BIOENERGY TECHNOLOGIES OFFICE

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

Biological and Environmental Research Advisory Committee

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Outline

I. Overview
II. Innovation versus Invention
III. Key Accomplishments FY12-13
IV. FY14 Budget and Current Funding Opportunities
V. FY14 Activities by Program Area
VI. Collaborations with the Office of Science
VII. Upcoming BETO Workshops and Events

The Challenge and The Opportunity

The Challenge

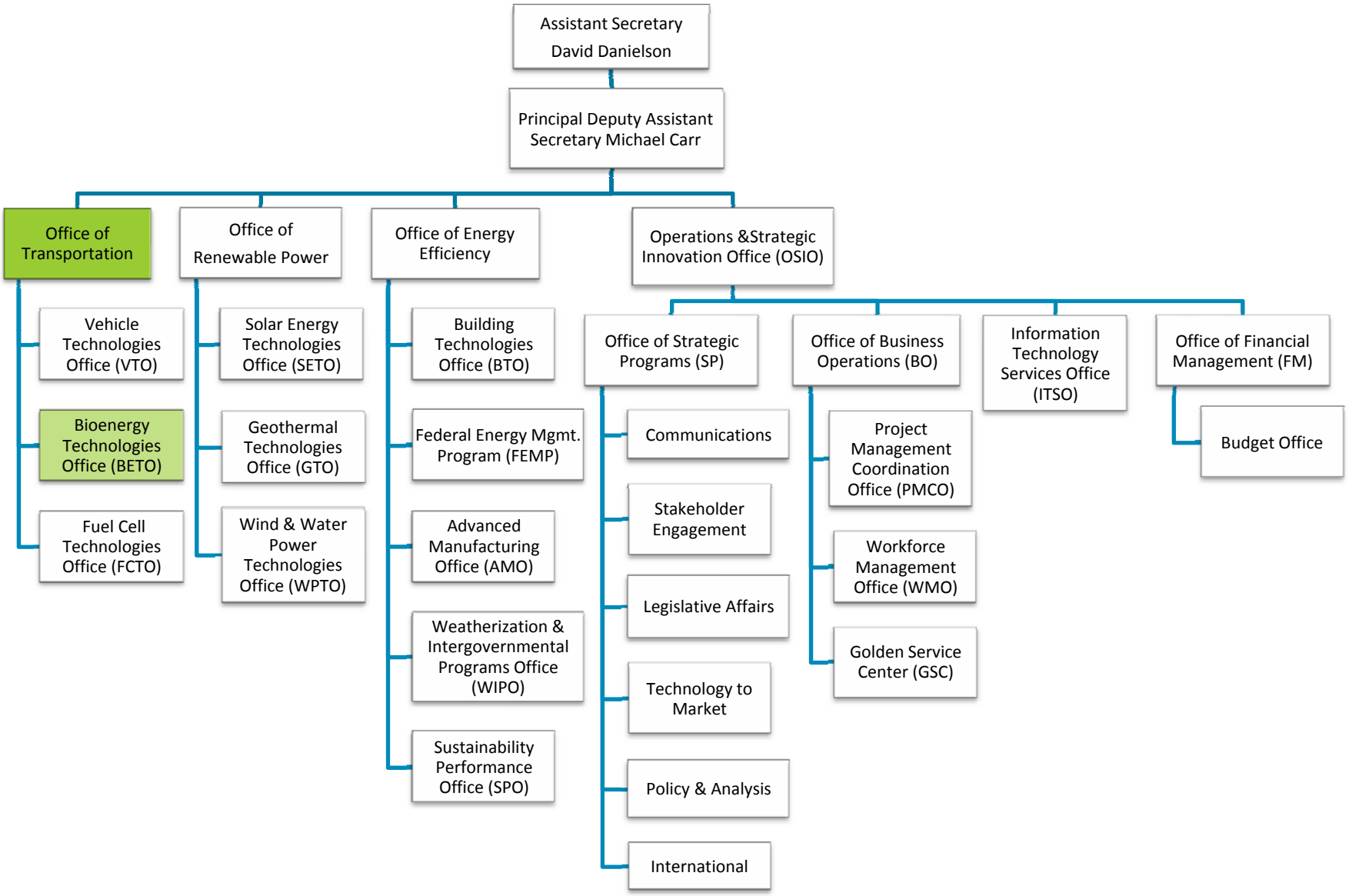
- More than 13 million barrels of fuel are required every day to fuel the U.S. transportation sector[1]
  - Ethanol is blended up to 10% in current gasoline
- Approximately 10% of U.S. crude oil imports are used to make chemicals and products such as plastics for industrial and consumer goods
  - Biomass derived chemicals make up 4% of current chemical sales
- Less than 2% of the oil consumed in the United States is used for power generation
  - Biopower electricity generation currently accounts for 1.4% of all electricity generated in the United States.

The Potential

- Biomass is a leading renewable resource with the potential to provide drop-in replacements for the 11 million barrels/day of petroleum fuels consumed in 245 million existing light duty and heavy duty vehicles on the road and specifically for air transportation needs (an additional 1 million barrels/day) utilizing existing infrastructure.
- 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 resource to displace 30% of U.S. current petroleum usage. This does NOT take into account algae.
- Produce advanced bioenergy while maintaining food/feed/fiber production, maintaining ecosystem services, and reducing GHG emissions by at least 50% compared to the fossil fuel it displaces.

1 EIA 2012 Energy Review

EERE Organization Chart



Bioenergy Technologies Office

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 biomass utilization 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 oil and encourage the creation of a new domestic bioenergy industry.

Performance Goals

- Through RD&D, make cellulosic biofuels competitive with petroleum-based fuels at a modeled cost for mature technology of $3 per gallon of gasoline equivalent (GGE) ($2011) based on EIA projected wholesale prices in 2017.
- Help create an environment conducive to maximizing the production and use of biofuels by 2022.
- By 2020, validate the technology and economics for the production of advanced biofuels that reduce GHG emissions by 50% or more compared to petroleum fuel at $3/gge wholesale at scale.

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.

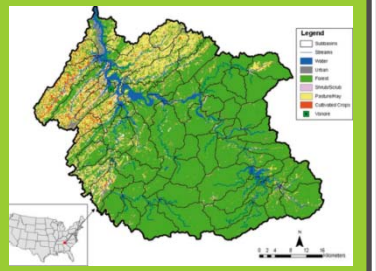
Demonstration at Increasing Scale

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

Cross Cutting

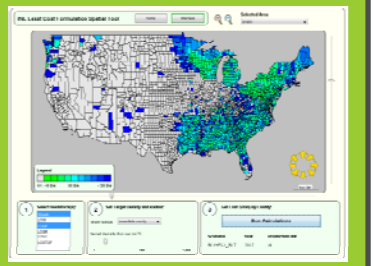
Sustainability

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



Strategic Analysis

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



Assistant Secretary David Danielson's Five Questions

- **HIGH IMPACT:** Is this a high impact problem?
- **ADDITIONALITY:** Will the EERE funding make a large difference relative to what the private sector (or other funding entities) is already doing?
- **OPENNESS:** Have we made sure to focus on the broad problem we are trying to solve and be open to new ideas, new approaches, and new performers?
- **ENDURING U.S. ECONOMIC BENEFIT:** How will this EERE funding result in enduring economic benefit to the United States?
- **PROPER ROLE FOR GOVERNMENT:** Why is what we are doing a proper high impact role of government versus something best left to the private sector to address on its own?

INNOVATION

-- Innovation is central to each question.

Innovation Versus Invention

- Innovation is the improvement of a product or process (often in combination) which creates meaningful social/economic impact

  "The successful translation of 'new ideas into tangible societal impact.''

  - USC Stevens Institute for Innovation

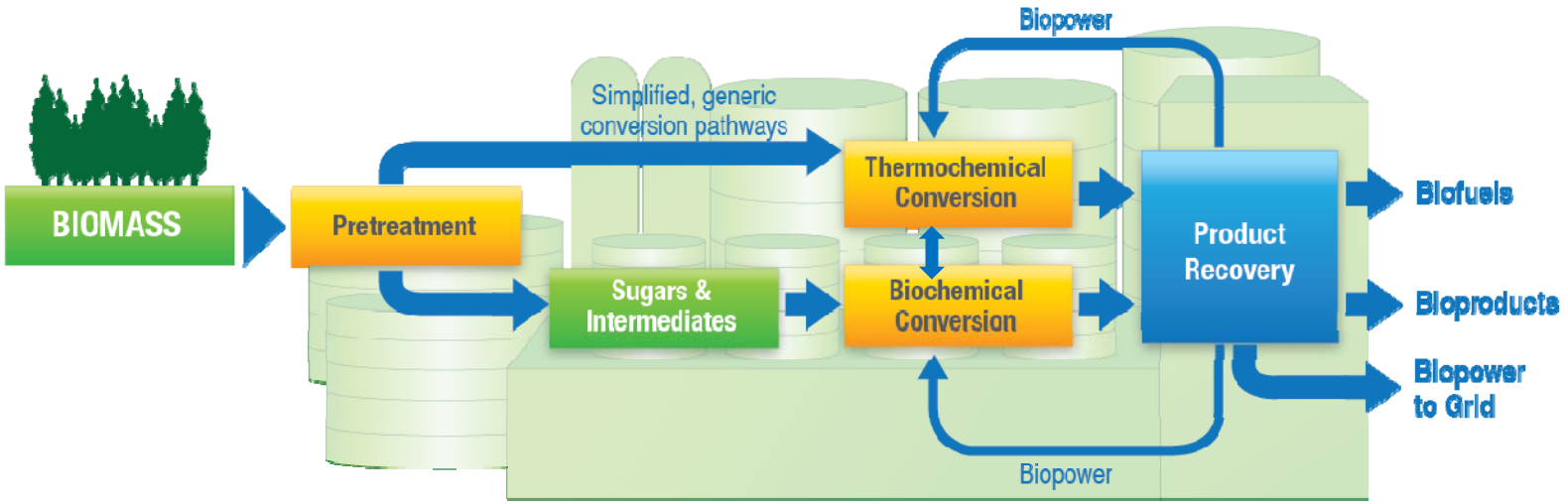
- Innovation often involves:
  - Significant advances along an entire value chain
  - Market demand and public acceptance
  - Correct timing – confluence of historical factors/trends
  - Cross-cutting, interdisciplinary inputs
  - Longer term and significant impacts on economics and culture

