



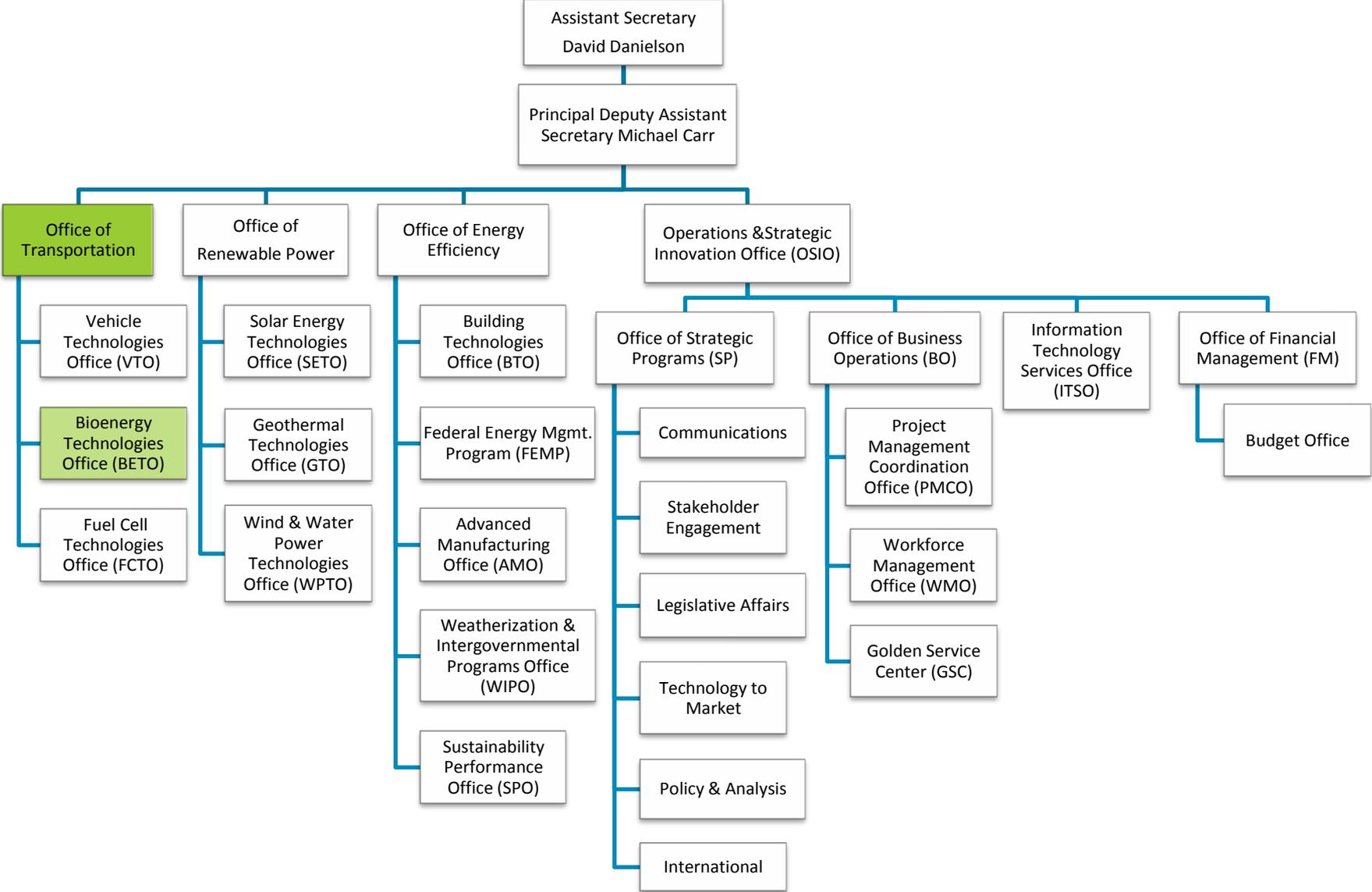
Biomass R&D Technical Advisory Committee

