



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Bioenergy Technologies Office –

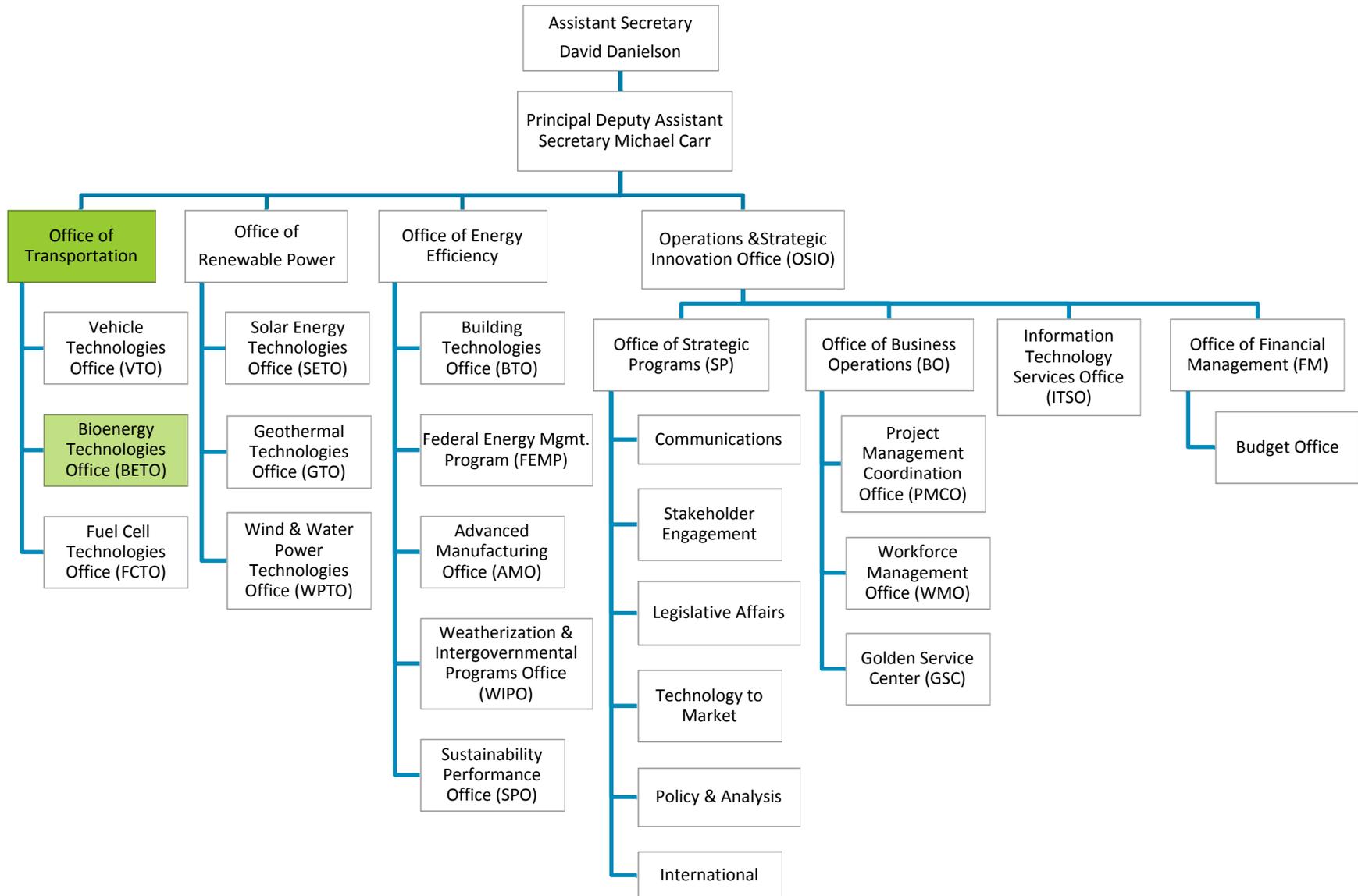
July 24, 2014

[http://www.energy.gov/eere/bioenergy/
bioenergy-technologies-office](http://www.energy.gov/eere/bioenergy/bioenergy-technologies-office)