- Invention is the starting point for innovation

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

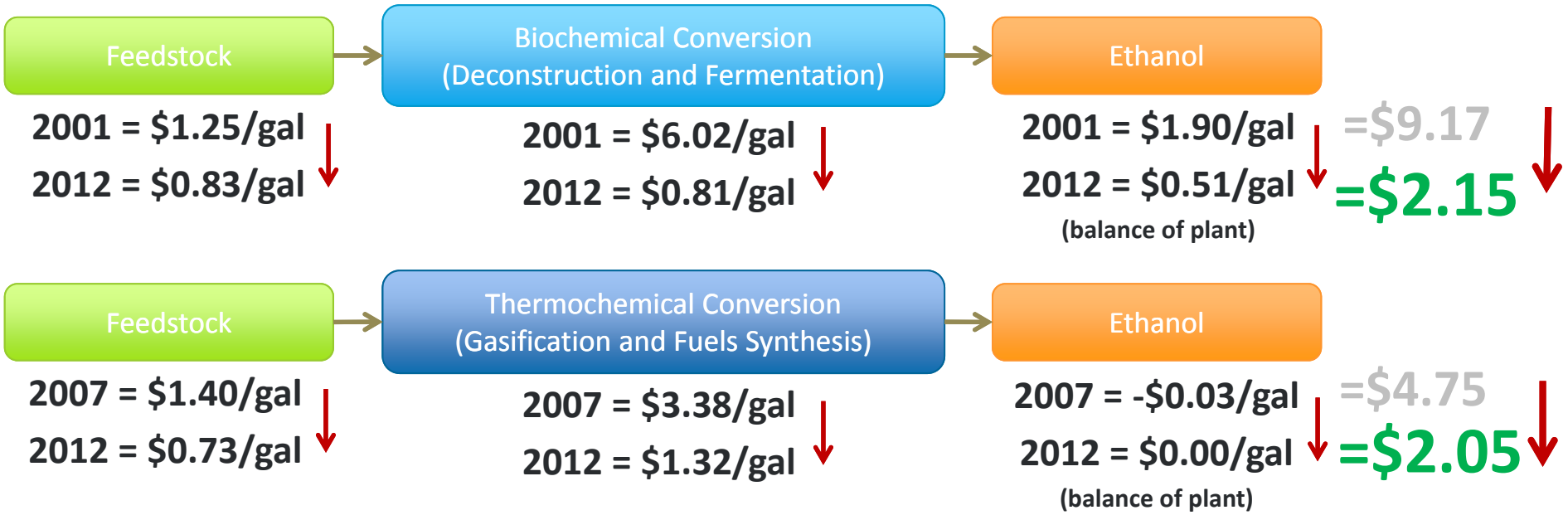


Biomass Key Challenges	Pretreatment Key Challenges	Conversion Key Challenges	Product Key Challenges
•Reliable supply •Consistent quality •Affordable delivery	•Biomass feeding •Biomass sizing and moisture •Solids handling •Construction materials	•Products Yields •Construction materials •Catalysts •Fermentation organisms	•Separations •Catalytic upgrading •Recycle loops

FY12 Key Accomplishment: Cellulosic Ethanol Validations

In September 2012, scientists at DOE's National Laboratories successfully demonstrated feedstock and conversion processes that reduced the cost of production of cellulosic ethanol

- ~90% reduction in enzyme cost through development of new enzymes for biochemical processing ($3.45/gal to $0.36/gal)
- New microbes that can use more sugars (glucose, xylose, arabinose) - from ~50% to >95%
- Improved methane conversion in thermochemical processes - from 20% to 80%

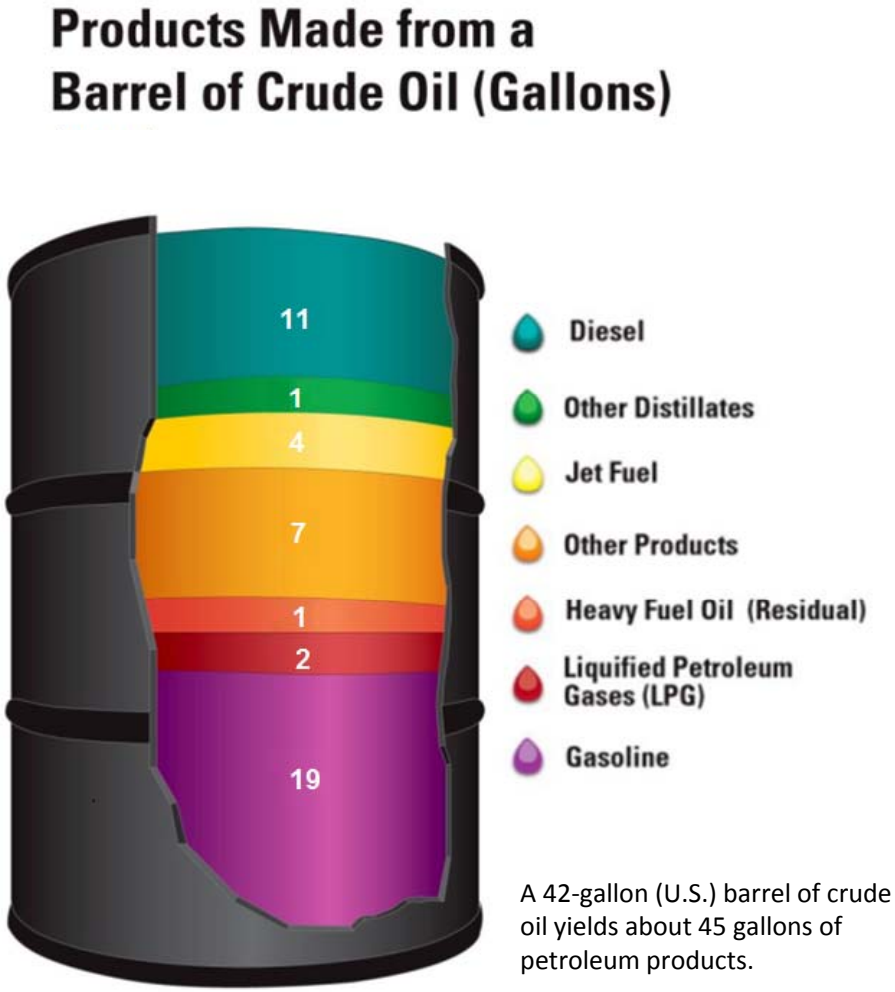


Replacing the Whole Barrel

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



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

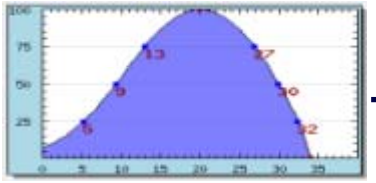
Source: Energy Information Administration (2011)

FY13 Accomplishments - Sun Grant Regional Feedstock Program Data Mapping Process

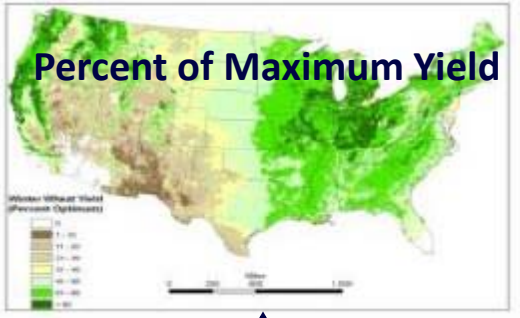
Network of land-grant universities working in partnership with DOE, industry, national labs, and USDA to establish field trials across the country to determine biomass productivity baselines of energy crops.

SSURGO Soil Maps

PRISM Climate Maps



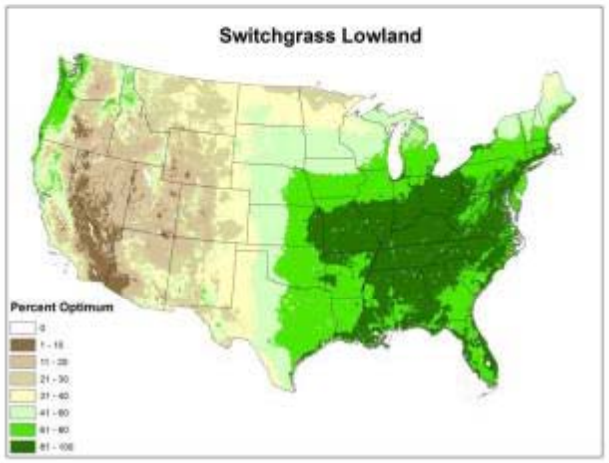
Crop Growth Model



Percent of Maximum Yield

Interface with Crop Experts

Field Trial Data (2008-2012 + historical)



Biomass Yield

Replicate for energy cane, biomass sorghum, *miscanthus x giganteus*, hybrid poplar, willow, pine, and CRP grasses- **Provisional Maps in FY14 Q2**

Partnership includes over 100 feedstock field trials focused on agricultural residues and energy crops

SunGrant INITIATIVE

OSU Oregon State University

PRISM Group

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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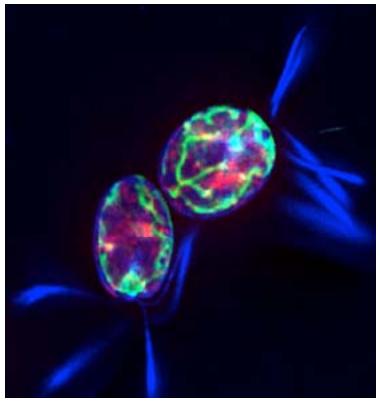
FY13 Algae Program Accomplishments

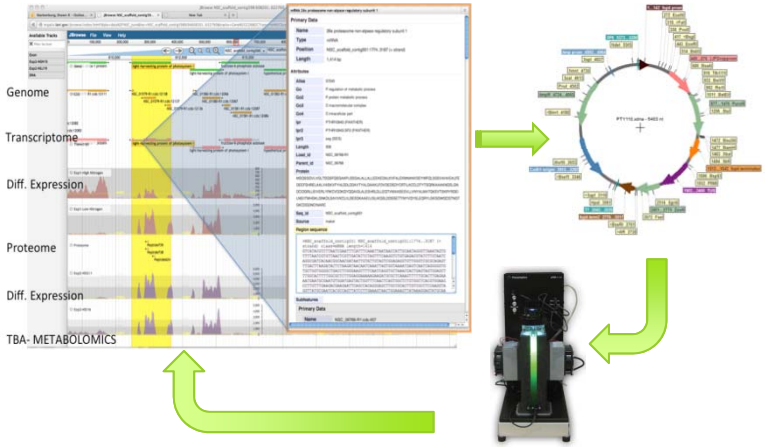


Rainbow Algae: Stacking of multiple traits localized throughout genome with robust expression and targeted protein localization