February 27, 2014

Jonathan Male

BETO Overview and 2014 Activities

EERE Organization Chart



New Deputy Assistant Secretary - Transportation

Reuben Sarkar

Deputy Assistant Secretary of Transportation (DAS-T) for EERE

Oversees:

- Bioenergy Technologies Office
- Vehicle Technologies Office
- Fuel Cells Technologies Office

Experience:

- Senior Director for Business Development and Director of Engineering at Proterra, Inc. (a leading start-up manufacturer of electric buses and fast charging stations)
- Lead Design Release Engineer at General Motors working on the electric drive unit for the Chevy Volt

Education:

- University of Michigan in Ann Arbor
 - Bachelor and Master of Science in Chemical Engineering
 - Master of Business Administration



FY13 Accomplishments

Sun Grant Regional Feedstock Partnership

- Commenced in 2007 to support the goal of providing a billion-ton annual supply of biomass
- Partnership includes over 100 feedstock field trials focused on agricultural residues and energy crops.
- A series of meetings were held in 2013-2014 to map crop productivity and contribute data to Oak Ridge National Laboratory's Bioenergy Knowledge Discovery Framework (KDF).



Advanced Logistical Systems and Harvesting Technologies

- AGCO received an award in 2009 to demonstrate an efficient harvesting and transport system for corn stover and other herbaceous feedstocks
- Partners included Stinger, Inc., Poet, Abengoa, Terrebon, as well as National Laboratory and university partners.
- As a result of this project, several technologies were developed, including:
 - Single pass combo Combine-Baler
 - High MOG (Material Other than Grain) Combine.
 - Enhanced Density Large Square Baler



Bioenergy Budget History

	FY 2012 Enacted	FY 2013 Final CR	FY 2014 OMB Request	FY 2014 Congressional Enacted
Feedstocks	35,922	48,500	40,500	47,000
Interface (Production)	1,027	5,000	8,500	5,000
Logistics	5,004	13,500	16,500	12,000
Algae	29,891	30,000	15,500	30,000
Conversion Technologies	105,531	76,809	141,000	101,446
Biochemical Conversion	52,304	35,132	51,700	35,000
Carbon Fiber Initiative	--	--	20,000	8,000
Waste-to-Energy	--	--	5,300	4,846
Incubator Program	--	--	--	5,800
Thermochemical Conversion	53,227	41,677	56,500	37,000
Gasification	--	--	7,500	5,000
Incubator Program	--	--	--	5,800
Integrated Biorefineries	42,897	43,868	78,000	64,829
IBR	42,897	43,868	33,000	19,829
Defense Production Act (DPA)	--	--	45,000	45,000
Analysis & Sustainability	9,951	15,000	13,500	12,154
Systems Analysis	3,980	9,000	5,500	6,084
Cross-cutting Sustainability	3,980	4,000	6,500	6,070
Systems Integration	1,991	2,000	1,500	--
Biopower/Cookstoves	4,975	4,253	4,000	2,000
NREL Site-Wide Facility Support	--	--	5,000	5,000
Total, Bioenergy Technologies	199,276	188,430	282,000	232,429

In thousands of dollars

FY14 Funding Opportunity Announcements (FOA)

Renewable Carbon Fiber – Released on February 3rd

- This FOA seeks to develop a cost competitive pathway to produce high performance carbon fiber for vehicle lightweighting from renewable non-food biomass.
- The objective of the FOA is to identify and develop a cost-competitive technology pathway to high performance carbon fibers using biomass as a starting raw feedstock and biomass derived ACN (bio-ACN) as a target product.
- The goal is to produce bio-ACN at a modeled cost of \$1.00/lb to enable the overall manufacturing of carbon fiber at \$5.00/lb by 2020.