Jonathan Male

Director

EERE Organization Chart



The Challenge and The Opportunity

The Challenge

- More than 13 million barrels of fuel are required every day to fuel the U.S. transportation sector.¹
- 67% of petroleum consumed in the U.S. is in the transportation sector – at a commercial value of \$350 billion; only 7% of petroleum consumption is in the chemicals and products sector – at a commercial value of \$255 billion.²

The Potential

- Biomass is a leading renewable resource with the potential to provide drop-in replacements for the 11 million barrels per day of petroleum fuels consumed in 245 million existing light and heavy duty vehicles on the road and specifically for air transportation needs (an additional 1 million barrels/day) utilizing existing infrastructure.¹
- The United States could produce more than 1 billion tons of sustainable biomass resources that can provide fuel for cars, trucks, and jets; make chemicals; and produce power to supply the grid.
- By 2030, there is the potential to develop terrestrial biomass resources to displace 30% of U.S. current petroleum usage. This does NOT take into account algae.³

¹ Energy Information Administration, 2012 Energy Review, U.S. Department of Energy, 2013

² Frost, John, Redefining Chemical Manufacture, *Industrial Biotechnology*, Spring 2005
(numbers are assumed to be annual figures for 2004)

³ Update to the Billion-ton Study, U.S. Department of Energy, 2011

Bioenergy Technologies Office (BETO)

Mission

Develop and transform our renewable biomass resources into commercially viable, high-performance biofuels, bioproducts, and biopower through targeted research, development, demonstration, and deployment supported through public and private partnerships.

Strategic Goal

Develop commercially viable bioenergy and bioproducts technologies to enable the sustainable, nationwide production of biofuels that are compatible with today's transportation infrastructure and can displace a share of petroleum-derived fuels to reduce U.S. dependence on foreign oil and encourage the creation of a new domestic bioenergy industry.

Performance Goals

- By 2017, validate at pilot scale at least one technology pathway for hydrocarbon biofuel at a mature modeled price of \$3/GGE with GHG emissions reduction of 50% or more compared to petroleum-derived fuel.
- By 2022, validate hydrocarbon biofuel production from at least two additional technology pathways at pilot or demonstration scale (1>ton/day).

Bioenergy Supply Chain

Objective: Through targeted RD&D, enable sustainable, nationwide production of advanced biofuels that that will displace a share of petroleum-derived fuels, mitigate climate change, create American jobs, and increase U.S. energy security.

Research, Development, and Demonstration at Increasing Scale

Feedstock Supply

Develop sustainable and affordable feedstock supply and efficient logistics systems.



Conversion R&D

Develop commercially viable technologies for converting feedstocks into liquid transportation fuels and products.



Demonstration at Increasing Scale

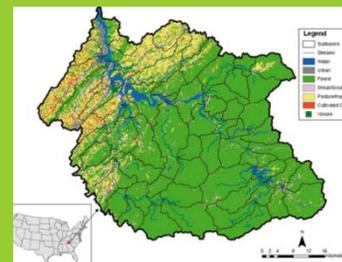
Validate integrated technologies at cost-shared pilot, demonstration, and pioneer scale facilities.



Cross Cutting

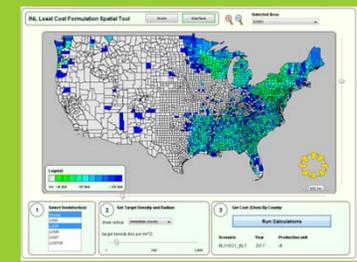
Sustainability

Promote the positive economic, social, and environmental effects of bioenergy.



Strategic Analysis

Conduct market, policy, environmental, and other analyses to inform planning and decisions.



