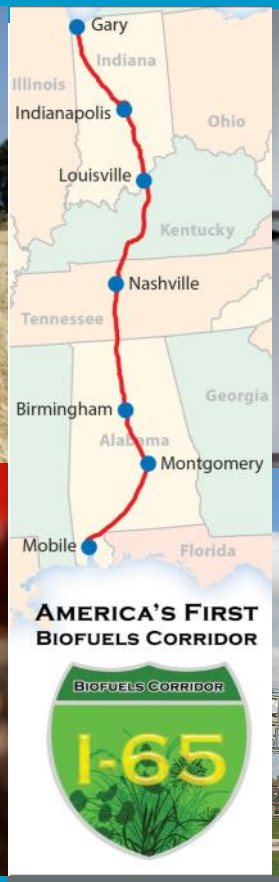
BIOENERGY TECHNOLOGIES OFFICE

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



Advanced Bioeconomy Feedstocks Conference

June 7, 2016

Jonathan L. Male

Director, Bioenergy Technologies Office (BETO)

Outline

I. Overview

II. Feedstock Supply and Logistics

III. Advanced Algal Systems

IV. Open Funding Opportunity Announcements

V. 2016 Billion Ton Update

VI. Bioenergy 2016

VII. Partnerships

The Challenge and the Opportunity

THE CHALLENGE

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

THE OPPORTUNITY

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

America's biomass resources can help mitigate petroleum dependence

Office of Energy Efficiency and Renewable Energy

Sustainable
TRANSPORTATION

Renewable
ELECTRICITY GENERATION

Energy Saving
HOMES, BUILDINGS, & MANUFACTURING

Mission-Critical Support
OPERATIONS

Bioenergy Technologies Office (BETO)

Vision

A thriving and sustainable bioeconomy fueled by innovative technologies

Mission

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

Performance Goals

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

*Mature modeled price at pilot scale.

BETO reduces risks and costs to commercialization through RD&D

BETO's Core Focus Areas

Program Portfolio Management

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

Research, Development, Demonstration, & Market Transformation

Feedstock Supply & Logistics R&D

- Terrestrial feedstocks
- Advanced Algal Systems
- Supply, Production, and Logistics

