Thermochemical Sciences Conference
November 1, 2016

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Director
Bioenergy Technologies Office
Outline

I. BETO Overview
II. FY16 Conversion Technical Accomplishments
III. FY17 Conversion Activities
IV. Additional BETO Activities
V. Recent Funding Opportunities
VI. 2017 BETO Peer Review
The Challenge and the Opportunity

THE CHALLENGE

- More than $1 billion is spent every three days on U.S. crude oil imports
- Transportation sector accounts for 67% of petroleum consumption and 26% of GHG emissions in the U.S.

THE OPPORTUNITY

- More than 1 billion tons of biomass could be sustainably produced in the U.S.
- 1 Billion tons of biomass could displace 30% of U.S. petroleum use by 2030 and reduce annual GHG emissions by 400 million tons

America’s biomass resources can help mitigate petroleum dependence
Bioenergy Technologies Office (BETO)

**Vision**
A thriving and sustainable bioeconomy fueled by innovative technologies

**Mission**
Developing and demonstrating transformative and revolutionary bioenergy technologies for a sustainable nation

**Performance Goals**
- By 2017, validate at least one pathway for $3/GGE* hydrocarbon biofuel with $\geq$ 50% reduction in GHG emissions
- By 2022, validate at least two additional pathways at pilot or demonstration scale (>1 ton/day)

*Mature modeled price at pilot scale.

**BETO reduces risks and costs to commercialization through RD&D**
Bioenergy Technologies Office’s Core Focus Areas

Program Portfolio Management
- Planning
- Systems-Level Analysis
- Performance Validation and Assessment
- MYPP
- Peer Review
- Merit Review
- Quarterly Portfolio Review
- Competitive
- Non-competitive
- Lab Capabilities Matrix

Research, Development, Demonstration, & Market Transformation

Feedstock Supply & Logistics R&D
- Terrestrial feedstocks
- Advanced Algal Systems
- Supply, Production, and Logistics

Conversion R&D
- Deconstruction and Fractionation
- Synthesis and Upgrading

Demonstration & Market Transformation
- Integrated Biorefineries
- Biofuels Distribution Infrastructure

Sustainability
- Sustainability Analysis and Communication
- Sustainable System Design

Strategic Analysis
- Technology and Resource Assessment
- Market and Impact Analysis
- Model Development and Data Compilation

Strategic Communications
- Public Awareness and Support of Office Goals
- New Communications Vehicles and Outlets
- Benefits of Bioenergy/Bioproducts
FY16 Technical Accomplishments

• Accomplished year end GPRA:
  Complete facility modifications and feedstock preparation required to perform technology performance verifications for 2 pathways in FY17. On the path to these FY17 verifications, technical performance will be demonstrated that reduces modeled mature-plant biochemical conversion cost to $4.97/GGE, down from $6.93/GGE; and thermochemical conversion cost to $3.01/GGE, down from $3.69/GGE.

• 2017 verification progress
  • 200 gallons of FP oil produced from clean pine (NREL)
  • Integrated IDL system built and tested (NREL)
  • Modified R3 reactor installed in TCPDU (ex-situ pyrolysis) (NREL)
  • Regeneration protocols developed for stabilization catalysts (PNNL)
  • Qualified a blended feedstock for the FY17 fast pyrolysis pilot verification run that met requirements for feedstock cost, industrial relevance, and conversion performance (INL)

• Progress toward 2022 goal
  • Technical targets for 4 BC routes identified (NREL)
  • Lipid yields doubled (0.34 - 0.68 g/L) (NREL)
  • New enzyme preparation produces high sugar yields at low loading (10mg/g) (NREL)
  • Lignin depolymerization >50% (NREL)
  • Enhanced DME homologation catalyst stability (NREL)
  • Engineered Pseudomonas putida to increased polyhydroxyalkanoate (PHA) production from DMR-EH lignin by 100% (ONRL/NREL)

• Coprocessing
  • Petrobras-NREL CRADA coming to a close – 3 major publications (NREL)
  • Four analytical methods published for bio-oil characterization (NREL)
FY16 Technical Accomplishments

• Process improvements
  • *T. aurantiacus* modification for enzyme production. (PNNL/LBNL)