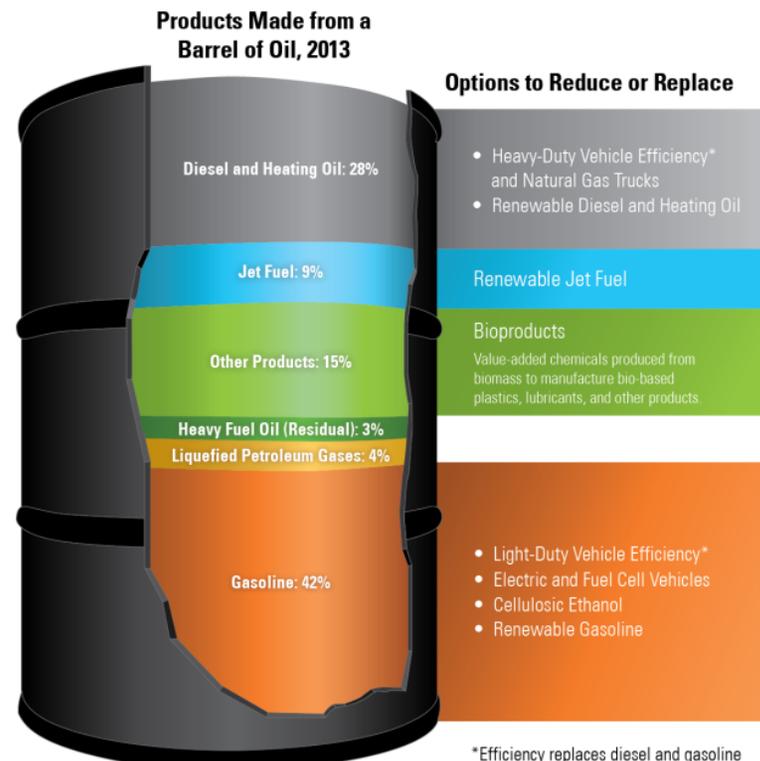
Replacing the Whole Barrel

Greater focus is needed on RD&D for a range of technologies to displace the *entire* barrel of petroleum crude

- U.S. spends about \$1B each day on crude oil imports.*
- Only about 40% of a barrel of crude oil is used to produce petroleum gasoline.
- Biofuels can only displace the portion of the barrel that is made into gasoline.
- Reducing our dependence on oil also requires replacing diesel, jet fuel, heavy distillates, and a range of other chemicals and products that are currently derived from crude oil.

*American Petroleum Institute

Reducing and Replacing Petroleum Use



Source: <http://go.usa.gov/kYqV>

Note: A 42-U.S. gallon barrel of crude oil yields about 45 gallons of petroleum products.

*Efficiency replaces diesel and gasoline because it reduces demand, while providing the same service.

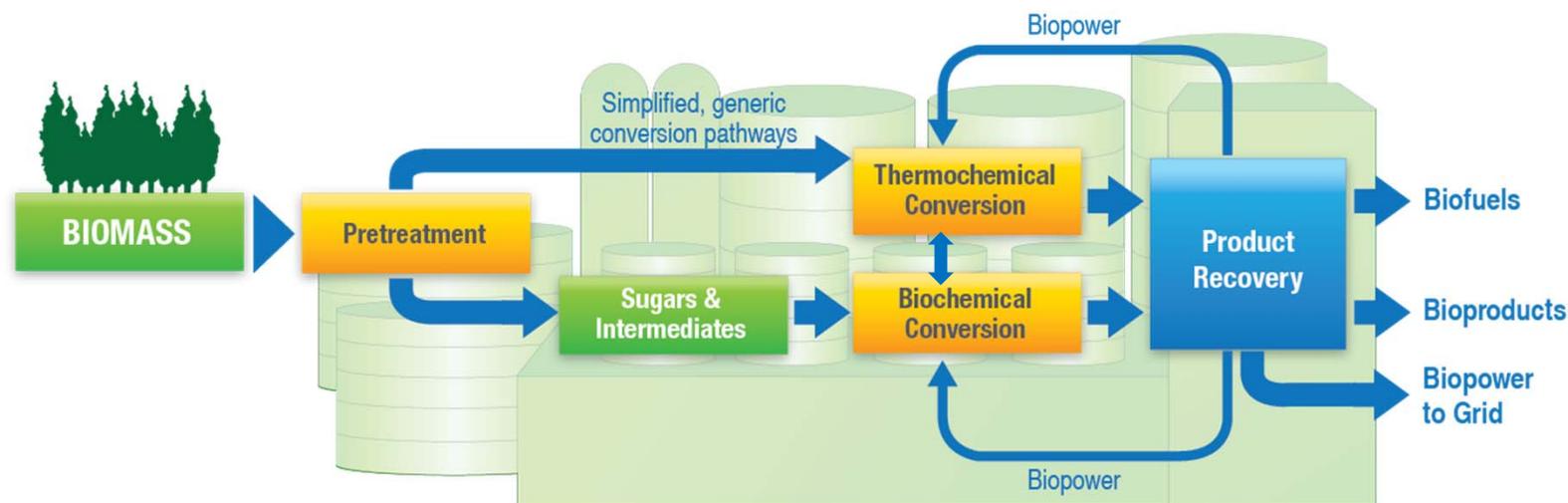
A 42-gallon (U.S.) barrel of crude oil yields about 45 gallons of petroleum products.