Conversion R&D

- Deconstruction and Fractionation
- Synthesis and Upgrading

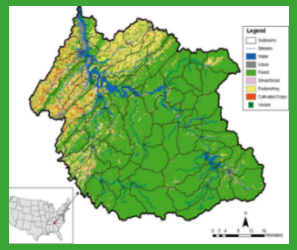
Demonstration & Market Transformation

- Integrated Biorefineries
- Biofuels Distribution Infrastructure

Crosscutting

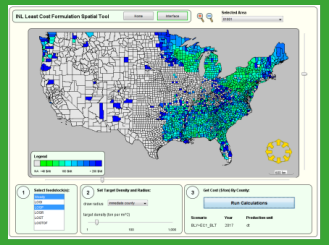
Sustainability

- Sustainability Analysis and Communication
- Sustainable System Design



Strategic Analysis

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



Strategic Communications

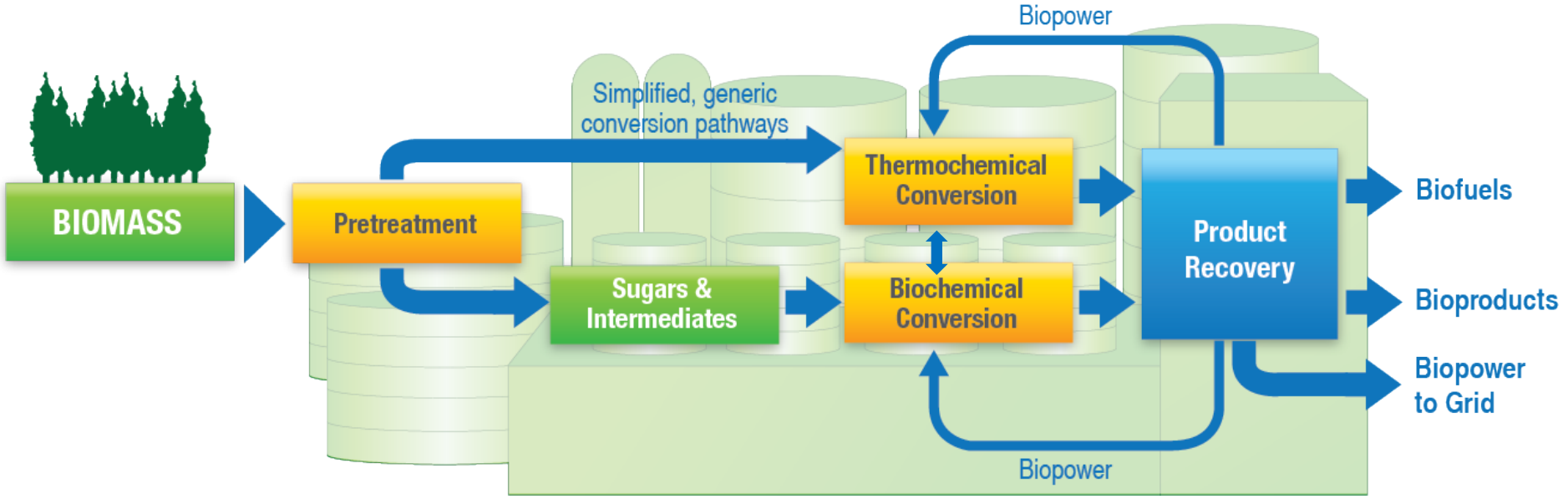
- Public Awareness and Support of Office Goals
- New Communications Vehicles and Outlets
- Benefits of Bioenergy/Bioproducts

BIO ENERGY U.S. DEPARTMENT OF ENERGY 2016

Key Challenge for Innovation – Lowering Risks

De-risking technologies is central to R&D through **demonstration** with greater **integration** and **scale**. BETO focuses on:

- Advancing renewable gasoline, diesel, and jet fuels technologies
- Technical, construction, operational and financial/market risks



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

Feedstock Supply and Logistics – Program Goals

- **Strategic Goal:** *Develop technologies to enable a sustainable, secure, reliable, and affordable biomass feedstock supply for the U.S. bioenergy industry,* in partnership with USDA and other key stakeholders.
- **Performance Goals:**
  - By **2017**, validate efficient, **low-cost**, and **sustainable** feedstock supply and logistics systems that can deliver feedstock to the conversion reactor throat at required conversion process infeed specifications, at or below **$80/dry ton** (2014$).
  - By **2022**, develop and validate feedstock supply and logistics systems that can **economically** and **sustainably** supply **285 million dry tons** per year at a delivered cost of **$80/dry ton** to support a biorefining industry (i.e., multiple biorefineries) utilizing a diversity of biomass resources.