- High impact demonstration of genetic engineering breakthroughs to allow for the insertion and expression of genes as well as the tagging of proteins throughout the algal cell[1]

Systems Biology for Strain Improvement: Molecular toolboxes for 5 production strains coupled with climate-simulating PBRs

- High-throughput pipeline of genomes and transcriptomes to target genes of interest and evaluate biomass potential in simulated production environments



Whole algae HTL Development: Continuous bench-scale liquefaction, separations, upgrading, and carbon recovery from waste-water for 10 unique algal feedstocks

- Development of a breakthrough design basis that both allows for production of advanced renewable diesel from fast-growing, low-lipid algae and captures >60% of the biogenic carbon in the biofuel

1. Rasala et al (2013). Expanding the spectral palette of fluorescent proteins for the green microalga *Chalmydomonas reinhardtii*. The Plant Journal, 14.3.13

Bioenergy Technologies Office 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

Scales of Action

Cellular/Molecular
1 µm

Reactor Size
meters

Processes
acres or hectares

Biochemical, molecular biology, catalytic domains, metal surfaces

Enzymes

Ethanologens

Syngas cleanup

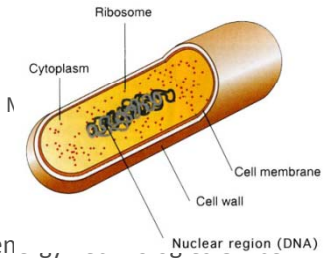
Pyoil R&D

Advanced biofuels

Targeted R&D

Catalyst Development

Algal systems

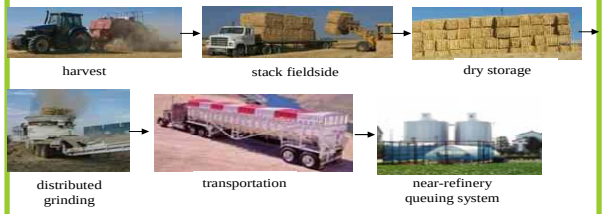


Biochemical engineering, reactor engineering, pilot plants

Process Demonstration Systems

- NREL BC and TC PDUs
- PNNL TC
- ANL Separative Bioreactor
- Algae Demonstration facilities

Feedstock Interfaces



Integration R&D & Analysis

Commercial - ethanologen, enzyme, gas clean up, feedstock storage and processing systems

Pilot Plants - 12 from 2009 ARRA, Innovative Pilots for FY2013 (4)

Process engineering, demonstration plants, precommercial and commercial plants

Fully integrated demonstration or pilot plants *(possess integrated feedstock supply & interface, conversion, product recovery and delivery systems)*

Commercial 932 operations and 10% scale Demonstrations (Seven)

Systems Analysis

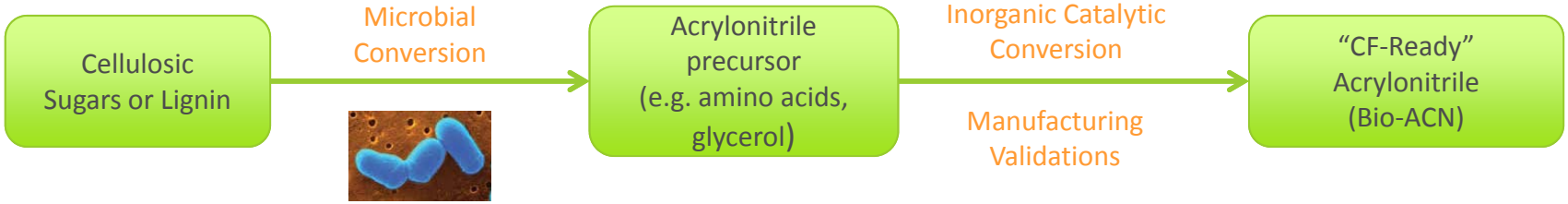
FY14 Funding Opportunity Announcements (FOA)

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 fiber using biomass as a starting raw feedstock and biomass derived acrylonitrile (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/#FoaId9c2b53f7-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=#FoaId28e0ebed-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

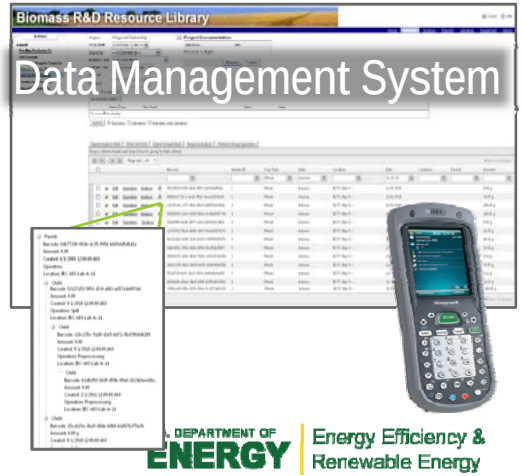
- Initiate blending and formulation strategies that upgrade feedstock quality to meet biorefinery in-feed specifications

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



Algal Biofuels

Key Challenges

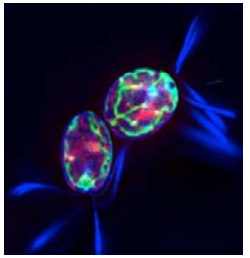
Affordable and scalable production

- Current commercial algae cultivation technologies are designed for production of high-value products (*nutraceuticals, food additives*) rather than high-yielding commodity products (*transportation fuel*).
- These facilities use high-cost pond liners, nutrient inputs, and predator controls.
- Higher yields of biomass are required to offset the operating and capital costs to produce algae as a commodity product.

Siting and sustainability

- Cultivation currently requires significant water resources.
- CO_2 delivery requirements limit siting decisions, and nutrient recycle has limited use.
- Harvesting and preprocessing technologies are not currently energy efficient.

Key Recent Accomplishments



Getting production strains outdoors

- National Alliance for Advanced Biofuels and Bioproducts (NAABB) has screened over 1,500 strains and identified 30 algae high-yield that show marked improvement over productivity baseline.
- NAABB has shared these high-yield strains with partners for testing in outdoor cultivation facilities.

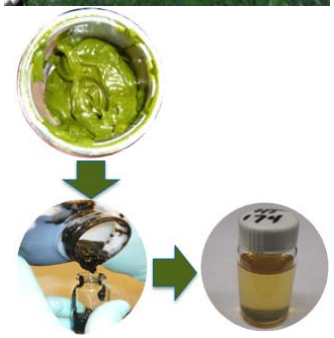
Genetic solutions to improve productivity

- Genetic engineering breakthroughs have allowed for the insertion and expression of desirable genes.
- Recent metabolic engineering of algae demonstrated the ability to improve lipid yield without inhibiting growth.

Advances in biofuel intermediate production

- Whole Algae Hydrothermal Liquefaction (HTL) for intermediate oil production has been demonstrated at continuous operation.
- HTL can produce renewable diesel from low-lipid, wet algae and captures > 60% of the biogenic carbon.

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

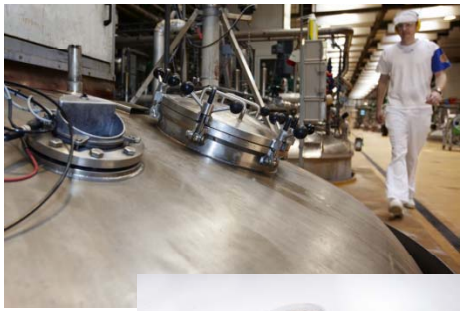
Garner Stakeholder Input to Refine MYPP Planning:

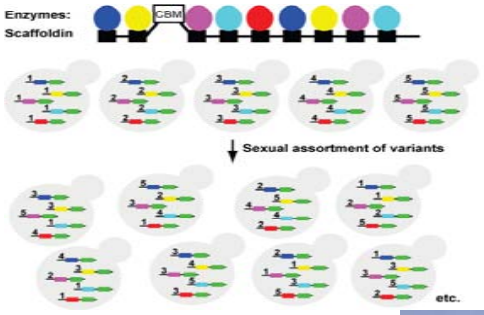
- Convened the Algal Biofuels Strategy Workshop Nov 19-20 in Mesa, Arizona, attended by 29 university, 17 national laboratory, 25 industry, 4 advocacy, and 13 government stakeholders
- A second workshop will be held March 26-27 in Charleston, SC
- Plan for refinement of Multi-Year Program Plan based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

FY14 Biochemical Activities and Direction D1

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

novozymes
Rethink Tomorrow

Slide 21

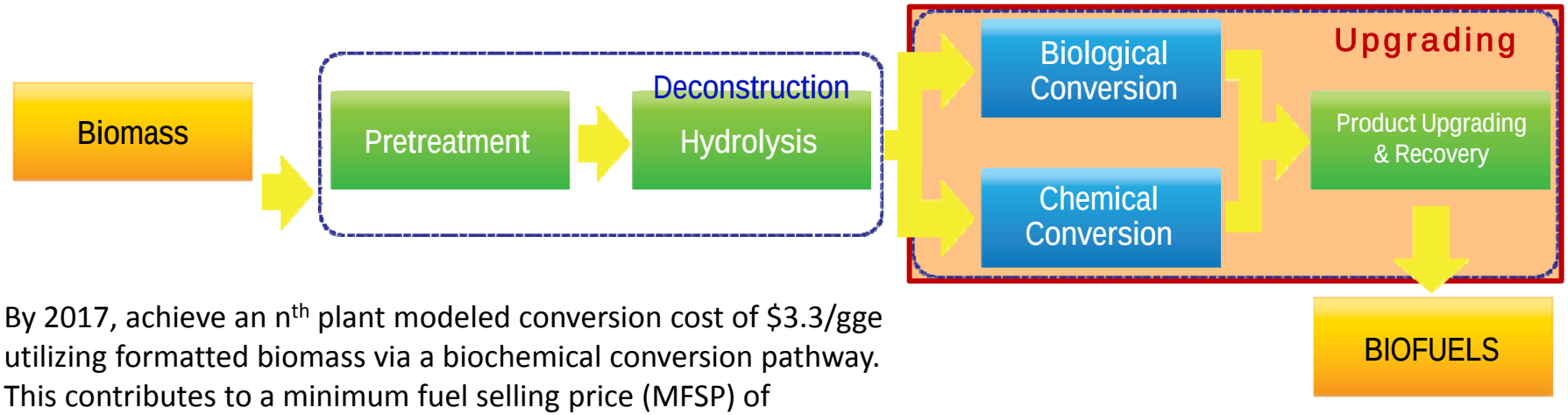
D1 We need more science and scientific details

DOEUSER, 3/3/2014

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.