• Supporting Technologies
  • ORNL with INL, NREL, developed a reactor model that accounts for important detailed feedstock particle characteristics impacting pyrolysis resulting in accurate prediction of pyrolysis yields in NREL’s 2-inch fluidized bed reactor.
  • Joint ORNL/NREL scientific article in the journal *Energy & Fuels*, entitled “Compatibility Assessment of Fuel System Elastomers with Bio-oil and Diesel Fuel” comparing the compatibility of many typical elastomers materials in alternative and conversional fuel blends
  • Discovered, developed and patented a light gas recirculation method, which when used with previously patented catalytic upgrading technology increases the liquid hydrocarbon yield from ethanol to 90% at moderate temperature and ambient pressure. (ORNL)
  • Completed comprehensive characterization of 50 commercial-type biomass samples. A set of key characteristics were determined related to the biological conversion of sugars pathway using a modeling approach. Models were developed based on chemical properties of multiple biomass resources to predict sugar release from dilute-acid pretreatment and enzymatic hydrolysis runs, with ≥85% correlation. (INL)
Replacing the Whole Barrel

• Only ~40% of a barrel of crude oil is used to produce petroleum gasoline

• Reducing oil dependence requires replacing diesel, jet fuel, heavy distillates, and other products

• EERE successfully achieved modeled mature cost goals for cellulosic ethanol in 2012

• EERE shifted its R&D to focus on hydrocarbon “drop-in” biofuels, jet fuels, and bio-based products

• Fuel makes up 76% of the volume of U.S. oil products and is worth $935B

• Chemical make up 17% of the volume of U.S. oil products and worth $812B

_BETO is working to displace the entire barrel of petroleum crude_
**Bioproducts to Enable Biofuels**

**DOE’s Focus for Bioproducts for R&D**

- Innovative approaches for bioproducts:
  - Molecular replacements for petroleum derived chemicals
  - Performance replacements for petroleum derived chemicals
    - Infancy stage – play to the strength of the oxygenated polymers in biomass
  - Lignin and waste streams to value added products (X2 the cost of biofuels on a mass basis)

**AMO Application**

- Industrial
  - Corrosion inhibitors, dust control, boiler water treatment, gas purification, emission abatement, specialty lubricants, hoses, seals
- Transportation
  - Fuels, oxygenates, anti-freeze, wiper fluids, molded plastics, car seats, belts, hoses, bumpers, corrosion inhibitors
- Textiles
  - Carpets, fibers, fabrics, fabric coatings, foam cushions, upholstery, drapes, lycra, spandex
- Safe Food Supply
  - Food packaging, preservatives, fertilizers, pesticides, beverage bottles, appliances, beverage can coatings, vitamins
- Environment
  - Water chemicals, flocculants, chelators, cleaners and detergents
- Communication
  - Molded plastics, computer casings, optical fiber coatings, liquid crystal displays, pens, pencils, inks, dyes,
Bioenergy Technologies Office Pillars

- **Feedstock-Conversion Interface**
- **Co-Optimization of Fuels and Engines (Co-Optima)**
- **Agile BioFoundry (ABF)**
- **Separations Collaboration**
- **Chemical Catalysis for Bioenergy (ChemCatBio)**
**Objective:** Move cost-effective, high-performing separations technology to market faster through coordinated separations research at the national laboratories that targets challenges relevant to BETO’s priority pathways and industry.

**Motivation:** Stakeholder input has highlighted the need for cost-effective separations technologies.

**Approach:** Interlab consortium working together to develop new technologies for to meet cost goals and improve process robustness of biofuel pathways. Supported by industrial advisory board that reviews progress and development in project.
The Agile BioFoundry will halve the time and cost and reduce the risk of bringing new, bio-derived chemicals to market by democratizing synthetic biology tools and knowledge. This includes decreasing the Design, Build, Test, Learn (DBTL) design time and scale-up time significantly over current approaches. Not only would these tools allow new companies more advanced starting points but they would vastly expand the variety of chemicals accessible to be profitably made from biomass.
ChemCatBio will bring new catalytic materials to commercial bioenergy applications at least two times faster and at half the cost by leveraging unique capabilities and experts within the DOE National Laboratories.

BETO/Energy Materials Network: ChemCatBio

- Addresses that catalytic materials significantly contribute to the cost of making advanced biofuels
- Streamlined processes for accelerated technological advances
- Builds off the successes of the CPC and Catalysis Working Group

Coordinated resource network with a suite of capabilities for advanced materials R&D working to solve critical technical bioenergy challenges.
Refinery Integration

• Refinery integration requires the development of a chain of process steps to allow biomass feedstock, and biomass intermediates to be effectively fed to a conventional petroleum refinery.
  – Through this integration energy and chemicals will be co-produced.