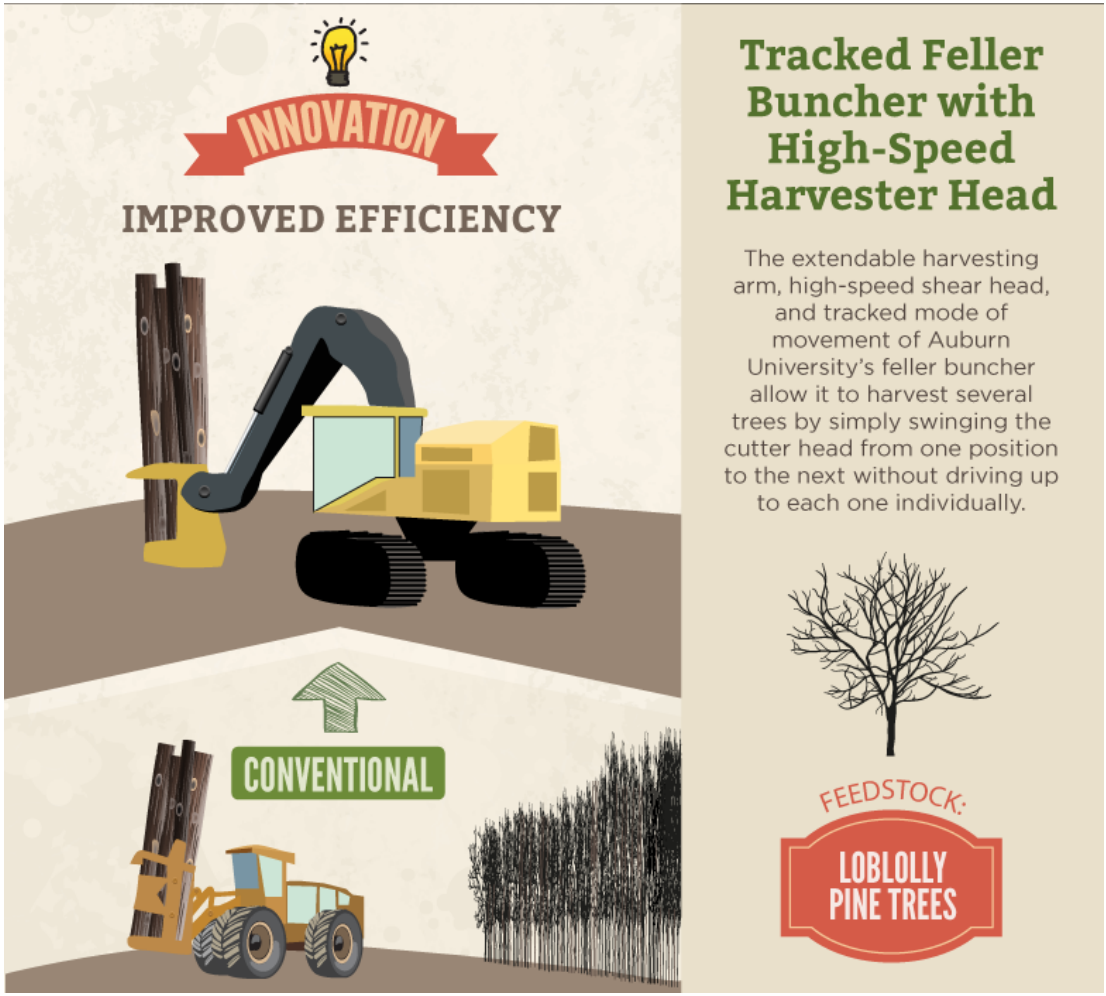
Feedstock Supply and Logistics – Accomplishments

Supply Systems to Handle and Deliver High-Tonnage Biomass Feedstocks

Goal: Design and demonstrate a high productivity system to harvest, process, and transport woody biomass from southern pine plantations

Impacts:

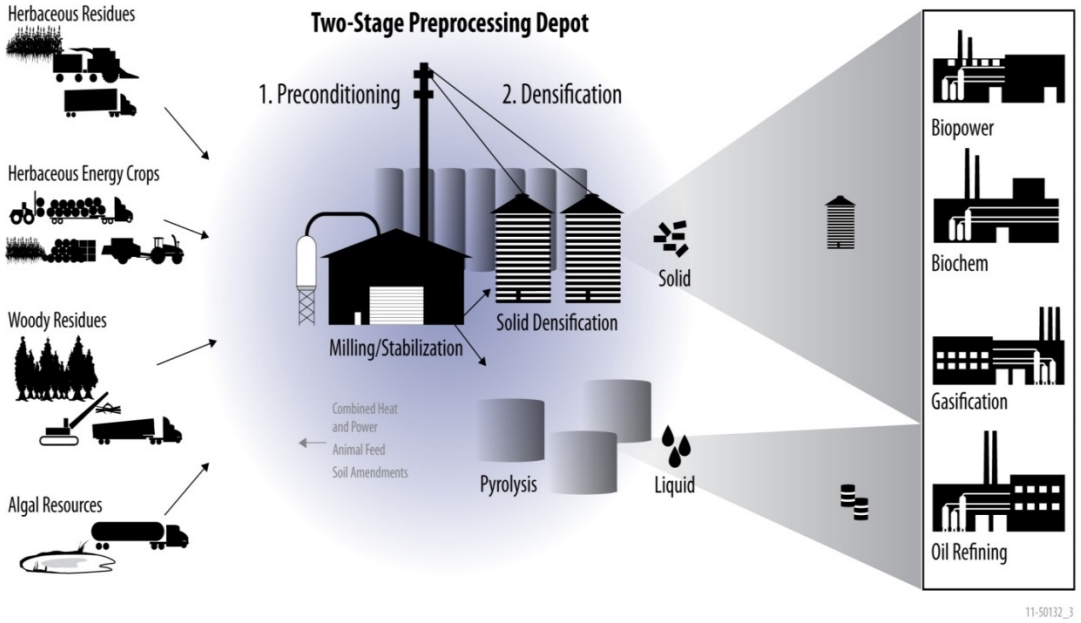
- By eliminating steps in feedstock harvesting and transport, this project saves money by reducing:
  - Machine time
  - Labor costs
  - Costs for fuel to operate the machinery and associated reductions in GHG emissions
- Harvesting in fewer operations means:
  - Potential for less contamination of harvested biomass by soil
  - Less machine travel on the field, which limits soil compaction and helps to maintain soil health, minimize soil erosion, and improve water quality