Source: Energy Information Administration (2011)

Innovation is Challenging and Involves Risks

De-risking of technologies is central to R&D into and through demonstration, addressing greater integration and scale:

- BETO is focusing on advancing more technologies, including renewable gasoline, diesel, and jet fuels
- Technical, construction, operational and financial/market risks



Biomass Key Challenges

- Reliable supply
- Consistent quality
- Affordable delivery

Pretreatment Key Challenges

- Biomass feeding
- Biomass sizing and moisture
- Solids handling
- Construction materials

Conversion Key Challenges

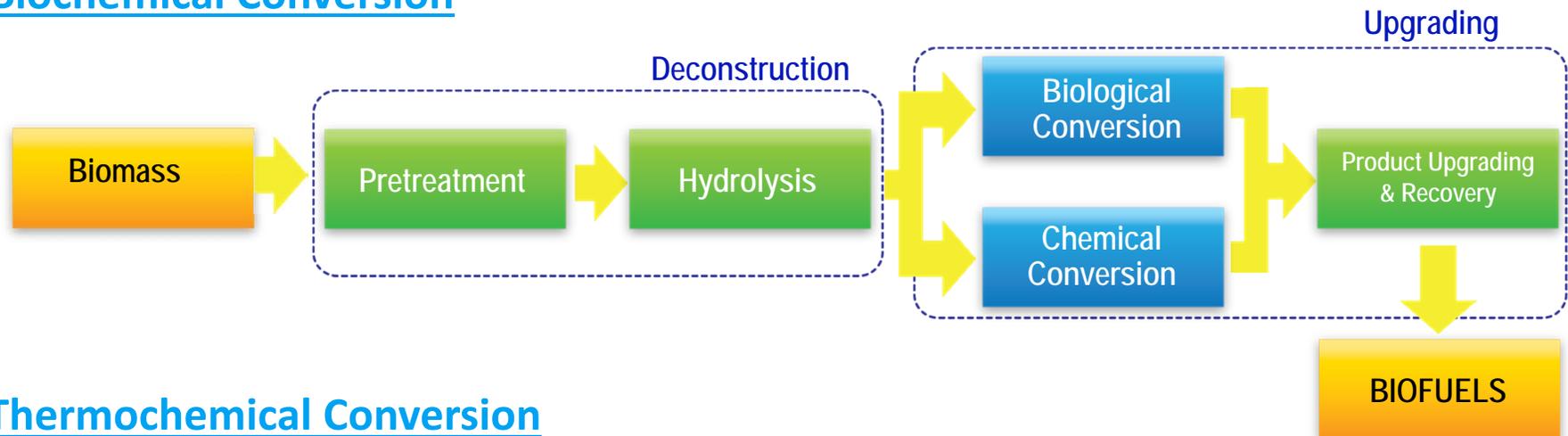
- Products Yields
- Construction materials
- Catalysts
- Fermentation organisms