Submission Deadlines:

- Concept Paper Submission Deadline: 3/3/2014 5:00 PM ET
- Full Application Submission Deadline: 4/11/2014 5:00 PM ET

Full FOA information is available on the EERE Exchange: <https://eere-exchange.energy.gov/#Foald9c2b53f7-d61a-45a1-b322-20df23a47d0b>

FY14 Funding Opportunity Announcements (FOA)

Bioenergy Technologies Incubator – Released on February 25th

- BETO issued a FOA for an Incubator Program to support accelerator technologies not currently included in a significant way within BETO's portfolio.
- The FOA will be “open” to any and all impactful ideas which significantly advance the mission of BETO.
- The total amount of funding for the FOA is \$10 million. The estimated period of performance will be approximately 12-24 months, with an award size from \$0.5 million to \$2.0 million, with 20% cost-share.

Informational Webinar will be Monday, March 3, 2014 at 1:00 p.m. - 3:00 p.m. EST

Submission Deadlines:

- Concept Paper Submission Deadline: 3/31/2014 5:00 PM ET
- Full Application Submission Deadline: 5/23/2014 5:00 PM ET

Full FOA information is available on the EERE Exchange: <https://eere.exchange.energy.gov/Default.aspx?Search=DE-FOA-0000974&SearchType=#FoalId28e0ebed-de32-4b3a-97f3-4184df7f5420>

FY14 Feedstock Supply & Logistics Activities

INTERFACE & PRODUCTION (\$5M)

Understand the range of biomass quality attributes across geography and genetics; validate resource assessment projections (i.e., volume) using on-the-ground yield data.

- Biomass R&D Resource Library (>60,000 samples)
- At least five years of production data for several perennial and annual species available through the Regional Feedstock Partnership Program (Sun Grant Universities, USDA ARS, and national laboratories)
 - Cornell University, Oklahoma State University, Oregon State University, South Dakota State University and the University of Tennessee.

Expand integration of environmental sustainability and feedstock quality criteria into biomass supply assessments for herbaceous and woody biomass

- In partnership with Analysis and Sustainability, two workshops focusing on Incorporating Bioenergy into Sustainable Landscape Designs will be conducted to inform future Multi-Year Program Planning

LOGISTICS (\$12M)

Reduce risks associated with supply-security and price volatility

- Initiate blending and formulation strategies that upgrade feedstock quality to meet biorefinery in-feed specifications

Establish path forward for meeting cost, quality, and volume targets; regularly gauge progress

- Delivering techno-economic analysis (TEA) showing pathway to achieve \$80/dry ton for woody feedstocks by 2017
- Annual State Of Technology and Resource Assessment updates

Reducing costs through increasing efficiencies and reducing losses through partnerships with Original Equipment Manufacturers (OEMs) (e.g. AGCO, TigerCat, Case New Holland, etc.)

- Consider alternate(s) from second Advanced Logistics FOA will be awarded



Biomass R&D Resource Library

Data Management System

Accession	Species	Genotype	Location	Year	Harvest	Quality
12-01-001	MS	Stellar	Idaho	A	2012	MS
12-01-002	MS	Stellar	Idaho	A	2012	MS
12-01-003	MS	Stellar	Idaho	A	2012	MS
12-01-004	MS	Stellar	Idaho	A	2012	MS
12-01-005	MS	Stellar	Idaho	A	2012	MS
12-01-006	MS	Stellar	Idaho	A	2012	MS
12-01-007	MS	Stellar	Idaho	A	2012	MS
12-01-008	MS	Stellar	Idaho	A	2012	MS
12-01-009	MS	Stellar	Idaho	A	2012	MS
12-01-010	MS	Stellar	Idaho	A	2012	MS

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

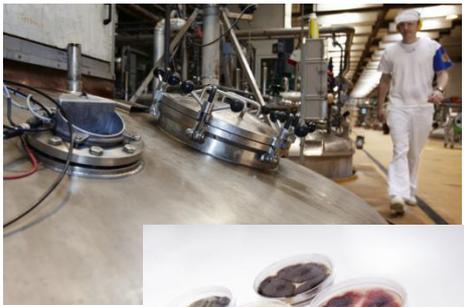
FY14 Biochemical Activities and Direction

Recent Funding Opportunity Announcement (FOA)