Tigercat® Tough • Reliable • Productive

Feedstock Supply and Logistics – Future Activities

Objective: *Transform raw biomass into high-density, stable, commodity feedstocks*



Priorities for next 5-10 years

- Identify and validate markets in which logistics can establish a competitive position vs. the current supply and demand
- Enhance the performance of the logistics equipment to efficiently handle different types of regional biomass
- Test and validate at-scale
- Enable national biomass utilization

Advanced logistics work for FY16

- Actively manage feedstock variability and supply uncertainty: downselect to working blends meeting cost, quality, and convertibility targets
- Scale-up: Advanced logistics projects; PDU

Advanced Algal Systems – Program Goals

- **Strategic Goal:** *Develop algae production and logistics technologies that, if scaled-up and deployed, could support the production of **5 billion gallons per year** of **sustainable, reliable**, and **affordable** algae-based advanced biofuels by **2030***
- **Performance Goal:**
  - By **2022**, demonstrate technologies to produce **sustainable** algal biofuel intermediate feedstocks that **perform reliably** in conversion processes to yield renewable diesel, jet, and gasoline fuels in support of BETO's **$3/GGE** advanced biofuels goal

Advanced Algal Systems – Accomplishments

Consortium for Algal Biofuels Commercialization (CAB-Comm)

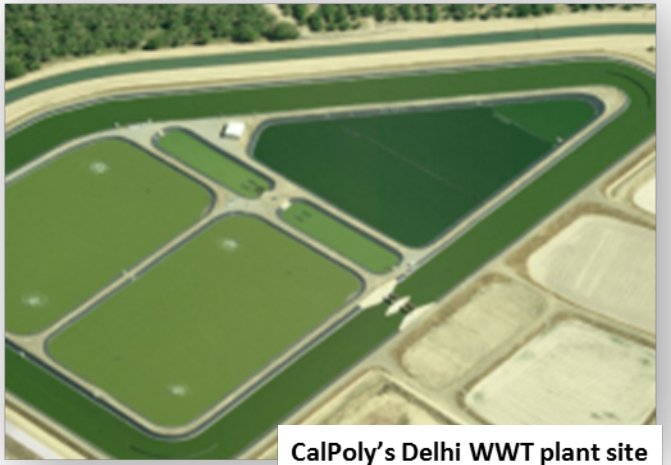
- **Goal:** Increasing biomass productivity and creating advanced biotechnology tools to enable the biofuel and bio-product industries
- **Research Areas:**
  - Crop Protection
  - Nutrient Utilization and Recycling
  - Genetic Tool Development
- **DOE Funding:** $11 million from 2011-2015
- **Impacts:**
  - EPA approved successful outdoor genetically modified (GM) algae test, which paves way for future commercial release.
  - Co-products are now in development with commercial partners.

Scale-up of Algal Biofuel Production Using Waste Nutrients

- **Goal:** Use **wastewaters** as a source of nutrients and water, and CO_2 derived from the combustion of biogas (from **anaerobic digestion** of biomass residues) or from **catalytic hydrothermal gasification**
- **DOE Funding:** $1,480,883
- **Impacts:**
  - Establishment of CalPoly's Delhi Field Site (9,000 L system with continuous automated process controls and harvest equipment at Delhi, CA WWT facility for the ABY project)

Unique Co-product: Surfboards from Algae

These sustainable "surfboards of the future" are made of algal oil, provided by Energy Department-funded and California-based biotech firm Solazyme. The oil is converted to polyols by UCSD chemists and then sent to the surfboard manufacturer Arctic Foam to shape the foam boards and coat them with fiberglass and a renewable plant-based resin.