• Refinery integration will allow for seamless integration of bio-refinery co-processing products to the end consumer for products like transport fuels (diesel, aviation jet, gasoline) and chemicals
  – Provides an important stimulus to biomass acceptance and technological development of biomass production routes.
This crosscutting project simultaneously tackles fuel and engine innovation to co-optimize performance of both elements.

The project will provide industry with the R&D needed to:

- Bring affordable and scalable near- and longer-term biofuels and advanced engine solutions to market more quickly
- Reduce petroleum consumption by billions of barrels a year
- Improve fuel economy 15%–20% beyond projected results of existing R&D efforts
- Deliver tens of billions of dollars in cost savings annually via improved fuel economy
- Dramatically decrease transportation sector criteria pollutants and GHG emissions.

Draws on collaborative expertise of two DOE research offices, nine national laboratories, and numerous industry and academic partners.
Defense Production Act (DPA) Initiative

In September 2014, 3 projects were selected under the DPA Initiative to build commercial biorefineries to produce:

- Drop-in fuels for military applications
- Domestic fuels from non-food biomass feedstocks
- Cost-competitive biofuels (w/o subsidies)

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Feedstock</th>
<th>Capacity</th>
<th>Groundbreaking</th>
<th>Off-Take Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMERALD BIOFUELS</td>
<td>Gulf Coast</td>
<td>Fats and Greases</td>
<td>82.0 MM g/yr</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Fulcrum Bioenergy</td>
<td>McCarran, NV</td>
<td>MSW</td>
<td>10.0 MM g/yr</td>
<td>Spring 2017</td>
<td>United Cathay Pacific</td>
</tr>
<tr>
<td>RED ROCK BIOFUELS</td>
<td>Lakeview, OR</td>
<td>Woody Biomass</td>
<td>12.0 MM g/yr</td>
<td>Winter 2016</td>
<td>Southwest Airlines FedEx</td>
</tr>
</tbody>
</table>

Interagency initiative to produce more than 100 million g/yr of advanced biofuels
Analyzing biofuel pathways to quantify progress towards reducing lifecycle greenhouse gases, regulated emissions, and fossil energy use.

Developing strategies and tools for producing biomass feedstocks while maintaining or enhancing soil quality.

Advancing landscape design approaches that increase biomass production while maintaining or enhancing ecosystem services and food, feed, and fiber production.

Assessing the water resource use and water quality of bioenergy production, and investigating opportunities for bioenergy crops to improve water quality.

Investigating relationships between bioenergy crops and biodiversity, and engaging with diverse experts to understand and promote practices that conserve wildlife and biodiversity.

Efforts also include evaluating sustainability indicators across the bioenergy supply chain, contributing to global scientific dialogues on bioenergy sustainability, and engaging with international organizations to understand and promote more sustainable outcomes.
Purpose of Multi Year Program Plan (MYPP)

• Articulate BETO’s mission and goals to internal and external stakeholders
• Provide budget request justification
  – Explain how pieces fit together and build to long term goals
• Operational guide
  – To help the Office manage and coordinate its activities
• 5-10 year planning horizon (2022 goals and beyond)
  – Office goals
  – Technology Area/Program Plans
  – Integrated across programs
  – Regularly updated using change control
EERE Strategic Plan – Vision & Mission

A strong and prosperous America, powered by clean, affordable, and secure energy

To create and sustain American leadership in the transition to a global clean energy economy
BETO Strategic Plan Linkages

**DOE Strategic Plan**
Mission: Enhance U.S. security and economic growth through transformative science, technology innovation, and market solutions to meet our energy, nuclear security, and environmental challenges

**EERE Strategic Plan**
Vision: A strong and prosperous America powered by clean, affordable, and secure energy
Mission: To create and sustain American leadership in the transition to a global clean energy economy

**BETO Vision (2040)**
A thriving and sustainable bioeconomy fueled by innovative technologies

**BETO Mission**
Developing and demonstrating transformative and revolutionary bioenergy technologies for a sustainable nation

**Key Opportunities**
- Bioenergy Value Proposition
- Mobilization of Our Nation’s Biomass Resources
- Bioproducts to Enable Biofuels
- End Use Markets and Customers
- Stakeholder Engagement and Collaboration

**Strategies**

**Strategic Goals**

**Success Indicators**

**MYPP Performance Goals**

**Annual Operating Plan/Project Management Plans**
What is the Bioeconomy?

“The biological sciences are adding value to a host of products and services, producing what some have labelled the “bioeconomy.” From a broad economic perspective, the bioeconomy refers to the set of economic activities relating to the invention, development, production and use of biological products and processes.”