- By 2017, achieve an n^{th} plant modeled conversion cost of $3.3/gge utilizing formatted biomass via a biochemical conversion pathway. This contributes to a minimum fuel selling price (MFSP) of $5.10/gge (in 2011$), an interim target on the path to $3/gge fuels.

AB PDU Core Competencies

- Feedstock Flexibility using lignocellulosics, cellulosics,algae, gas
- Up-to-date automated data acquisition, process control systems, and analysis of process performance
- Diverse technologies integrated for process demonstration, process validation, and Techno-economic/Life Cycle analysis
- Projects designed to generate intellectual Property and helping industrial partners commercialize technologies.
- Versatility incorporating equipment from sponsors and collaborators into end-to-end process integration

- 10L to 210L Reactors
- Compositional, Calorimetric, & Rheological Analysis

- 2L to 300L Fermentation Systems
- Anaerobic & Aerobic
- Fed-Batch and Continuous modes
- Nutrient, metabolite, product analytics

- Continuous liquid-liquid separation and extraction
- Gas & liquid chromatography
- Protein analysis
- Compositional analysis
- Techno-economics/Life cycle analysis

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 H_2 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

Computational Pyrolysis Consortium

- **Goal/Objective**: Through multi-lab collaboration with industry feedback, develop and implement computational tools aimed at major technical barriers and risks for compatible bio-fuels production via pyrolysis oil upgrading.
- **Key Barriers Addressed**: Tt-E Improve bio-oil quality, improve carbon efficiency; Tt-G Improve upgrading catalysts; Tt-K Improve process integration and scale-up.
- **Approach**: Apply and integrate multiple computational approaches for modeling and improving key process steps and components based on the latest chemical and physical information coming from(and guiding) ongoing experiments at the national labs.
- **Accomplishments and Progress**: Project just started in April, 2013.
- **Relevance**: By targeting key risks and uncertainties in latest biomass pyrolysis design studies, supports the BETO MYPP goal of identifying viable pyrolysis pathway options for producing $3.00/gal bio-diesel and bio-gasoline by 2022.
- **Future Plans**: Continue with full process simulations using advanced catalysts pending Go/No Go decision in 3rdquarter 2014.

Partners & Roles

- ORNL
  - Overall coordination
  - Global reactor models
  - Model interfacing/integration
- NREL/ANL
  - Pyrolysis & catalysis data
  - Vapor-phase catalysts & models
  - Biomass reaction models
- PNNL/U Delaware/TU Munich
  - Hydrotreating & aqueous catalysts
  - Reduced order upgrading kinetics
- INL
  - Detailed feedstock characterization

FY14 Demonstration Portfolio

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 April 2014; Commissioning for CY 2014
- 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.

FY14 Demonstration Portfolio

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 CO_2 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

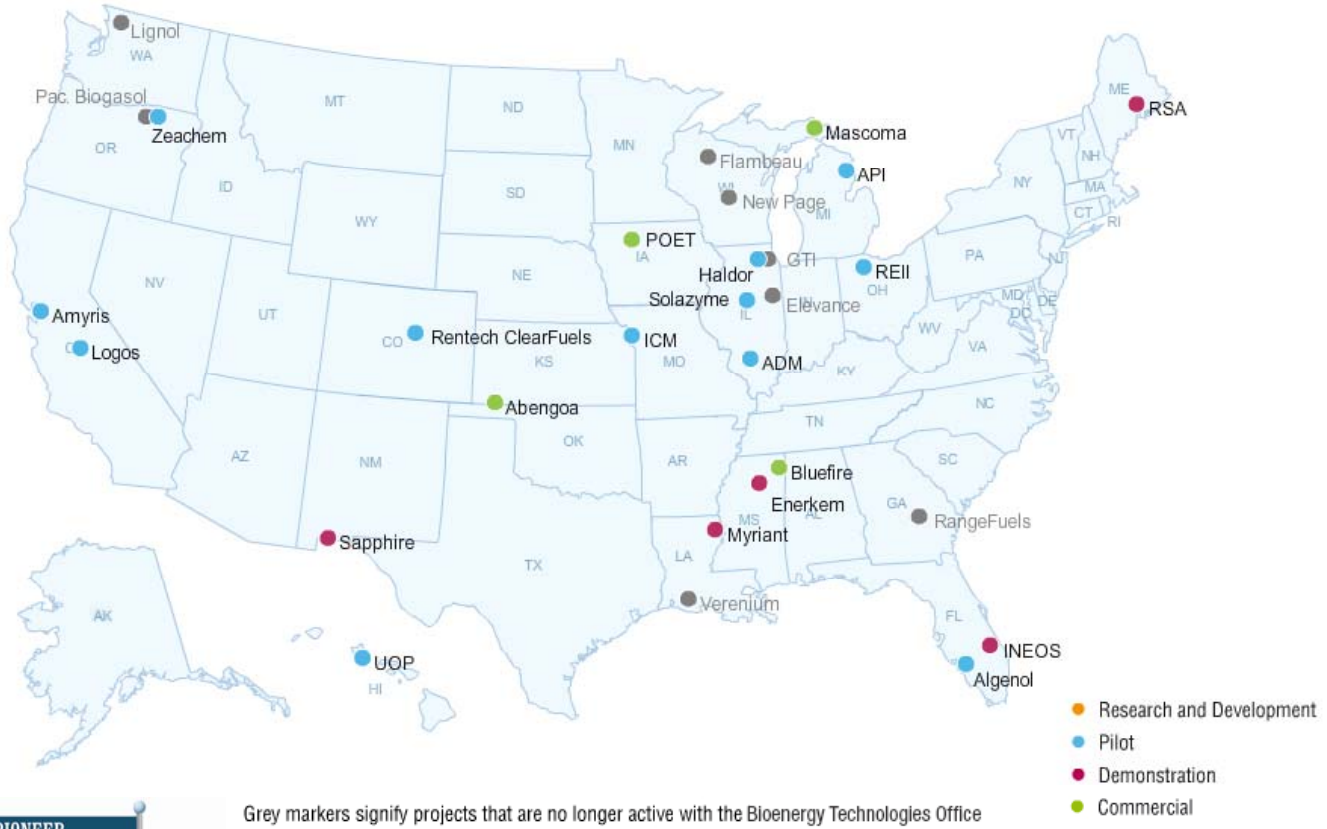
American Process, Inc., Alpena, MI

- 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)
- Accomplishments to date:
  - First batch of pure cellulosic ethanol produced in early FY14;
  - Anticipate first RIN batch to ship in the spring of CY14.
- DOE share: $22,481,523; Cost share: $8,459,327

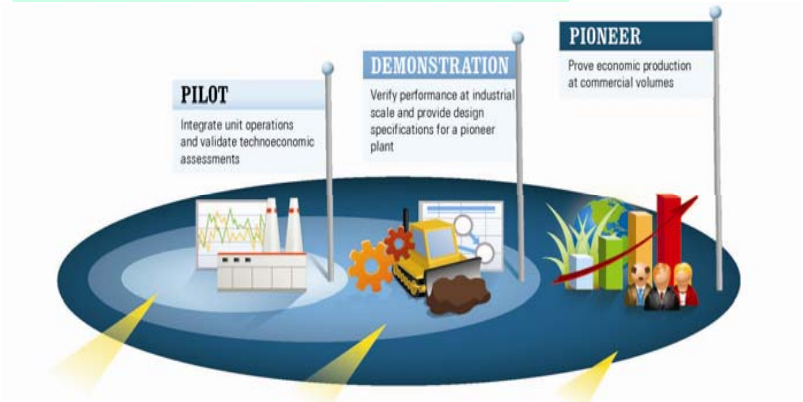
BETO-Funded Demonstration Portfolio

- 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



Grey markers signify projects that are no longer active with the Bioenergy Technologies Office



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

Note: 4 iPilot Projects do not appear on this map

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

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.

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

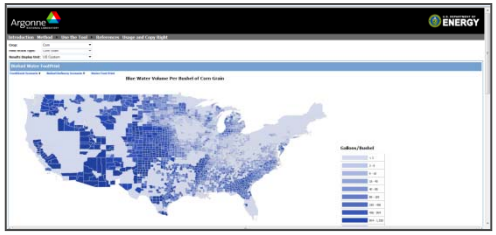
- Conduct techno-economic analysis of new hydrocarbon fuel pathways; assess technical and economic incentives, risks, and uncertainties of refinery integration
- Enhance GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) to maintain it as an industry-standard LCA model; develop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

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

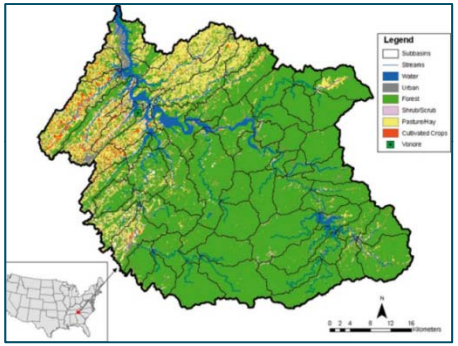
- Deliver a multi-attribute analysis framework for evaluating trade-offs/synergies between environmental and socio-economic sustainability indicators
- Release version 2 of web-based water footprint tool (WATER) that includes new perennial grass pathway
- Develop air emissions targets for seven criteria 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

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



WATER Analysis Tool - Argonne National Laboratory (ANL)



Watershed analysis of Ohio River Basin - ANL

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

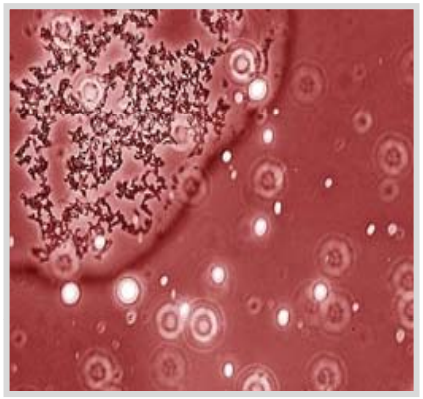
Aviation – Accomplishments/Milestones

- 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

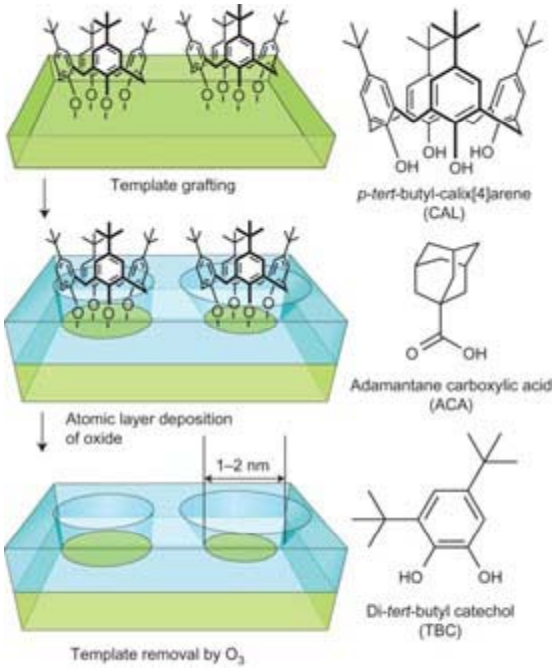
Collaboration with the Office of Science