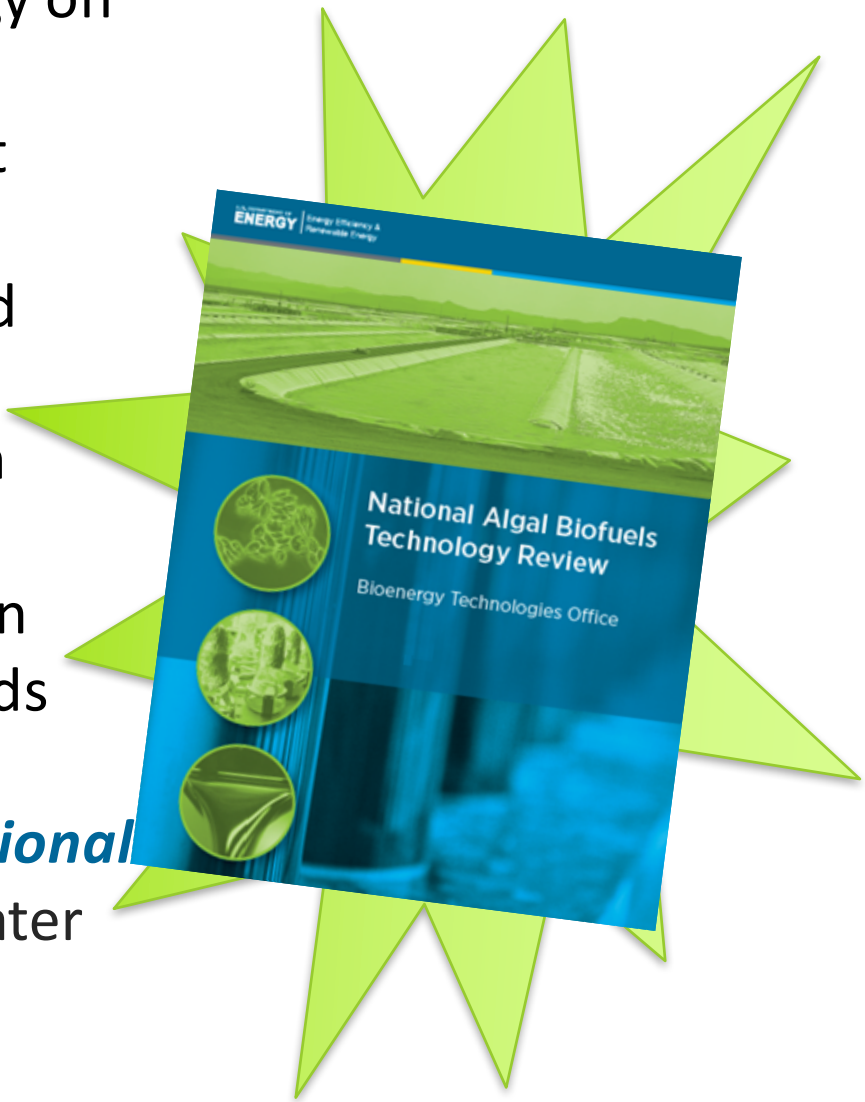
CalPoly's Delhi WWT plant site

CAL POLY
SAN LUIS OBISPO

Advanced Algal Systems – Future Activities

- Coordinate with DOE Fossil Energy on **carbon utilization** activities
- Incorporate **co-products** into cost targets
- Identify key technical barriers and priorities around **algal biology**
- Initiate next phase of research on **yield improvement** through selections of the Advancements in Algal Biomass Yield Phase 2 awards

BETO will be releasing our ***2016 National Algal Biofuels Technology Review*** later this month!



Incorporating Sustainability

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.

Funding Opportunity Announcement: Integrated Biorefineries

Project Development for Pilot- and Demonstration-Scale Manufacturing of Biofuels, Bioproducts, and Biopower