Product Key Challenges

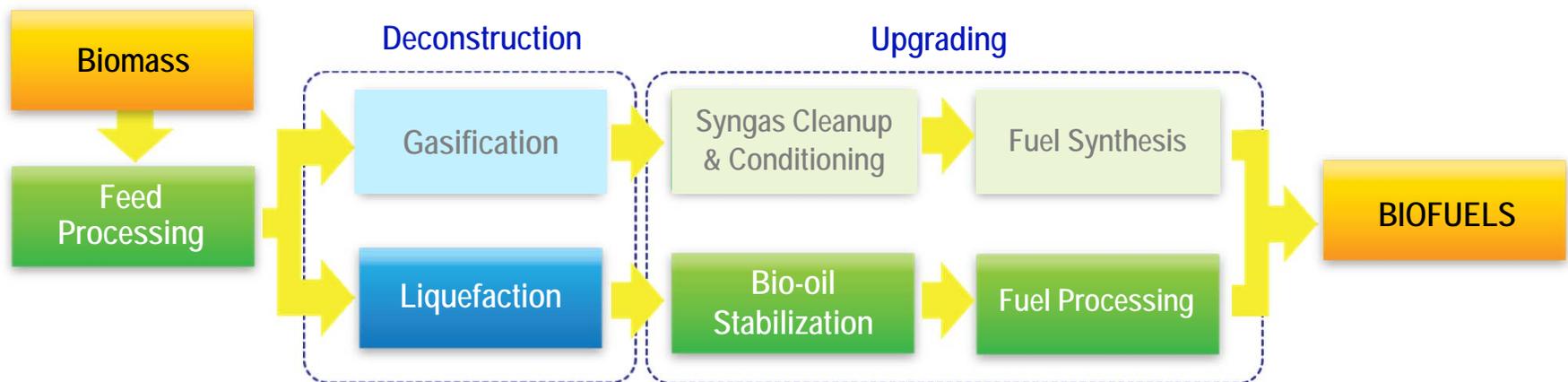
- Separations
- Catalytic upgrading
- Recycle loops