Biological and Environmental Research Program (BER)
Basic Energy Sciences Program (BES)

- Overlapping R&D areas of interest
  - Energy crops (BER)
  - Systems biology (BER)
  - Climate change and sustainability (BER)
  - Photosynthesis (BES)
  - Catalysis (BES)



Microbe secreting hydrocarbons (Credit: Eric Steen, JBEI)



Nanosieves to improve catalyst specificity (Credit: Brandon O'Neil, Argonne EFRC)

- Biomass R&D Act
  - Biomass R&D Board and Working Groups
  - Biomass R&D Technical Advisory Committee
- Bridging Gaps Through Partnerships
  - Bioenergy Research Centers (BER)
  - Energy Frontiers Research Centers (BES)
  - Advanced Biofuels Process Demonstration Facility (BETO)

Upcoming BETO Workshops and Events

Demonstration and Deployment Strategy Workshop

March 11–12, 2014

- The Workshop intends to discuss, reassess, and prioritize the D&D efforts needed to realize affordable, scalable, and sustainable production of hydrocarbon biofuels. This workshop was announced in the Federal Register on February 4, 2014, and will be held at Argonne National Laboratory just outside of Chicago, Illinois.

Biomass Indirect Liquefaction Workshop

March 20–21, 2014

- The focus of this workshop is to support research and development planning efforts within the thermochemical conversion program. This workshop will discuss and develop ideas and research areas to advance a potential funding opportunity solicitation. This workshop will take place, in Golden, Colorado.

Algal Biofuels Spring Strategy Workshop

March 26–27, 2014

- BETO's Algae Program is hosting the spring Algal Biofuels Strategy Workshop, which will focus on the research and development needed to achieve affordable and sustainable algae-based biofuels. The event is a follow-up to the November workshop, and will take place in Charleston, South Carolina.

Bio-Oil Co-Processing: Expanding the Refinery Supply System

April 3, 2014

- This workshop plans to have renewable technology developers engage with conventional petroleum refiners to clear up any misconceptions about using biomass-derived oils as additional feedstock. Participants will be engaged in discussions about the potential advantages, disadvantages, and challenges of bio-oil integration in the current U.S. petroleum refinery infrastructure. The event will be held in New Orleans, Louisiana.

Upcoming BETO Workshops and Events

Woody Feedstock Workshop

March 4–6, 2014

- BETO is hosting a forestry-focused workshop to assess the state of the science, current research needs, and tools and methodologies for deploying landscape design for bioenergy systems. The event is invitation only, and will be held in New Bern, North Carolina.

Herbaceous Feedstock Workshop

June 24–26, 2014

- BETO is hosting an agriculture-focused workshop to assess the state of the science, current research needs, and tools and methodologies for deploying landscape design for bioenergy systems. The event is invitation only, and will be held in Chicago, Illinois.

Biomass 2014: Growing the Future Bioeconomy

July 29-30, 2014 at Washington Convention Center (tentative)

- 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.

Useful Links

1. Incubator FOA: https://eere exchange.energy.gov/Default.aspx?Search=DE-FOA- 0000974&SearchType=#FoaId28e0ebed-de32-4b3a-97f3-4184df7f5420
2. Renewable Carbon Fiber FOA https://eere-exchange.energy.gov/#FoaId9c2b53f7-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/

Appendix

FY13 Accomplishments D2

Sun Grant Regional Feedstock Partnership

- Network of land-grant universities working in partnership with DOE, industry, national labs, and USDA to establish field trials across the country to determine biomass productivity baselines of energy crops.
- 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

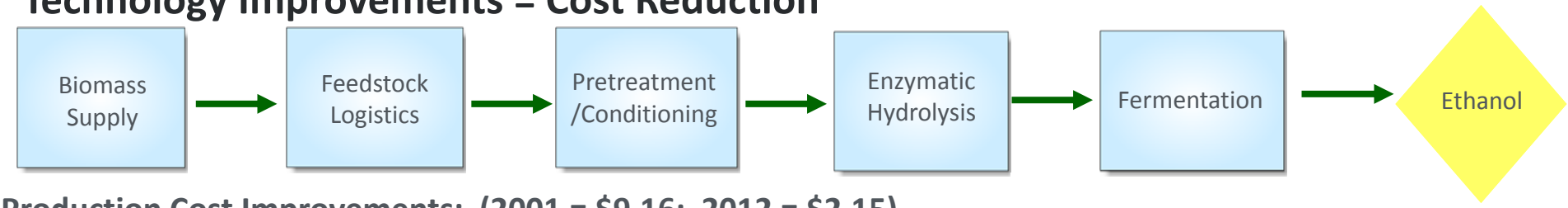
Slide 36

D2 Where are the scientific accomplishments for FY13?

DOEUSER, 3/3/2014

Biochemical Conversion of Corn Stover

Technology Improvements = Cost Reduction



Production Cost Improvements: (2001 = $9.16; 2012 = $2.15)

Biomass Supply	Feedstock Logistics	Pretreatment /Conditioning	Enzymatic Hydrolysis	Fermentation	Ethanol
2001 = $1.25/gal 2012 = $0.34/gal	2001 = $1.25/gal 2012 = $0.49/gal	2001 = $1.37/gal 2012 = $0.27/gal	2001 = $4.05/gal 2012 = $0.39/gal	2001 = $0.60/gal 2012 = $0.15/gal	2001 = $1.90/gal 2012 = $0.51/gal (Balance of Plant)

Technology Improvements:

Biomass Supply	Feedstock Logistics	Pretreatment /Conditioning	Enzymatic Hydrolysis	Fermentation	Ethanol
Improved Biomass Supply Analysis • economic availability of feedstocks • feedstock prices specified by quantity and year • Incorporation of sustainability metrics • Development of four yield scenarios • Spatial distribution	**Better Collection Efficiency** • *43% to 75%* **Higher Bale Density** • *9.2% to 12.3%* **Lower Storage Losses** • *7.9% to 6%* **Higher Grinder Capacity** • *17.6 to 31.2 ton/hr*	**Better Xylan to Xylose Yields** • *63% to 81%* **Lower Degradation Product Formation** • *13% to 5%* **Lower Acid Usage** • *3% to 0.3%* **Reduced Sugar Losses** • *13 to <1%* **Reduced Ammonia Loading** • *decreased by >70%*	**Enzyme Cost Reductions** • *$3.45 to $0.36/gal* **Enzyme loading Reductions** • *60 to 19 mg/g* **Higher Cellulose to Glucose Yields** • *64% to 78%* **Process Efficiency Improvements** • *washed solids to whole slurry mode of hydrolysis*	**Improved Overall Ethanol Yield** • *52% to 96%* **Better Xylose to Ethanol Yields** • *0% to 93%* **Better Arabinose to Ethanol Yields** • *0% to 54%* **Improved Ethanol Tolerance** • *36 to 72 g/L titers*	

Scale Improvements:

Biomass Supply	Feedstock Logistics	Pretreatment /Conditioning	Enzymatic Hydrolysis	Fermentation	Ethanol
National to county-level detail	Model Estimates to Field/Pilot Demonstration	Bench (1L batch) to Pilot (1 ton/day, continuous)	Bench (1 L batch) to Pilot (1 ton/day, continuous)	Bench (1L) to Pilot (8000L)	

Renewable Fuel Standard (RFS) in 2014

On November 15th, the Environmental Protection Agency (EPA) issued its proposed 2014 standards for the RFS program.

- DOE's primary role in EPA's rule-making process is to ensure that accurate and realistic information is used in setting the regulatory standards
- DOE's long-term role is to invest in the RD&D for advanced bioenergy technologies needed to meet the goals of the RFS

	Vol. used 2013 standards (gal.)	Proposed 2014 vol. req. (gal.)	Req. vol. for 2014 under the CAA (gal.)
Cellulosic Biofuel	6 M	17 M	1,750 M
Biomass-based Diesel	1,280 M	1,280 M	≥ 1,000 M
Advanced Biofuel	2,750 M	2,220 M	3,750 M
Renewable Biofuel	16,550 M	15,210 M	18,150 M

Company/ Location	Projected 2014 Vol. (Gal.)
Abengoa, KS*	0-18 M Gal.
DuPont, IA*	0-2 M Gal.
INEOS, FL*	2-5 M Gal.
POET, IA*	0-6 M Gal.
KiOR, MS	0-9 M Gal.