“A bioeconomy is one based on the use of research and innovation in the biological sciences to create economic activity and public benefit.”

White House Bioeconomy Blueprint, 2012

“The U.S. is a world leader in technology and agricultural prowess, which puts it in a powerful position to capitalize on the vast potential of bio-based alternatives to petrochemicals. The potential markets are huge, given the importance of petrochemicals in industrial economies.”

Unleashing the Power of the Bio-economy, 2013

For the purpose of this presentation, the “bioeconomy” is defined “the global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits.”

The Bioeconomy Concept

- Revenue and economic growth
- Broad spectrum of new jobs
- Rural development
- Advanced technologies and manufacturing
- Reduced emissions and Environmental Sustainability
- Export potential of technology and products
- Positive societal changes
- Investments and new infrastructure
Federal Activities Report on the Bioeconomy

• On February 18\textsuperscript{th}, the Biomass R&D Board released the \textit{Federal Activities Report on the Bioeconomy} (FARB).

• This report aims to educate the public on the wide-ranging, federally funded activities that are helping to bolster the bioeconomy.

• The FARB details a vision for a Billion Ton Bioeconomy—tripling the size of today’s bioeconomy by 2030.

• Achieving this vision would provide economic, environmental, and social benefits, including a considerable reduction in GHG emissions.

• The FARB has been promoted through USDA and DOE blogs and social media, and has been picked up by leading bioenergy digests and websites including Biofuels Digest, Renewable Energy World, and Bioenergy Industrial Organization.
Funding Opportunity Announcements

Incubator 2

- Up to $10 million in funding to advance the production of advanced biofuels, substitutes for petroleum-based feedstocks, and bioproducts made from renewable, non-food-based biomass, such as algae, agricultural residues, and woody biomass.
- **Goal:** To make drop-in biofuels more accessible and affordable and meet the cost target equivalent of $3 per gallon of gasoline by 2022.
- Project began work in FY16.

Projects Selected:

- **Arizona State University:** Engineer cyanobacteria for the production of ethyl laurate
- **Arizona State University:** Will develop mixotrophic algae which can consume CO\(_2\) and cellulosic sugars, and significantly improve algal biomass growth
- **Duke University:** Will enable a dramatic reduction in costs for commercial-scale biorefineries through “dynamic metabolic control”
- **Lygos, Inc.** will develop microbial catalysts to convert renewable cellulosic sugars into higher-value commodity and specialty chemicals.
- **White Dog Labs** will develop new metabolic pathways in microorganisms so that they can concurrently consume a cellulosic sugar feedstock and CO\(_2\), thus limiting the amount of CO\(_2\) released from the process.
- **LanzaTech, Inc.** will work on technology to enable manufacturing of the high-value industrial chemical building block, acetone, via biomass-derived syngas.
Recent Funding Opportunity Announcements

Advancements in Algal Biomass Yield Phase II (ABY2)

- On July 14, 2016, BETO announced up to $15 million for three projects aimed at reducing the costs of production of algae-based biofuels and bioproducts through improvements in algal biomass yields.

Selections:

- **Global Algae Innovations Inc.**, in San Diego, California, will accelerate the commercialization of algal biofuels through development of an integrated, photosynthetic, open raceway pond system to produce algal oil. Their approach is to combine best-in-class cultivation and pre-processing technologies with some of the world’s leading strain development laboratories.

- **Algenol Biotech LLC**, in Ft. Meyers, Florida, has formed a team to advance the state of the art in algal production and biofuel processing with the end goal of a sustainable, economically viable biofuel intermediate through enhanced productivity of cyanobacteria, the conversion of the biomass to a biofuel intermediate, and the cost-sensitive operation of a photo-bioreactor system.

- **MicroBio Engineering, Inc.**, in San Louis Obispo, California, will deliver integrated technologies that achieve high yields of biofuels, combined with treatment of wastewater, higher value co-products, and carbon dioxide mitigation.
MEGA-BIO Projects: Bioproducts To Enable Biofuels

- On August 2, 2016, BETO announced $11.3 million for three projects that support the development of biomass-to-hydrocarbon biofuels conversion pathways that can produce variable amounts of fuels and/or products based on external factors, such as market demand.