Biomass Conversion RD&D

Biochemical Conversion

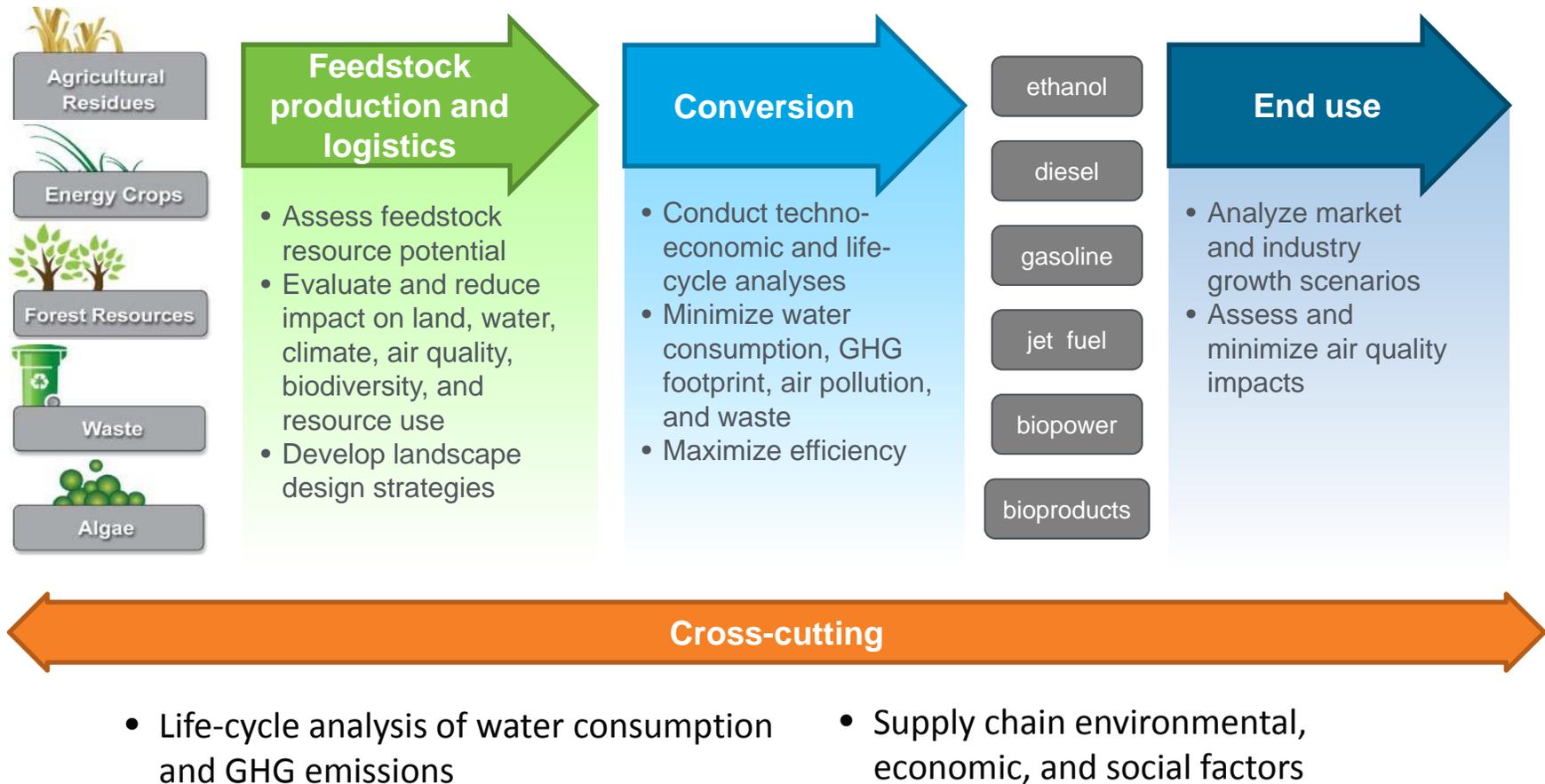


Thermochemical Conversion



Analysis and Sustainability

Identifying and addressing the challenges for sustainable bioenergy production through field trials, applied research, capacity building, modeling, and analysis.



Sustainability Project Highlights

Climate Change and Air Quality



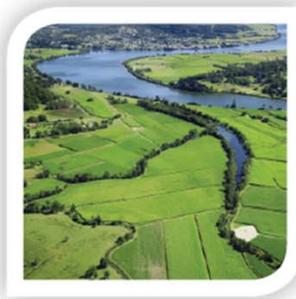
Analyzing biofuel pathways to quantify progress towards reducing [lifecycle greenhouse gases](#), [regulated emissions](#), and [fossil energy use](#).

Soil Quality



[Developing strategies and tools](#) for producing biomass feedstocks while maintaining or enhancing soil quality.

Land Use and Productivity



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

Water Quantity and Quality



Assessing the [water resource use and water quality](#) of bioenergy production, and investigating opportunities for bioenergy crops [to improve water quality](#).

Biological Diversity



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.

Feedstock Accomplishments

Sun Grant Regional Feedstock Partnership

- Network of land-grant universities working in partnership with DOE, industry, national labs, and the U.S. Department of Agriculture to establish over 100 field trials across the country to determine biomass productivity baselines of energy crops.
- Maps of crop productivity contribute data to Oak Ridge National Laboratory's Bioenergy Knowledge Discovery Framework (KDF).

<https://www.bioenergykdf.net/>



Advanced Logistical Systems and Harvesting Technologies

- AGCO (with partners) received an award in 2009 to demonstrate an efficient harvesting and transport system for corn stover and other herbaceous feedstocks.
- As a result of this project, several technologies were developed, including:
 - Single pass combo Combine-Baler (which increased bale density by 15%).
 - High MOG (Material Other than Grain) Combine.