- Process Integration (\$34M) (FY11-14)
 - Genomatica, MBI, TEES, Virent
 - Focusing on improvements to Pretreatment, Hydrolysis, Saccharification and Fermentation processes for the economical production of advanced hydrocarbon biofuels and biobased chemicals
 - All stage gates will be completed by Q2 FY14
- Synthetic biology (\$10.5M) (FY12-13)
 - Pacific Northwest National Laboratory, Novozymes, Texas-Agrilife, J Craig Venter
 - Bring to bear the power of synthetic biology to accelerate the biochemical production of specific fuel precursors
 - Initial validations began in Q4 FY13

FY 2014 Activities, New FOAs, and Initiatives

- Utilizing the core competencies of DOE National Labs (\$25M):
 - Complete analysis work to establish new technical targets
 - Advance pretreatment and enzyme hydrolysis
 - Develop breakthrough organisms to produce fuel precursors
 - Enable lignin conversion to high value products
 - Develop separations to enhance yield of desired products
- Renewable Carbon Fibers Initiative FOA (\$8M)
 - Enabling fuel savings through economic renewable carbon fibers
- Incubator FOA (\$11M)
 - Innovative ideas not currently a part of the BETO portfolio
- Waste to Energy (\$5M)
 - Advanced anaerobic digestion



FY14 Biochemical Activities and Direction (Cont.)

Biological and Chemical Upgrading for Advanced Biofuels and Products (BCU) FOA (\$10M)

- Goals: Development, improvement and demonstration of integrated biological or chemical upgrading technology for the production of substitutes for petroleum-based feedstocks, products and fuels.
- Targets
 - Yield of 45gge/ton of biomass
 - Biological, chemical and hybrid (multi step, chemical and biological) upgrading processes
 - Upgrading of cellulosic sugars, lignocellulose derivatives, lignin, biosolids and biogases
- Topic areas: Process development and optimization of:
 - Topic 1 - one or more unit operations for the upgrading of biologically derived intermediates to fuels and products utilizing heterotrophic algae.
 - Topic 2 - a single unit operation for the upgrading of biologically derived intermediates to fuels and products. Single step biological or chemical upgrading processes will be the focus of this topic area.
 - Topics 3 - multiple unit operations for the upgrading and separations of biologically derived intermediates to fuels and products. Hybrid chemical and biological upgrading processes with the integration of separation steps will be the focus of this topic area.

Biosolids: The nutrient-rich organic materials resulting from the treatment of sewage sludge (EPA)

- Approximately 7.1 million dry tons generated annually in the U.S.
 - 55% currently land-applied
 - Minimum potential for 320 million gallons per year based on FOA targets
- Current management options include land-filling, combustion/incineration, and soil amendment
- New options could:
 - Address environmental issues
 - Provide value-added products (fuels, chemical intermediates)
 - Improve biorefinery economics (low cost or “tipping” fee)
 - Reduced potential for water contamination
- Successful technology development could open the door to conversion of other waste materials, e.g. dairy waste, to value-added products
- Life Cycle Assessment needed to understand carbon benefits versus current use

FY14 Algae Activities

Manage Applied R&D in Commercially Relevant Scales:

- Algae Testbed Public-Private Partnership (led by Arizona State University) and Regional Algal Feedstock Testbed Partnership (led by University of Arizona) (FY12 \$15M, FY13 \$8M) – Year 2 activities
- Advancements in Algal Biomass Yield (ABY) Projects (FY13 16.5M) – Year 1 activities
 - Hawaii Bioenergy, Sapphire Energy (NM), California Polytechnic State University, and New Mexico State University
 - Projects have successfully completed validation and are beginning work on integrating R&D on increased biological productivity, efficient harvest and preprocessing, and decreased capital & operating costs



Conduct Data Validation to improve Office Analyses:

- Validate Office techno-economic models using algae biorefinery data (Sapphire Energy and Algenol) in order to inform DOE baseline metrics and better evaluate performer successes (FY14 \$435k)
- Use data at scale to develop techno-economic analyses of promising new technologies – Algal Lipid Extraction and Upgrading, and Whole Algae Hydrothermal Liquefaction (included in National Lab FY14 budget)



Increase Portfolio Diversity:

- Select Algal Biomass Yield (ABY) alternates and co-manage with Conversion an algal- Carbon, Hydrogen, and Separations Efficiencies (CHASE) alternate to increase probability of successful solutions.