**Selections:**

- **The Dow Chemical Company** (Midland, Michigan) – The Dow Chemical Company, in partnership with LanzaTech and Northwestern University, will develop a process for the bioconversion of biomass-derived synthetic gas (syngas) to C6-C14 fatty alcohols as a pathway to biofuels.

- **Amyris, Inc.** (Emeryville, California) – Amyris, Inc., in cooperation with Renmatix and Total New Energies, will develop a manufacturing-ready process to produce farnesene, a hydrocarbon building block used in the manufacture of a variety of consumer products ranging from cosmetics to detergents, as well as in the transportation industry for diesel and jet fuel.

- **Research Triangle Institute** (Research Triangle Park, North Carolina) – Research Triangle Institute will partner with Arkema and AECOM to investigate the technical feasibility and economic potential, as well as the environmental and sustainability benefit, of recovering mixed methoxyphenols from biocrude as building block chemicals, alongside the production of biofuels.
FY15 DOE BRDI Selections

• Announced on May 9, 2016 by Dr. Danielson; with total DOE funding of $3M

• DOE Selections
  – The Ohio State University (OSU) – The OSU project is titled “Biomass Gasification for Chemicals Production Using Chemical Looping Techniques.” OSU proposes to develop the biomass to syngas (BTS) chemical looping process for efficient production of value-added chemicals and liquid fuels from biomass. This BTS process is expected to deliver high quality syngas from biomass in a single step, with a potential to reduce capital costs for syngas production by 44% compared to conventional processes.
  – Massachusetts Institute of Technology (MIT) – The MIT project is titled “Improving Tolerance of Yeast to Lignocellulose-derived Feedstocks and Products.” The primary goal of this research is to enhance production of cellulosic ethanol by improving tolerance towards three common inhibitors during cellulosic ethanol production. This same tolerance mechanism is expected to also enhance production of products beyond ethanol, such as monoethylene glycol, an important precursor material used in the production of bottling, fabrics, and anti-freeze.
## FY15 USDA BRDI Selections

### Feedstock Development

<table>
<thead>
<tr>
<th>Institution</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>North Carolina Biotechnology Center</td>
<td>Mid-Atlantic Biomass Sorghum Collaborative to Optimize Agronomic Production and Grower Profitability</td>
</tr>
<tr>
<td>University of Montana</td>
<td>Forest Bioenergy and Biofuels Integration: Sustainability, Energy Balance, and Emissions from Forest Restoration in the Southern Rocky Mountains</td>
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### Biofuels and Biobased Products Development

<table>
<thead>
<tr>
<th>Institution</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>Dartmouth College</td>
<td>Cotreatment of Low-Cost Fermentation of Cellulosic Biomass</td>
</tr>
<tr>
<td>University of California-Riverside</td>
<td>Integrated Biorefinery to Produce Ethanol, High Value Polymers, and Chemicals from Lignocellulosic Biomass</td>
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### Biofuels and Biobased Products Development Analysis

<table>
<thead>
<tr>
<th>Institution</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>SUNY-ESF</td>
<td>Development of Stochastic Techno-Economic and Life Cycle Models for Quantifying the Economic and Environmental Costs of Cellulosic Bioenergy Pathways</td>
</tr>
</tbody>
</table>
## FY16 Release 2 Phase I SBIR/STTR BETO Selections

### Design and Fabrication of Solids Handling for Biomass Conversion Systems

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>Altex Technologies Corporation, Sunnyvale, CA</td>
<td>Innovative Feeding System (IFS) for Biomass</td>
</tr>
<tr>
<td>Shockwave, LLC, Des Moines, IA</td>
<td>Fractionation and Dehydration of Existing Feedstock for Biomass and Biopower Production</td>
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### Liquefaction of Wet Organic Waste Streams using Sub- and Supercritical Fluids

<table>
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<th>Company Name</th>
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<tbody>
<tr>
<td>CF Technologies, Inc., Hyde Park, MA</td>
<td>Supercritical transesterification of brown grease to produce biodiesel</td>
</tr>
<tr>
<td>Dynaflow, Inc., Jessup, MD</td>
<td>Enhanced Subcritical Water Extraction of Biomass From Wet Organic Wastes using Hydrodynamic Cavitation</td>
</tr>
<tr>
<td>Mainstream Eng. Corp, Rockledge, FL</td>
<td>Hydrothermal Liquefaction of Food Waste to Produce Biocrude</td>
</tr>
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### Co-utilization of CO₂ and CH₄ to Produce Biofuel and Bioproduct Precursors