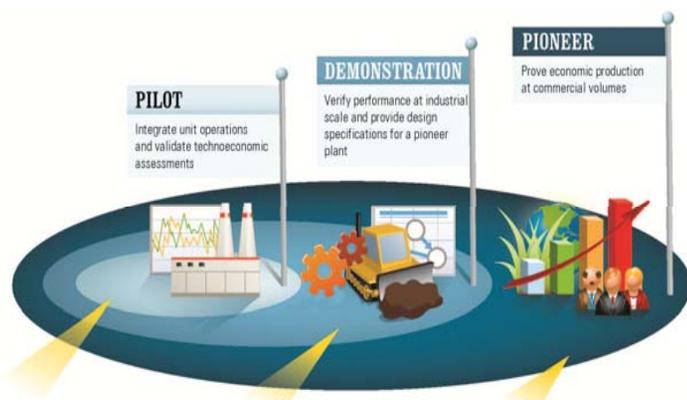
Demonstration Portfolio – Overview

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

Map of BETO-funded Projects



Note: 4 I-Pilot Projects do not appear on this map



Pioneer 
Demonstration 
Pilot 

For more information visit:
http://www.eere.energy.gov/biomass/integrated_biorefineries.html

Demonstration Portfolio – Selected Projects

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
- Mechanical completion is scheduled for July 2014; Commissioning for CY2014
- 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
- Major construction began in November 2012, start of commercial production is scheduled for Q4 FY2014
- 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.



Defense Production Act (DPA) Initiative

In July 2011, the Secretaries of Agriculture, Energy, and Navy signed a Memorandum of Understanding to commit \$510 million (\$170 million 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 (without subsidies).
- Domestically produced fuels from non-food feedstocks.
- Drop-in, fully compatible 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 group of projects selected under DPA are:

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

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

Waste to Energy (WTE)

BETO's Interest in Waste to Energy

- Key Wet Waste Streams to Target in the U.S. of interest in BETO include:
 - Food Scraps: 35.2 million tons wasted in 2014
2014 Opportunity: 71.4 TBtu
2030 Opportunity: 80.5 TBtu
 - Wastewater and biosolids
2014 Opportunity: 27.3 TBtu
2030 Opportunity: 30.8 TBtu
- BETO is interested in potentially supporting technologies that can handle diverse wet waste streams, complementing ongoing work in other agencies and teams focused on dry and single source waste streams.
- Other potential technical interests include: productivity enhancements/cost reductions in the process unit operations associated with anaerobic digestion technology applications, feedstock pre-processing/pretreatment, biogas cleanup/upgrading and methane splitting, effluent refining, digestate stabilization, water recycling, process optimization and control, anaerobic consortia strain identification/culture techniques.

BETO is planning a workshop on WTE technologies in October in order to solicit stakeholder input on industry needs and an appropriate role for the Office.

Upcoming BETO Workshops and Events

Biomass 2014: Growing the Future Bioeconomy

July 29-30, 2014 at Washington Convention Center

- BETO plans to host its 7th annual biomass conference to bring together top government officials and members of Congress—with industry leaders and experts from across the bioenergy supply chain—to continue our ongoing dialogue about the critical challenges and key opportunities for the industry.
- This year's conference will focus on the innovative technologies, priority pathways, financing strategies, and public policies needed to grow the bioeconomy of the future.



STILL TIME TO REGISTER!!

Extra Slides

Commitment to Sustainability

Sustainability Strategic Goal: to understand and promote the positive economic, social, and environmental effects and reduce the potential negative impacts of bioenergy production activities.



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 Fiber Initiative FOA (\$8M)
 - Enabling fuel savings through economic renewable carbon fiber
- Incubator FOA (\$11M)
 - Innovative ideas not currently a part of the BETO portfolio
- Waste to Energy (\$5M)
 - Advanced anaerobic digestion