Support R&D Breakthroughs: (FY14 \$9M)

- Continue directing R&D at DOE national labs
- Accelerate innovation pipeline with incubator/seed projects to capture potential of currently off-roadmap technologies



Garner Stakeholder Input to Refine MYPP Planning:

- Convened the Algal Biofuels Strategy Workshop Nov 19-20 in Mesa, Arizona, attended by 29 university, 17 national laboratory, 25 industry, 4 advocacy, and 13 government stakeholders
- A second workshop will be held March 26-27 in Charleston, SC
- Plan for refinement of Multi-Year Program Plan based on input from workshops and the 2013 peer review.

FY14 Thermochemical Activities and Direction

FY13 Carbon, Hydrogen, and Separation Efficiencies (CHASE) Funding Opportunity Announcement (FOA) (\$13M original)

- Awardees included: Ceramatec (UT), Oak Ridge National Laboratory (TN), University of Oklahoma (OK), and Virent Inc. (WI)
- Awards target key research challenges:
 - **Carbon efficiency:** developing selective fractionation and separation systems in bio-oil processing
 - **Hydrogen efficiency:** improving H₂ production, use, and transfer in biomass liquefaction and bio-oil upgrading; and
 - **Separations efficiency:** developing technologies for use and mitigation of the aqueous fraction of bio-oil.

FY14 Activities and Initiatives

- Consider awards to two new projects from the CHASE FOA
- Focus Applied R&D with the National Laboratories (\$32.2M):
 - Complete analysis work to establish new technical targets
 - Feedstock interface – uniform feedstock development and characterization
 - Continued improvements in catalyst performance
 - Conversion of carbon in aqueous phase to higher value products
 - Syngas conversion to hydrocarbon fuels
 - Initiated pyrolysis modeling consortium leveraging Office of Science computational capabilities
 - Multi-lab effort on the fundamental modeling of pyrolysis reactions through computational chemistry to enable improved process/reactor design
- Workshop on Refinery Integration Multi-Year Program Planning to enable biofuels to leverage existing refinery infrastructure
 - Tentatively planned for New Orleans, April 4-5, 2014

Updated Pyrolysis Design Case Published



- Completed by PNNL, NREL, INL
- Update incorporates latest published data
- Currently working with ANL regarding LCA and GREET

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23053.pdf

<http://www.nrel.gov/docs/fy14osti/61178.pdf>

2013 Design Case Comparison with 2009 Design Case

- Yield 
 - 106 gal/ton (original)
 - 84 gal/ton (updated)
- NG Consumption 
 - 42 scf/gallon (original)
 - 20 scf/gallon (updated)
- Pyrolysis Area Capex (2011\$) 
 - \$109MM (original) (1x 2000 metric tpd unit)
 - \$279MM (updated) (2x1000 metric tpd units)
 - Updated with published capex from Envergent
- Upgrading Area Capex (2011\$) 
 - \$131(original)
 - \$229 (updated)
 - Added stabilizer & reduced 1st stage LHSV from 1 to 0.5
 - Stabilizer & 1st stage reactors use Ru/C catalyst instead of CoMo/Al

Carbon Recovery Effect on Yield			
	Total hydrocarb on gal/ton	Organic FP oil mass yield on dry wood	HDO hydrocarbon product yield on organic FP oil
Revised 2017	84	62%	44%
Original 2017	106	65%	55%

2017 MFSP

- \$2.59/gge (original)
- \$3.39/gge (updated)

2017 Conversion Cost

- \$1.73/gge (original)
- \$2.47/gge (updated)