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Project Description</th>
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<tbody>
<tr>
<td>Microvi Biotech Inc., Hayward, CA</td>
<td>Consortium-Based Conversion of CO₂ and CH₄ from Biogas into Butyric Acid</td>
</tr>
<tr>
<td>MOgene Green Chemicals, Saint Louis, MO</td>
<td>Engineered Methanotrophs to Convert CO₂ and CH₄ from Biogas into Bioproducts</td>
</tr>
<tr>
<td>Nexceris, LLC, Lewis Center, OH</td>
<td>Thermochemical Conversion of CO₂ and CH₄ from Biogas to Liquid Fuels Using Superior Catalysts</td>
</tr>
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Recent Funding Opportunity Announcement

Co-Optimization of Fuels and Engines—August 1, 2016

- Up to $7 million in project funding to accelerate the introduction of affordable, scalable, and sustainable high-performance fuels for use in high-efficiency, low-emission engines

**DOE seeks to address:**

- Fuel characterization and fuel property prediction
- Kinetic measurement and mechanism development
- Emissions and environmental impact analysis
- Impact of fuel chemistry and fuel properties on particulate emissions
- Small-volume, high-throughput fuel testing
- Additional barriers

- Eligibility for this FOA is restricted to U.S. Institutions of Higher Education and nonprofit research institutions that operate as a division under the U.S. Institutions of Higher Education.

**Applications were due:** October 17th
Project Development for Pilot- and Demonstration-Scale Manufacturing of Biofuels, Bioproducts, and Biopower (DE-FOA-0001232)

- Up to $90 million in funding for projects focused on designing, constructing, and operating integrated biorefinery facilities that manufacture biofuels, bioproducts, or biopower. The FOA seeks applications for projects to first design (Phase 1), and then construct and operate IBR facilities (Phase 2).

**Topic Areas:**

1. **Pilot-scale production** of biofuels from high-impact cellulosic, algal, or biogas feedstocks. Minimum feedstock throughput is 1 dry metric ton (DMT) per day or equivalent of algal biomass or biogas.

2. **Demonstration-scale production** of biofuels from high-impact cellulosic, algal, or biogas feedstocks. Minimum feedstock throughput must be 50 DMT per day or equivalent of algal biomass or biogas.

3. **Production of biopower or biofuels** from biosolids and other allowable wet-waste feedstocks. Minimum feedstock throughput must be 1 DMT per day.

**Technical Merit Review Date:** Week of 9/12/16
**Selection Planned Sign Date:** 10/17/16
**Selection Announcement Planned Date:** 10/31/16
BETO Requests For Information

BETO is seeking input or recently sought input on:

**Advanced Biofuel Blends in Small Engines**
- The potential to optimize and/or modify small engines to utilize ethanol blends greater than 10% (E10)
- The barriers limiting the expansion of overall biofuel consumption in the small engine industry. The small engines of interest for this RFI are spark-ignition, internal combustion engines

**High Yields through Productivity and Integration Research**
- Supply systems and services for the cultivation, logistics, and preprocessing of algal feedstocks

**Co-Optimization for Fuels and Engines**
- The development of new fuels and engine architectures that are co-optimized
- Perspectives and interest in co-optimization of fuels and engines, 2)
- Technical aspects of fuel and advanced compression ignition (ACI) engine interactions
- Barriers to market acceptance and deployment of co-optimized fuels and engines

**Biofuels and Bioproducts Process Pilot Varication Capabilities**
- Identify existing pilot or process development scale facilities with the capability to perform process verifications for biomass conversion pathways to biofuels, bioproducts or intermediates which integrate multiple unit operations on a scale of approximately 0.5 or greater tons of dry biomass input per day

**Revolutionary Biomass Supply Systems Supporting a Billion Ton Bioeconomy Vision**
- Identify information about current high-technology operations, improved equipment and processes, as well as barriers and solutions associated with the collection/harvest, storage, preprocessing, and transportation of increasing volumes of biomass
The 2017 Peer Review will include simultaneous review sessions of projects across BETO’s technology areas:

Date: March 5-10, 2017
Location: Sheraton Downtown Denver (1550 Court Pl, Denver, CO 80202)