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

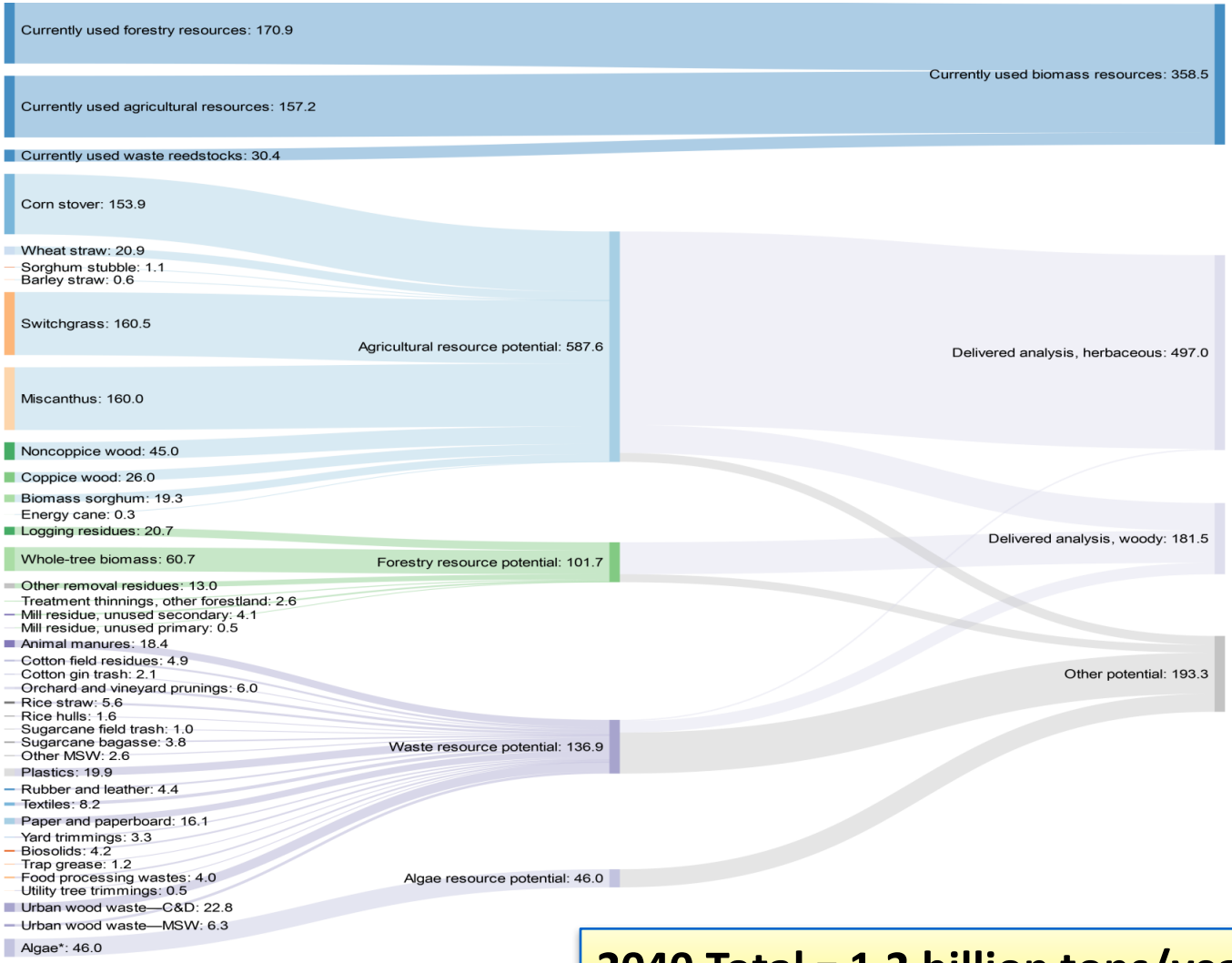
Topic Areas:

1. **Pilot-scale production** of biofuels from **high-impact cellulosic, algal, or biogas feedstocks**. Minimum feedstock throughput is **1 dry metric ton (DMT) per day** or equivalent of algal biomass or biogas.
2. **Demonstration-scale production** of biofuels from **high-impact cellulosic, algal, or biogas feedstocks**. Minimum feedstock throughput must be **50 DMT per day** or equivalent of algal biomass or biogas.
3. **Production of biopower or biofuels** from **biosolids** and other allowable **wet-waste feedstocks**. Minimum feedstock throughput must be **1 DMT per day.**

- **Concept Paper Submission Deadline: 6/6/2016 5:00 PM ET**
- **Full Application Submission Deadline: 7/22/2016 5:00 PM ET**
- **All inquiries must be submitted to PB2B3@ee.doe.gov**

2016 Billion-Ton Report

Sankey Diagram of All Resources up to $60/dry ton in Executive Summary of Billion Ton Update 2016



2040 Total = 1.2 billion tons/year

Volume I to be Released July 2016

Bioenergy 2016 and Sustainable Transportation Summit

Sustainable Transportation Summit 2016

Sustainable TRANSPORTATION

Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

When: July 11 -12, 2016

Walter E. Washington Convention Center, Washington, DC

BIO ENERGY
U.S. DEPARTMENT OF ENERGY
2016

MOBILIZING THE BIOECONOMY THROUGH INNOVATION

JULY 12-14, 2016
Walter E. Washington Convention Center
Washington, DC

CEREF
CLEAN ENERGY RESEARCH & EDUCATION FOUNDATION

Register Today!

ceref.org/bioenergy-2016

Early bird discounts run through June 17!

