data Sets, Design Methods, and Modeling/Simulation Tools (ADO A&M, Thursday 11:30 a.m.)

LYGOS

We engineer microbes to produce bio-products

Vision: \$B global biotechnology company specializing in innovative **monomers** and **materials** from renewable feedstocks

Mission: Building the future by replacing petrotech with biotech to make **better** products sustainably

Strategy: Work with **partners** to leverage Lygos' technology platform to quickly bring new molecules to market to create safer products with value-added performance

Execute on commercializing the malonates platform and leverage the platform to **accelerate commercialization** of new product programs





Technology Platform Differentiators

Our competitive advantage comes from our focus on developing a platform with depth, vertically integrated from the microbe through to materials

Low pH Yeast Platform

The microbe enabling production of compounds not readily accessible using other host organisms

Focused on organic acids & malonyl-CoA based chemicals today



DOE SBIR awards

BioFab and Codebase

The physical tools, software, and genetic info needed for high-throughput R&D

Enabling researchers to do more, higher quality work



BETO awards

Machine Learning and AI

A critical tool used to solve complex biological & material problems

We believe value is locked up in the data, not the algorithms



Agile BioFoundry

New Materials Development

A value-multiplier layered on top of the monomer programs

Deliver novel materials addressing performance gaps with current solutions



Panel Member Presentations - Lygos

- *Two-Phase Production of an Organic Acid with CO₂ Sequestration (SBIR, Monday Poster)*
- Implementing a Design, Build, Test, Learn P. Kudriavzevil Engineering Cycle for Production of an Organic Acid Product (ABF, Tuesday Poster)
- Accelerating Engineered Microbe Optimization Through Machine Learning and Multiomics Datasets (BEEPS, Tuesday Poster)
- Fermentative Production of Tricarboxylic Acid Cycle-Derived Chemicals using Cellulosic Sugars (Biochemical Conversion, Wednesday 1:50 p.m.)



LanzaTech

BETO Partnerships

2018 LanzaTech. All rights reserved.

Recycling Carbon



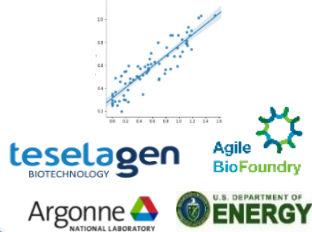
**Industrial Off Gas
Biomass, MSW Syngas**



Case Study: Building a Synthetic Biology Platform For Acetogens

ABF Funding

Modelling & Machine Learning



*Less than 10 years ago,
gas-fermenting acetogens
were considered
genetically in accessible*



TCF Funding

Microfluidics strain construction



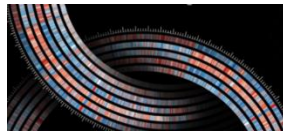
- Reduced footprint
- >10x time savings
- >1000x reagent cost savings

JBEI
Joint BioEnergy Institute

U.S. DEPARTMENT OF
ENERGY

Competitive FOA

Multi-Omics



OAK
RIDGE
National Laboratory

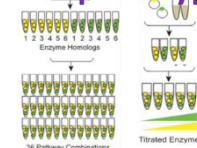
THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

U.S. DEPARTMENT OF
ENERGY

*Today, a suite of tools and
technologies across the
development cycle is
available*