Comments from External Reviewers

Area	Comments	Design Report
Capital cost		
Fast Pyrolysis Section	Capital cost is a range of their estimate.	
Hydrotreating Reactors	Capital cost is in a range of their estimate.	
Hydrogen plant	There is less expensive (approx. 25% less) hydrogen package plant available.	Hydrogen plant cost is based on a standard hydrogen package plant in SRI. Sensitivity to the cost is performed.
Yield		
Fast pyrolysis yield	<ul style="list-style-type: none"> ▪ Higher organic yield is 64 - 66 wt% (before filtration) from low ash wood. ▪ 3.3% wt product loss from cold filtration. 	<ul style="list-style-type: none"> ▪ 64% in target case. Sensitivity to fast pyrolysis yield is shown. ▪ 3.1% in target case
Overall yield	Seems low. Depending upon types of biomass, expect to see 82-94 gal/dry ton	We are at 84 gal/dry ton. This could be because of density effect (more diesel in our case). Sensitivity to hydrotreating yield is shown.
Equipment Design		
Biomass dryer	Operated at 320 C (608 F) seems to be too high.	Biomass dryer is designed at 310C (584 F). Flue gas conditions are based on literature for biomass waste heat dryer.
Sand burner	Possibly be difficult to operate at high temperature (non-condensable gas volume can be huge)	Design based on data available in public literature.
Other		
	<ul style="list-style-type: none"> ▪ Costs and yields look fine. ▪ Bio-oil hydrotreater might not be different from traditional hydrotreater in the refineries if the reactor design allows quench streams to efficiently control the exotherm. 	

FY14 Demonstration and Market Transformation

Abengoa Bioenergy, Hugoton, KS

- Expected to produce 25 million gallons per year of ethanol and 18 megawatts of green electricity at full capacity
- Anticipated job creation: 70 during operation and >1,100 during peak construction
- Energy self-sufficient – creates enough heat and power to support itself
- DOE Share = \$100M (EERE) and \$135M DOE loan guarantee; Equity: >\$400 M



POET-DSM Project LIBERTY, Emmetsburg, IA

- Expected to produce 20 million gallons per year of cellulosic ethanol at full capacity
- Anticipated job creation: 35 during operation and >200 during peak construction
- Demonstrates commercial viability of lignocellulose-to-ethanol process
- DOE Share = \$100M; Cost share = \$130M; joint venture with DSM



INEOS, Vero Beach, FL

- Expected to produce 8 million gallons per year of cellulosic ethanol and 6 MW of power from wood and vegetative waste
- DOE Share = \$50M; Cost share = \$82M
- Created 400 construction jobs; 65 permanent jobs are expected for operation
- Major construction began in October 2010, commissioning was completed in June 2013, and the facility initiated commercial production of cellulosic ethanol in July 2013
- First commercial production of cellulosic ethanol in the U.S.



FY14 Demonstration and Market Transformation Activities

Sapphire Energy Inc., Columbus, NM

- Algae to green fuels – jet and diesel
- Demo Scale – 1,000,000 gallons per year
- At scale will utilize ~50+ metric tonnes of CO₂ per day
- Anticipated job creation: 30 during operation and 120 during phase one construction
- Joint development agreement with Phillips 66; expanded their partnership with Linde Group to commercialize a downstream conversion technology; and entered a commercial agreement with Tesoro Refining for the purchase of Green Crude produced in Columbus, NM



American Process, Inc., Alpena, MI

- Feedstock: waste hydrolyzate stream from hardboard manufacturing process (mixed northern hardwood and aspen)
- Capacity: 894,200 gallons/year of cellulosic ethanol and 696,000 gallons/year of aqueous potassium acetate (De-Icer)
- DOE share: \$22,481,523; Cost share: \$8,459,327



FY14 Demonstration and Market Transformation Activities

Myriant Succinic Acid Biorefinery , Lake Providence, LA

- Biochemical conversion of sorghum grits to succinic acid.
- Expected to process 50 dry tons/day to produce 30 Million Lbs/year of succinic acid and gypsum
- Accomplishments to Date:
 - Commissioning with dextrose and sorghum grits
 - Produced / sold succinic acid
- DOE share: \$50,000,000; cost share: \$55,304,038; additional USDA LG & New Market Tax Credits