Register now for a discounted general public rate of $150.

Receive 10% off admission when you register for both together!

Project Partners

BETO works with partners in industry , universities, and the National Labs

Appendices

Inter-Agency Collaboration

Other Federal Agencies

USDA — USDA focuses on feedstock production and rural development, co-chairs the BRDI Board with DOE, and partners with BETO on interagency efforts to support the bioeconomy.

FAA — BETO provides technical expertise on the Farm-to-Fly 2.0 initiative to produce renewable jet fuel.

EPA — The EPA administers the Renewable Fuel Standard and works with BETO on life cycle analysis for different fuel pathways.

DOT — The DOT invests in national infrastructure and works with BETO on challenges related to bioenergy transportation and logistics.

DOD — Under the Defense Production Act, the DOD partners with USDA and DOE to produce drop-in fuels for the military.

NSF — NSF supports innovative chemical, environmental and bio-engineering analysis which informs BETO research.

Key Partnerships of the Bioenergy Technologies Office

Department of Energy

Office of Energy Efficiency & Renewable Energy

Vehicle Technologies Office (VTO)

VTO partners with BETO on fuel and infrastructure characterization and new work on the co-optimization of fuels and engines.

Advanced Manufacturing Office (AMO)

AMO works with BETO to research and develop renewable, low-cost carbon fiber for lightweight vehicles.

Bioenergy Technologies Office (BETO)

BETO's mission is to accelerate the commercialization of advanced biofuels and bioproducts through targeted RD&D supported by public and private partnerships.

The White House Office of Science and Technology Policy

BETO contributes to White House goals for the reduction of GHG emissions and oil imports under the Climate Action Plan.

Fossil Energy — BETO collaborates with the Office of Fossil Energy to utilize biomass for carbon capture.

Office of Science — The Office of Science focuses on early stage basic science with eventual commercial applications for bioenergy.

ARPA-E — ARPA-E invests in innovative technologies including electro-fuels and the PETRO program for direct biofuel production.

ENERGY.GOV Loan Programs Office — The Loan Programs Office provides loan guarantees for commercial biorefinery projects.

EIA — BETO contributes data to the EIA to support their accurate energy forecasting for consumption and production.

National Laboratories

NREL National Renewable Energy Laboratory; INL Idaho National Laboratory; Los Alamos National Laboratory Est. 1943; Oak Ridge National Laboratory; Argonne National Laboratory; Pacific Northwest National Laboratory; Sandia National Laboratories; Brookhaven National Laboratory; Lawrence Livermore National Laboratory; Berkeley Lab Lawrence Berkeley National Laboratory

BETO partners with other DOE Offices, other Federal agencies, and the national labs to achieve U.S. goals on bioenergy

Bioenergy Administration Goals

National Energy Goals & Climate Action Plan

Net Oil Imports	GHG Emissions
50% by 2020	26-28% by 2025 >80% by 2050

BETO Performance Goal: Hydrocarbon Biofuel Production

$3/GGE by 2017	50% GHG reduction vs. petroleum fuel

BETO Performance Goal: Hydrocarbon Pathway Validation

Two Additional Pathways by 2022	Pilot or Demo Scale (>1 ton/day)

BETO's goals support the Presidential Initiatives on Energy

What is the Bioeconomy?