*DOE-supported technology

- EPA is requesting stakeholder comment on proposed 2014 rule-making
- Comments were submitted up to January 28, 2014
- EPA is assessing comments received

RD&D Pipeline Evolution of Technology

Bioenergy Technologies Office – D & D Program

Demonstrate and Deploy technologies impacting EERE goals and objectives

Interact with: BETO D&D Program & DOE Loan Programs (supporting role)

Pilot Operations | Integrated Pilots | Demonstrate | Commercial Demos

Example: Interface Fuel Cells

Commercial Partnerships

Bioenergy Technologies Office – Feedstocks Logistics & Conversion Program

Development of industrially relevant or applicable technologies

Concept Designed | Concept Engineered | Engineering Development | Proof at scale

Interagency Interactions: USDA
-Biomass R&D Board
-Feedstocks
- DOD
- NSF

Early Stage R&D

Proof of concept of scientific principles, concepts or technologies

Interact with:
ARPA-E, SBIR
BRCs (SC), EFRC (SC)
Seed Projects

Synergism occurs as interactions increase – Outcomes help (re)define R&D

Reactor Size meters

Cellular/Molecular 1 µm

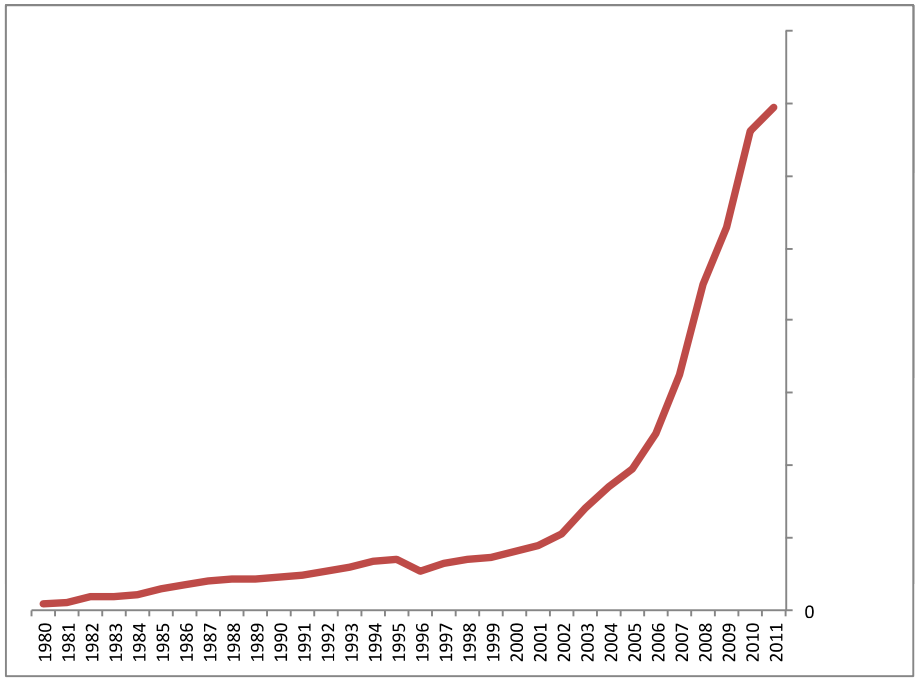
Highest risk/broad reward – TRL 1-3

Risk/reward favorable for investment – TRL 7-9

Multi-Decade Endeavor

Corn Ethanol

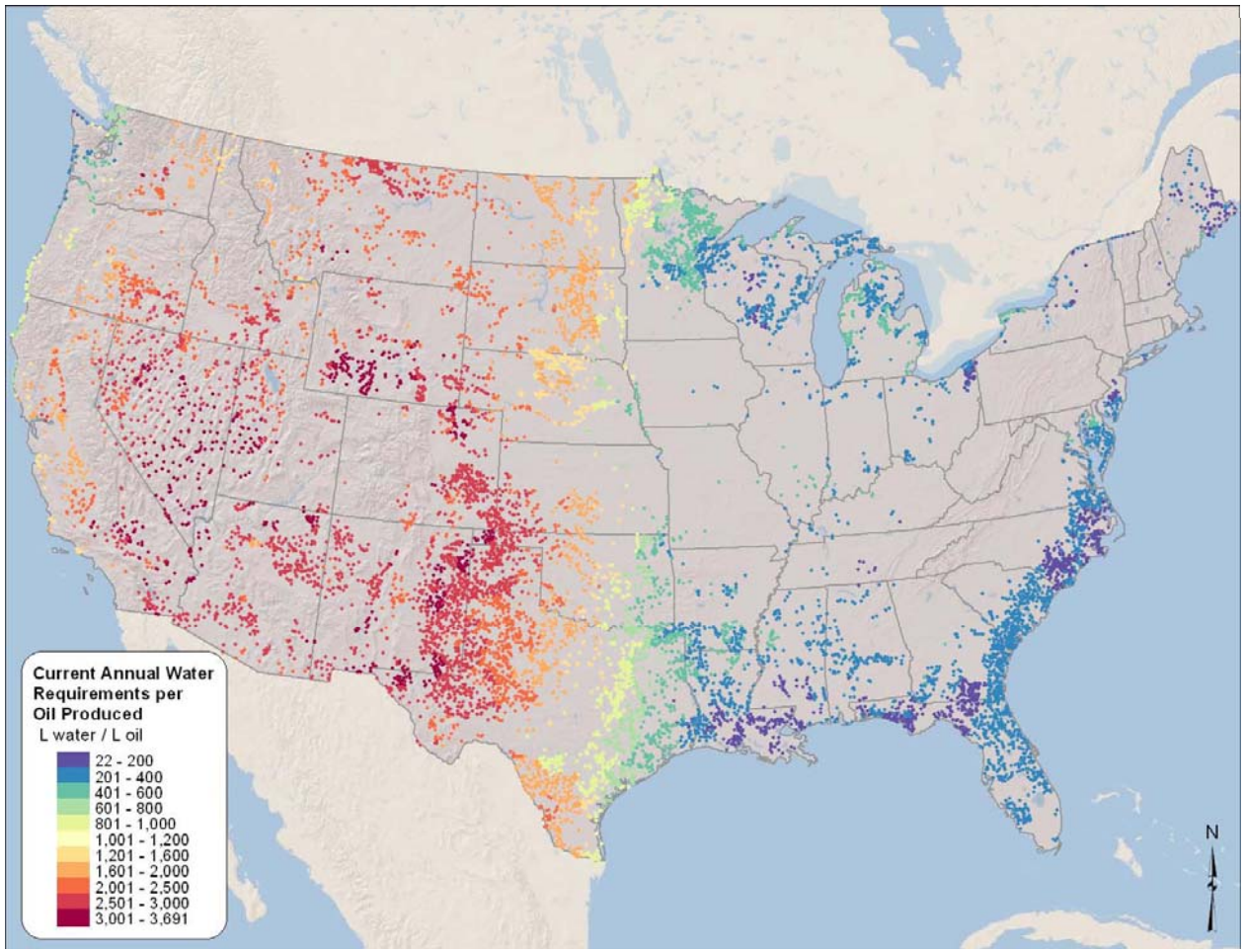
We did not get there overnight



- >11 years to reach 1 billion gallons/year
- +10 years to exceed 2 billion gallons/year
- Latest decade
  - From 2 billion gallons/year to nearly 14 billion gallons/year

Source: Renewable Fuels Association: http://ethanolrfa.org/pages/statistics

Microalgae Resource Assessment



- By 2017, model the sustainable production of algae to support cultivation of 1 million metric tons ash free dry weight algae biomass by 2017

Wigmosta et al. *Water Resources Research Journal. 2011*

Physics and Geospatial Information Systems (GIS) analysis

- "Unit Farm" Concept
- Land
- Water
- Sunlight

Initial Finding

•>10 B gallons of biofuels technically feasible

• Water use is relatively high compared to cellulosic biofuels production

Pacific Northwest NATIONAL LABORATORY

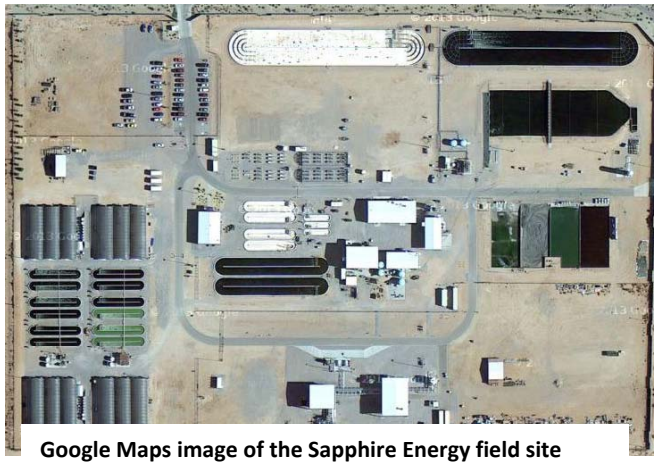
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ABY Selections

ABY Goal: Through integrated R&D on algal biology and downstream processing, demonstrate biofuel intermediate yield of greater than 2,500 gallons per acre by 2018

- **Hawaii Bioenergy**: The project will develop a cost-effective photosynthetic open pond system to extract algal oil.
- **Sapphire Energy**: The project will work on improving algae strains and increasing yield through cultivation improvements and thermal processing of whole algae.
- **New Mexico State University**: The project will genetically engineer improved productivity of a microalgae and develop a 2-stage thermal processing system.
- **California Polytechnic State University**: The project will be based at a municipal wastewater treatment plant in Delhi, California that has six acres of algae ponds.

Photograph of the 8 acre Hawaii Bioenergy Algae Farm

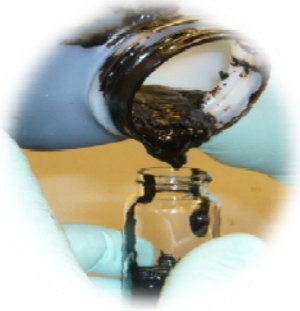


Google Maps image of the Sapphire Energy field site

Bing.com image of Delhi WWT Plant in central California

Hydrothermal Liquefaction of Whole Algae

HTL of whole algae results in high yield of biomass to bio-oil which can be upgraded using commercial HT catalysts. Potential to use fast growing, low lipid accumulating algae



Description	%
Lipid content of whole algae	33%
Bio-oil from HTL as % algae AFDW*	64%
% of algae carbon in HTL oil	69%

Description	C%	H%	O%	N%	S%	Ash
Whole Algae	55.9	8.3	23.7	4.1	0.6	7.4
HTL oil	77.9	10.2	5.0	*4.6*	*0.42*	*0.10*
Upgraded HTL	84.5	14.1	0.8	*<500ppm*	*<50ppm*	*nd*

Elliott, D. and Oyler, J. (2012). Hydrothermal processing: Efficient production of high-quality fuels from algae. *2nd International Conference on Algal Biomass, Biofuels and Bioproducts*, San Diego, CA, June 2012.