Approximately 90% of projects in BETO’s research, development, and demonstration portfolio will be presented to the public and systematically reviewed by external subject-matter experts from industry, academia, and federal agencies.
Project Partners

Bioenergy Technologies Office

BETO works with partners in industry, universities, and the National Labs
Questions?
Appendices
Advancements in Algal Biomass Yield Phase II (ABYII)

**FOA:** Up to $15 million for projects aimed at reducing the costs of production of algae-based biofuels and bioproducts through improvements in algal biomass yields

**Selections:**

- **Global Algae Innovations Inc.** in San Diego, California, will accelerate the commercialization of algal biofuels through development of an integrated, photosynthetic, open raceway pond system to produce algal oil. Their approach is to combine best-in-class cultivation and pre-processing technologies with some of the world’s leading strain development laboratories.

- **Algenol Biotech LLC** in Ft. Meyers, Florida, has formed a team to advance the state of the art in algal production and biofuel processing with the end goal of a sustainable, economically viable biofuel intermediate through enhanced productivity of cyanobacteria, the conversion of the biomass to a biofuel intermediate, and the cost-sensitive operation of a photo-bioreactor system.

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MEGA-BIO Projects: Bioproducts To Enable Biofuels

- On August 2, 2016, BETO announced $11.3M for three projects that support the development of biomass-to-hydrocarbon biofuels conversion pathways that can produce variable amounts of fuels and/or products based on external factors, such as market demand.

- This funding will develop new strategies for biorefineries, resulting in long-term benefits to the U.S., including chemicals and products manufacturing.

  - **The Dow Chemical Company** (Midland, Michigan) – The Dow Chemical Company, in partnership with LanzaTech and Northwestern University, will develop a process for the bioconversion of biomass-derived synthetic gas (syngas) to C6-C14 fatty alcohols as a pathway to biofuels.

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Co-Optimization of Fuels and Engines—August 1, 2016

- Up to $7 million in project funding to accelerate the introduction of affordable, scalable, and sustainable high-performance fuels for use in high-efficiency, low-emission engines.
- DOE seeks proposals that address one or more of the following sub-topics:
  - Fuel characterization and fuel property prediction
  - Kinetic measurement and mechanism development
  - Emissions and environmental impact analysis
  - Impact of fuel chemistry and fuel properties on particulate emissions
  - Small-volume, high-throughput fuel testing
  - Additional barriers

- Eligibility is restricted to U.S. Institutions of Higher Education and nonprofit research institutions that operate as a division under the U.S. Institutions of Higher Education.
- Applications are closed, selections anticipated in late 2016 or early 2017.

The Co-Optima initiative aims to simultaneously transform both transportation fuels and vehicles in order to:
- Maximize performance and energy efficiency,
- Minimize environmental impact, and
- Accelerate widespread adoption of innovative combustion strategies.
Project Development for Pilot- and Demonstration-Scale Manufacturing of Biofuels, Bioproducts, and Biopower (DE-FOA-0001232)

- Up to $90 million in funding for projects focused on designing, constructing, and operating integrated biorefinery facilities that manufacture biofuels, bioproducts, or biopower. The FOA seeks applications for projects to first design (Phase 1), and then construct and operate IBR facilities (Phase 2).

**Topic Areas:**

1. **Pilot-scale production of biofuels from high-impact cellulosic, algal, or biogas feedstocks.** Minimum feedstock throughput is **1 dry metric ton (DMT) per day** or equivalent of algal biomass or biogas.

2. **Demonstration-scale production of biofuels from high-impact cellulosic, algal, or biogas feedstocks.** Minimum feedstock throughput must be **50 DMT per day** or equivalent of algal biomass or biogas.

3. **Production of biopower or biofuels from biosolids and other allowable wet-waste feedstocks.** Minimum feedstock throughput must be **1 DMT per day.**

**Selections Anticipated Late Fall 2016**
Refinery Integration – Possible Routes

• Utilize processes such as biomass gasification, gas purification, Fischer Tropsch synthesis, hydrocracking and optimal product recovery via distillation/fractionation strategies.

• Develop processes achieving the production of drop-in hydrocarbon fuels, new biofuels, biochemical, bio-intermediates combined with the coker, gas purification, hydrocracking and a fractionation
  – Possible to use bolt-on technologies at new and existing starch and cellulosic plants with combination of other refinery and chemical plant processes, or via integration of other chemical plant process units (e.g. steamcracker).