ICM/Pilot Integrated Cellulosic Biorefinery, St. Joseph, MO

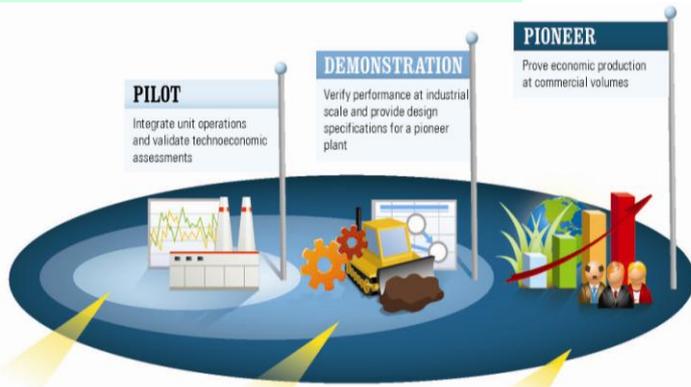
- Demonstrate the proposed process to convert high-impact cellulosic feedstocks (switchgrass and energy sorghum) and captive corn fiber in a process that will pretreat, enzymatically hydrolyze to C5 and C6 sugars, and then ferment to ethanol.
- Expected to produce 28,570 gallons of ethanol/day
- DOE share: \$25,000,000; Cost Share: \$6,272,081



BETO-Funded Demonstration Portfolio

- The Integrated Biorefineries (IBR) program manages a diverse portfolio of demonstration projects focused on the scale-up of biofuels production technologies from pilot- to demonstration- to pioneer-scale.
- Of the total 33 biorefineries that have received funding through BETO, 3 have been completed, 5 are in close-out, and 5 have either been terminated or withdrawn.
- The remaining 20 IBRs are considered active and utilize a broad spectrum of feedstocks and conversion techniques.

Map of BETO-funded Demonstration Projects



For more information visit:

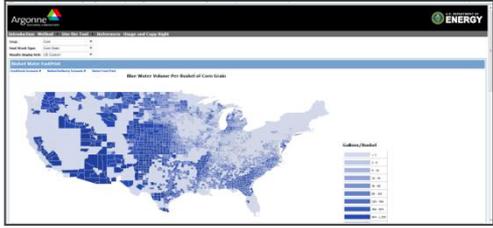
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

Note: 4 iPilot Projects do not appear on this map

FY14 Analysis & Sustainability Activities

Deepen understanding of markets, opportunities, and policy interactions (\$3.5M)

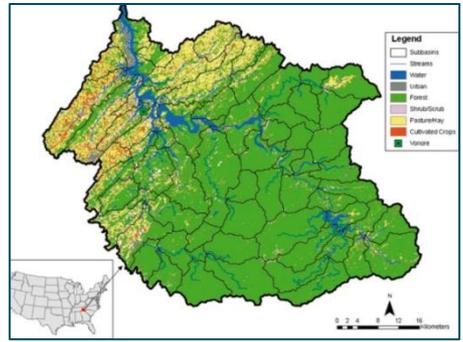
- Update biomass resource assessments and initiate annual BETO market assessment of advanced biofuels and bioproducts
- Assess opportunity for high octane fuels (e.g. E30-E40) to increase markets for biofuels.
- Complete evaluation of the effect of ethanol RIN credit prices on biomass feedstock prices utilizing currently available data.



WATER Analysis Tool - Argonne National Laboratory (ANL)

Enhance integrated techno-economic and life-cycle analysis (\$2.5M)

- Conduct techno-economic analysis of new hydrocarbon fuel pathways; assess technical and economic incentives, risks, and uncertainties of refinery integration
- Enhance GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) to maintain it as an industry-standard LCA model; develop aviation and marine fuel pathways



Watershed analysis of Ohio River Basin - ANL

Assess sustainability performance of feedstock and bioenergy production systems through data collection, analysis, and tool development (\$3.5M)