Advanced Biofuels (AB) Process Development Unit (PDU)

Timeline

- Facility funded in 2010 and functional in 2012
- Initial projects completed in Mar 2013
- Currently working in 3 DOE projects and considering 15 potential project for DOE labs and the biofuel industry

Barriers

- Facility/Equipment Start-up
- Staffing and training
- Identifying clients and projects

Budget

- Funding for FY11 = 1.2M
- Funding for FY12 = 3.0M
- Funding for FY13 = 1.0M

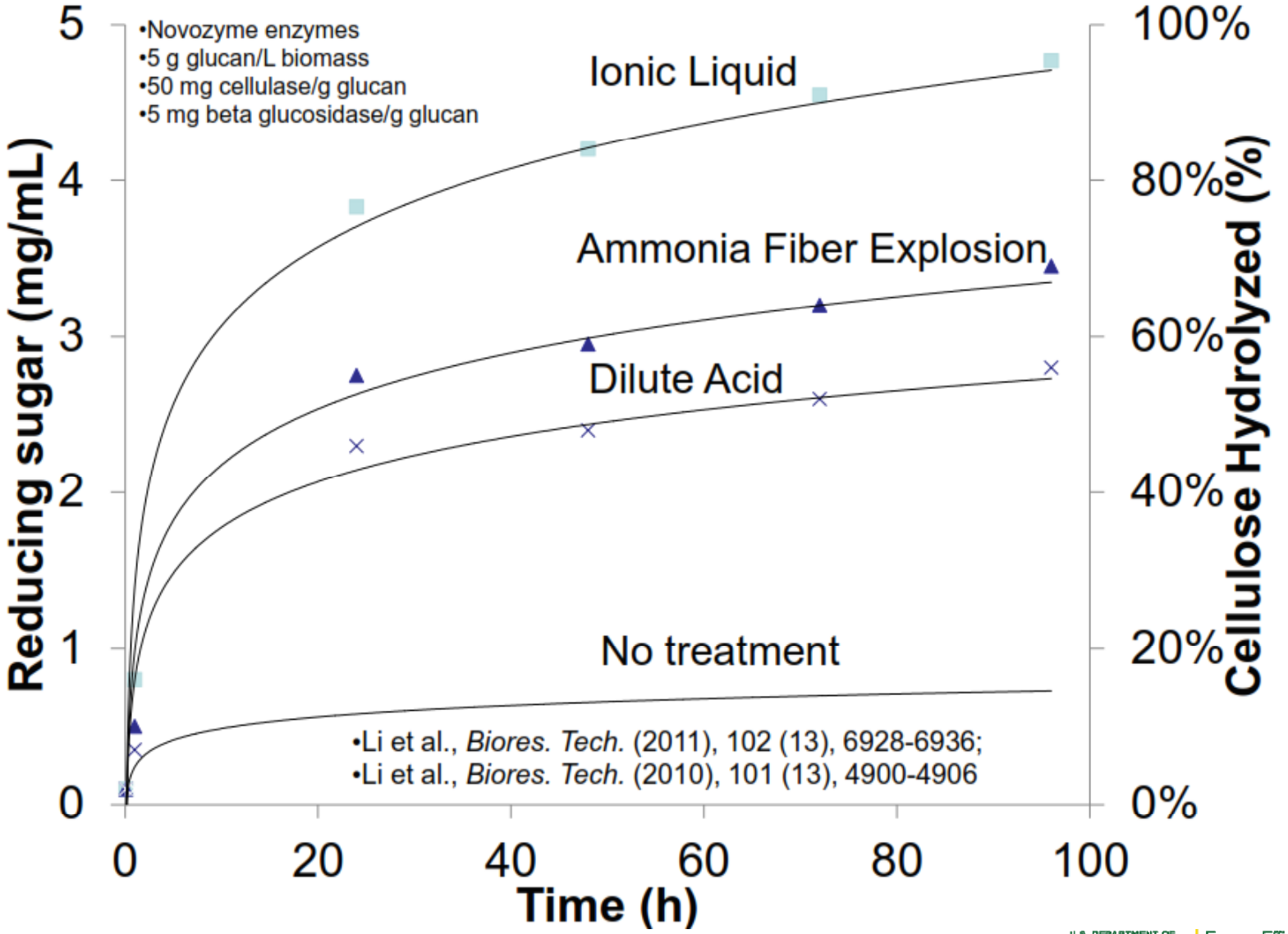
100% DOE funding

FY10 = $17.7M from the American Recovery and Reinvestment Act funds

Partners

- JBEI ionic liquid pretreatment
- JBEI advance biofuel production
- GLBRC cellulase production
- GLBRC alkaline pretreatment
- INL biomass processing
- Over 10 companies for biomass pretreatment and biofuel production

AB PDU Efficiency of Ionic Liquid Treatment for Corn Stover



AB PDU Summary

1. Established that the ABPDU is capable to work with research organizations to demonstrate technology for:
   - Effective pretreatment of diverse feedstocks
   - Enzymes adapted to to be used in novel pretreatment technologies
   - Advanced biofuel production through the use of synthetic biology

2. Developed effective collaborations with DOE research centers (JBEI, GLBRC, INL) and with over 10 companies working in the development of improved technologies for biomass/post-consumer product pretreatment and biofuel/biochemical production.

3. Integrated Techno-economic analysis in all programs.

4. Considering novel technologies to better serve clients (gases as feedstock, plant expression systems)

Selected Project: University of Oklahoma (CHASE)

Project Title: Fractionation and Catalytic Upgrading of Bio-Oil

Objectives: This project will investigate selective fractionation of biomass pyrolysis products by two methods: thermal fractionation of raw biomass via torrefaction/pyrolysis and supercritical fluid (SCF) extraction of full bio-oil and thermal fractionation cuts. These fractionation strategies will be combined with catalyst design, synthesis, characterization and testing for C-C bond formation and hydrodeoxygenation upgrading reactions under two alternative modes: liquid phase and vapor phase.

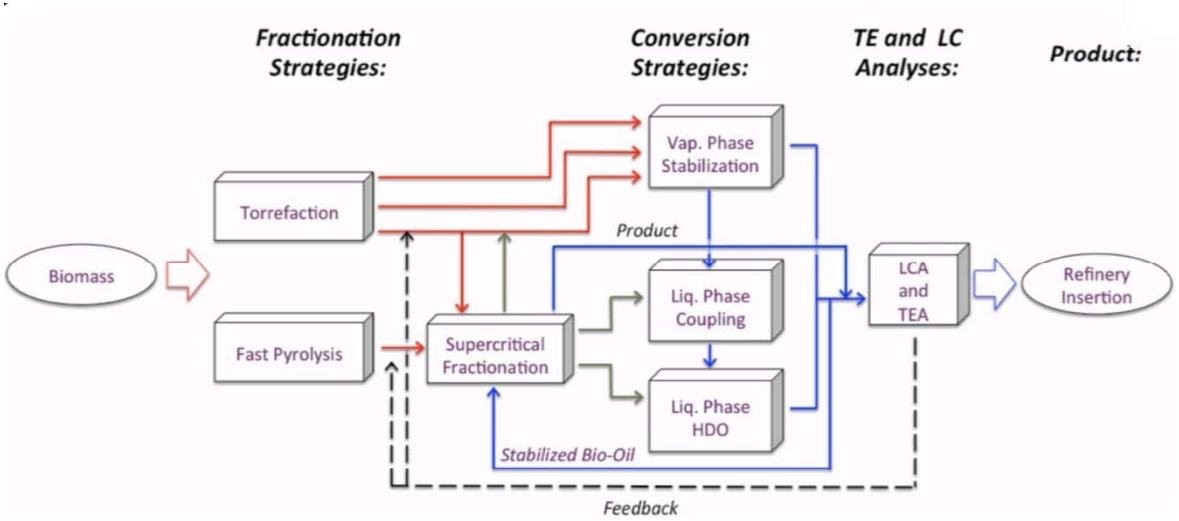
Innovation: The applicants identify that a single upgrading process is not appropriate for all components of the biomass. The applicant proposes several fractionation steps that will produce several relatively homogenous product streams. Upgrading steps can be tailored to specific products and as a result, carbon and hydrogen efficiencies should be greatly enhanced.

Budget:

- DOE Share $ 4,000,000
- Cost Share $ 1,000,000 (20%)

Partners:

- University of Wisconsin, Madison
- University of Pittsburgh
- Pacific Northwest National Laboratory
- Idaho National Laboratory



Computational Pyrolysis Consortium

Timeline

- Start Date: May1, 2013 (**Just started)**
- End Date: September 30, 2017
- (Go/No-Go decision March 31, 2014)

Budget

- Funding received in FY 2011: $0
- Funding in FY 2012: $0
- Expected Funding for FY 2013:
- Total DOE - $2.2MM
  - ORNL- $550K
  - NREL- $621K
  - PNNL/U Del - $360K/$250K
  - INL- $115K
  - ANL- $300K
- Years funded & avg. funding/yr:
- NEW PROJECT

Barriers Addressed

- Improve bio-oil quality, improve carbon efficiency
- Improve upgrading catalysts
- Improve process integration & scale-up

Partners & Roles

- ORNL
  - Overall coordination
  - Global reactor models
  - Model interfacing/integration
- NREL/ANL
  - Pyrolysis & catalysis data
  - Vapor-phase catalysts & models
  - Biomass reaction models
- PNNL/U Delaware/TU Munich
  - Hydrotreating & aqueous catalysts
  - Reduced order upgrading kinetics
- INL
  - Detailed feedstock characterization