Competitive FOA

Cell-free prototyping

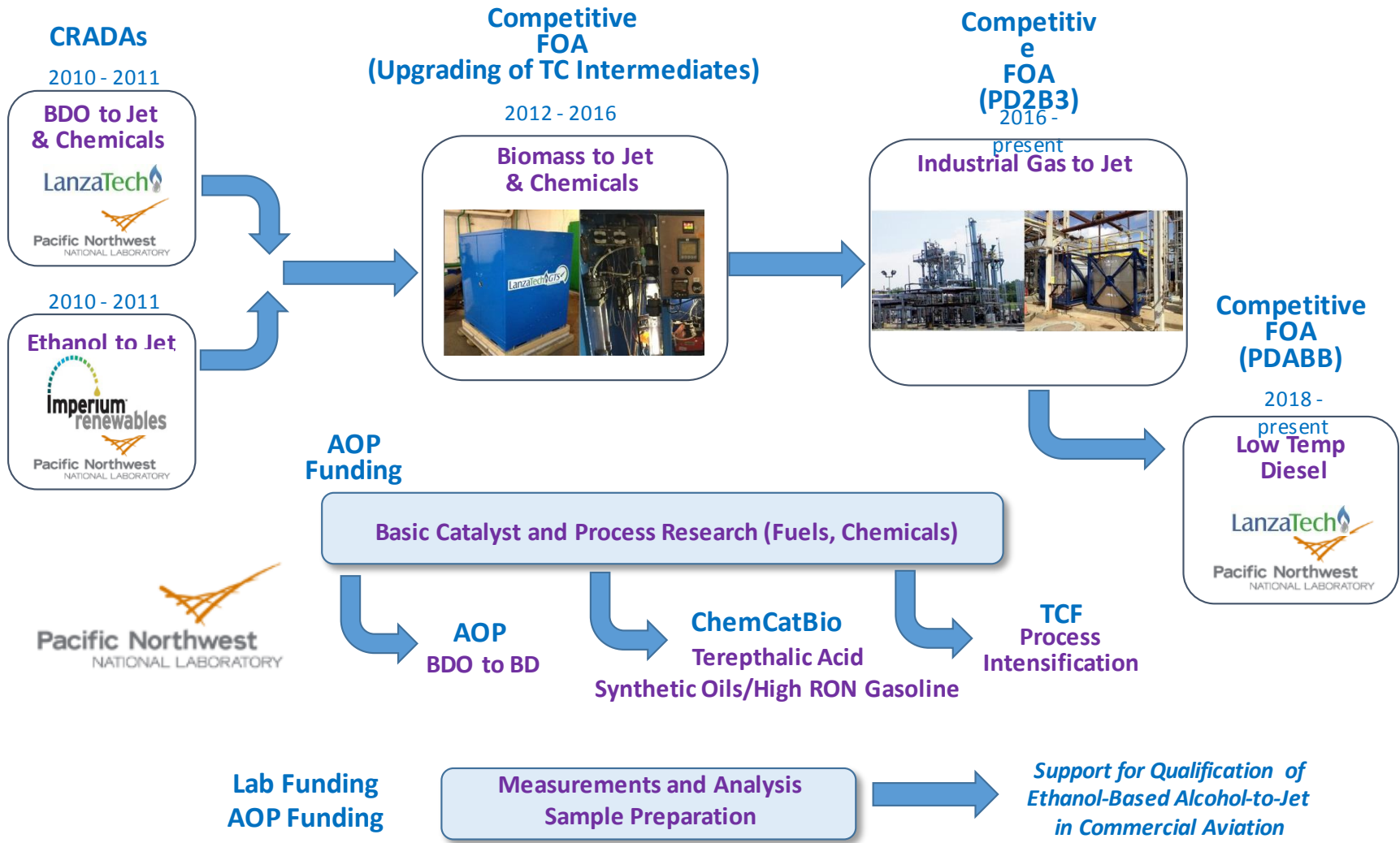


- >20x time savings
- >10x cost savings
- >100x higher throughput

Northwestern
CENTER FOR
SYNTHETIC BIOLOGY

U.S. DEPARTMENT OF
ENERGY

Case Study: History of Ethanol to Jet and Chemicals



Panel Member Presentations - LanzaTech

- Development of a Sustainable Green Chemistry Platform for Production of Acetone (Biochemical Conversion, Wednesday 2:15 p.m.)
- Data Integration and Deep Learning for Continuous Gas Fermentation Optimization (ABF, Tuesday Poster)
- CCB DFAs: Terephthalic Acid Synthesis from Ethanol via p-Methyl Benzaldehyde (Catalytic Upgrading, Wednesday 10:15 a.m.)
- CCB DFAs: Improved Value of the Gasoline and Fuel Oil Co-Product Fractions (Catalytic Upgrading, Wednesday 10:45 a.m.)
- Production of Bioproducts from Electrochemically-Generated C1 Intermediates (BEEPS, Tuesday Poster)
- Ultra-low Sulfur Winterized Diesel (PDABB, Tuesday Poster)