- Deliver a multi-attribute analysis framework for evaluating trade-offs/synergies between environmental and socio-economic sustainability indicators
- Release version 2 of web-based water footprint tool (WATER) that includes new perennial grass pathway
- Develop air emissions targets for seven criteria air pollutants (2013 Sugars to HC design case)
- Disseminate US research on bioenergy sustainability and promote consistent, science-based evaluation through engagement with IPCC, ISO, GBEP, the Roundtable on Sustainable Biomaterials, and others



Bioenergy Crop Workshop, March 2013 in Fairbury, Illinois - ANL

Conduct land-use research and develop landscape design approaches (\$2.5M)

- Continue field research projects testing impact of feedstock production (willow and short rotation pine) on water, soil, and productivity
- Deliver analysis of optimized integrated landscape design that quantifies improved environmental (GHG, water, soil) and economic performance compared to traditional management
- Host two workshops (forestry and agriculture-focused) to assess the state of the science, current research needs, and tools and methodologies for deploying landscape design for bioenergy systems

Defense Production Act (DPA) Initiative

In July 2011, the Secretaries of Agriculture, Energy, and Navy signed an Memorandum of Understanding to commit \$510 M (\$170 M from each agency) to produce hydrocarbon jet and diesel biofuels in the near term. This initiative sought to achieve:

- Multiple, commercial-scale integrated biorefineries
- Cost-competitive biofuel with conventional petroleum (w/o subsidies)
- Domestically produced fuels from non-food feedstocks
- Drop-in, fully compatible, MILSPEC fuels (F-76, JP-5, JP8)
- Help meet the Navy’s demand for 1.26 billion gallons of fuel per year
- Contribute to the Navy’s goal of launching the “Great Green Fleet” in 2016



The first projects selected under DPA are:

★ DOE has a \$45M appropriation for DPA in FY14

Company	Location	Feedstock	Conversion Pathway	Capacity (MMgpy)
	Gulf Coast	Fats, Oils, and Greases	Hydroprocessed Esters and Fatty Acids (HEFA)	94.0
	South Sioux City, NE	Fats, Oils, and Greases	Hydroprocessed Esters and Fatty Acids (HEFA)	65.8
	Western United States	Municipal Solid Waste	Gasification – Fischer Tröpsch (FT)	17.0
	Lakeview, OR	Woody Biomass	Gasification – Fischer Tröpsch (FT)	16.0

Aviation – Accomplishments/Milestones

- Commercial aviation market is currently 20 B gallons/year; CAAFI has set a goal of 1 B gallons/year of alternative jet fuel by 2018.
- BETO staff have played an active role by participating in and providing technical expertise in various high-level aviation activities including:
 - Co-hosted with Federal Aviation Administration (FAA) and CAAFI the Aviation Biofuels Techno-Economic Analysis Workshop, November 2012. (Follow-up workshop being planned for September 2014, BETO goal for preliminary cost targets for jet fuel by December 2014.)
 - Serves on the CAAFI Steering Group and participates in monthly calls.
 - Under Secretary Michael Knotek served as a keynote speaker at CAAFI annual general meeting January 28/29, 2014.
 - DOE and FAA are providing leadership roles in National Alternative Jet Fuels Strategy Roadmap effort (Roadmap expected in December 2014)
 - Supports FAA's newly established Center of Excellence in alternative jet fuels led by Washington State University/MIT.
 - NREL and PNNL are participants in this Center as are many other organizations and institutions.
 - Increased technical work at National Laboratories to enable achievement of alternative jet fuel goals



References:

1. Incubator FOA: <https://eere-exchange.energy.gov/Default.aspx?Search=DE-FOA-0000974&SearchType=#Foald28e0ebed-de32-4b3a-97f3-4184df7f5420>
2. Renewable Carbon Fiber FOA <https://eere-exchange.energy.gov/#Foald9c2b53f7-d61a-45a1-b322-20df23a47d0b>
3. Updated Fast Pyrolysis Design Report:
http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23053.pdf
4. BETO News and Announcements
<http://www1.eere.energy.gov/bioenergy/news.html>
5. 2013 Peer Review http://www1.eere.energy.gov/biomass/peer_review2013.html
6. Biomass R&D Board <http://www.biomassboard.gov/>