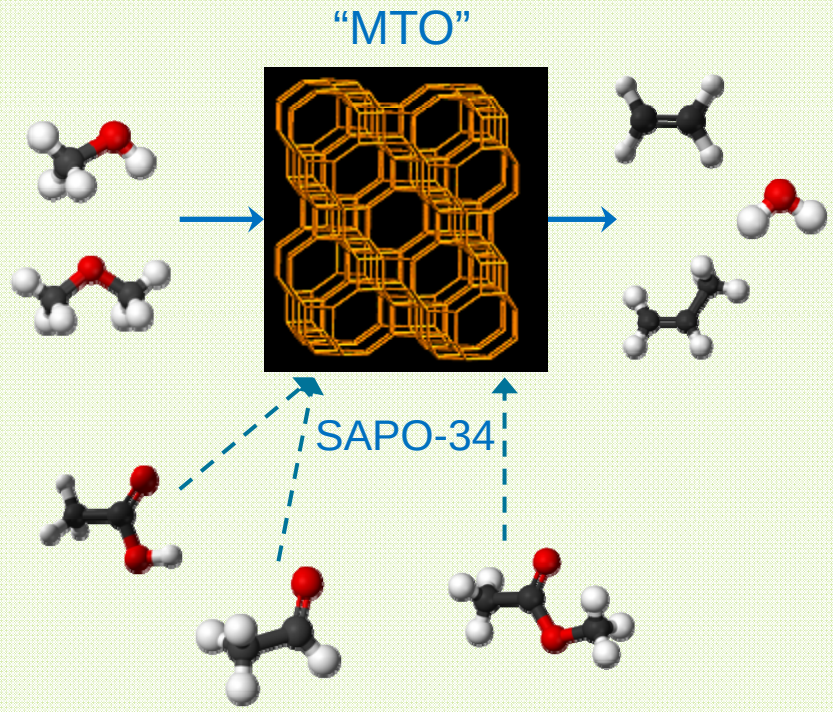
Computational Pyrolysis Consortium

Future Work: Our Longer Range Vision

	Year 1	Year 2	Year 3	Year 4	Year 5
ORNL	Organize consortium	Baseline pyrolysis simulations	Refined vapor phase upgrading simulations	Linked vapor & liquid-phase upgrading simulations	Collaborative full plant simulations of conventional, in situ, & ex situ fast pyrolysis with advanced vapor & liquid-phase catalysts & multiple feedstock blends in support of refined TEA and LCA
INL	Identify reference feedstocks & set up database	Refine feedstock data per NREL/ORNL feedback	Develop property models for feedstock blends	Interface feedstock prep models with pyrolysis inputs	
NREL	Baseline coke formation & particle transport models	Link coke & particle models with pyrolysis reactor model	Vapor catalyst kinetics & deactivation/regen models, lab validations	In situ & ex situ kinetics refinement with lab & PDU experimental validations	
PNNL	Micro-kinetic catalysis models for aqueous carbs with oxide support metals	Procedures for liquid phase reaction network mapping & mechanism reduction	Refine aqueous & organic liquid phase catalyst formulations	Reduced liquid phase catalyst mechanism & kinetics for aqueous & organic phases	
ANL	Vapor catalysts for furan & pyran coupling; energetics for anhydrosugars	Baseline vapor phase catalyst formulations and kinetics	Mechanisms for vapor phase catalyst deactivation, regeneration	Reduced models for vapor catalysis kinetics and deactivation/regeneration	

Dehydration of Mixed Oxygenates

Baseline



Targets

- Demonstrate dehydration of *mixed* alcohols to mixed olefins
- Evaluate ability of zeolite catalysts to incorporate carbon from non-alcohol oxygenates
- Consider impacts of high conversion on product selectivity/catalyst stability for TC Analysis team

Anticipated

- Proof of concept demonstrated in Q2
- General understanding on the need to convert non-alcohol oxygenates to alcohol or ability to use as-is
- Potential to produce larger olefins explored

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
- Accomplishments to Date:
  - Completed 1,000 hour test run on dry fractionation corn fiber
  - Completed pretreatment test of energy sorghum
- DOE share: $25,000,000; Cost Share: $6,272,081

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:

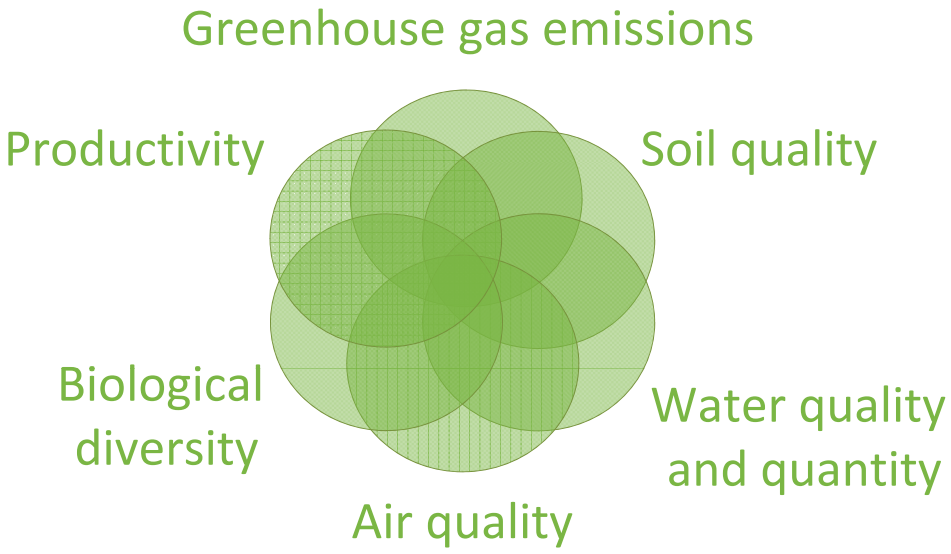
- Multiple, commercial-scale integrated biorefineries
- Cost-competitive biofuel with conventional petroleum (w/o subsidies)
- Domestically produced fuels from non-food feedstocks
- Drop-in, fully compatible, MILSPEC fuels (F-76, JP-5, JP8)
- Help meet the Navy's demand for 1.26 billion gallons of fuel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

DOE has a $45M appropriation for DPA in FY14

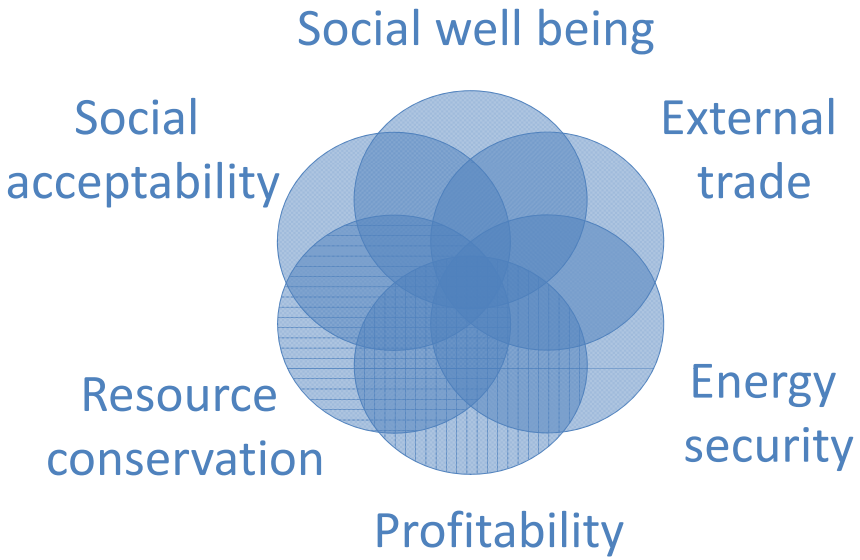
The first projects selected under DPA are:

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

Categories for Sustainability Indicators



McBride et al. (2011) *Ecological Indicators* 11:1277-1289.



Dale et al. (2013) *Ecological Indicators* 26:87-102.

Recognize that measures and interpretations are context specific

[Efroymson et al. (2013) *Environmental Management* 52:291-306]

CBES
Center for BioEnergy Sustainability

http://www.ornl.gov/sci/ees/cbes/

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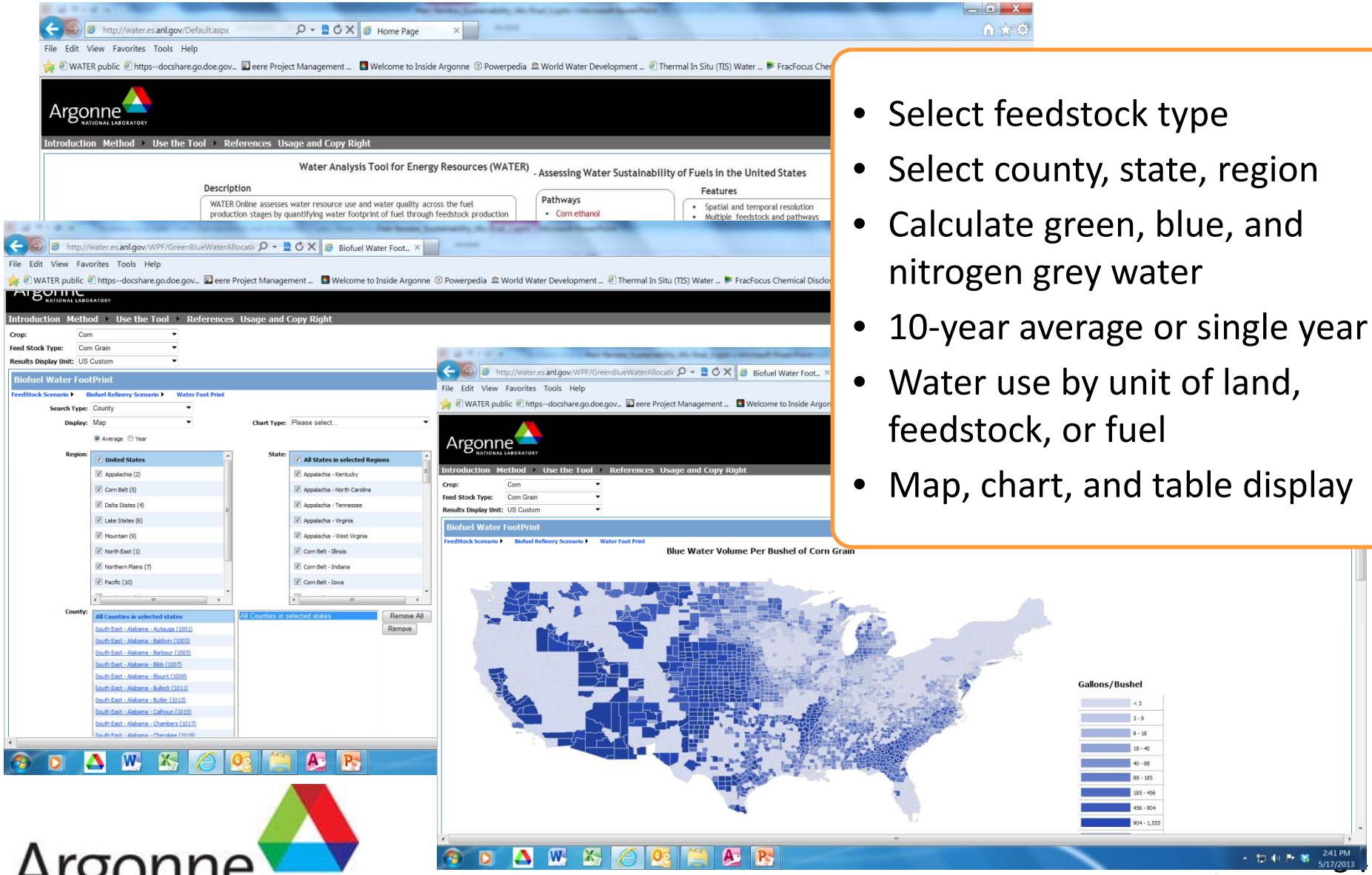
Water Analysis Tool - water.es.anl.gov



- Select feedstock type
- Select county, state, region
- Calculate green, blue, and nitrogen grey water
- 10-year average or single year
- Water use by unit of land, feedstock, or fuel
- Map, chart, and table display

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