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

OECD: The Bioeconomy to 2030: Designing a Policy Agenda, 2009

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

White House Bioeconomy Blueprint, 2012

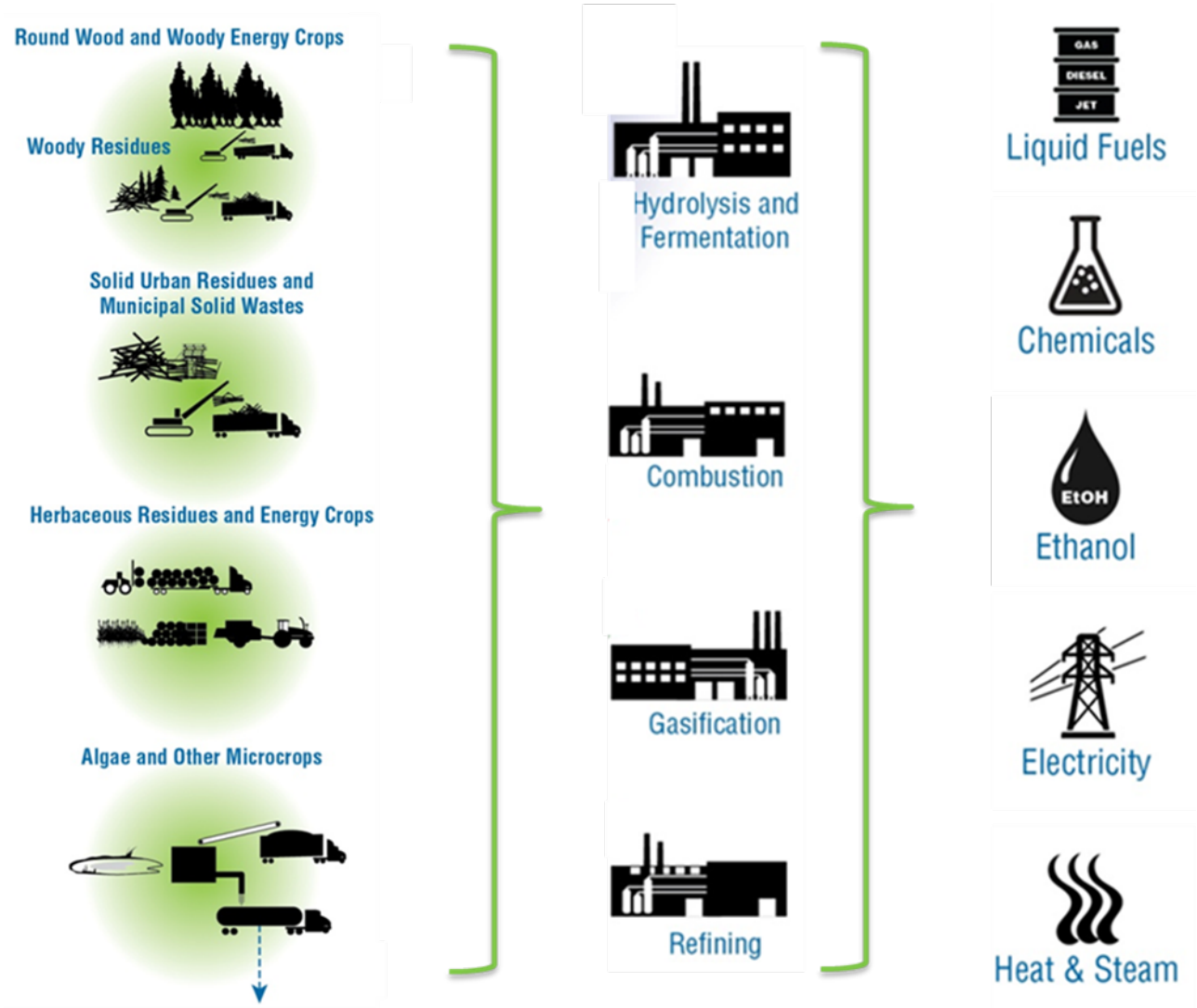
"The U.S. is a world leader in technology and agricultural prowess, which puts it in a powerful position to capitalize on the vast potential of bio-based alternatives to petrochemicals. The potential markets are huge, given the importance of petrochemicals in industrial economies."

Unleashing the Power of the Bio-economy, 2013

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

-- From 2014 Report: Why Biobased? Opportunities in the Emerging Bioeconomy: Why BioPreferred

The Bioeconomy Concept



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

Bioproducts: From Niche to Necessity

- Bioproducts can replace petroleum-based chemicals and products
- Provide much higher value-added margins, relative to transportation fuels
- Bioproducts could be early adopter markets
- Chemicals/products represent **16%** of petroleum consumption and **$812B** in market value
- Fuels represent **76%** of petroleum consumption, and **$935B** in market value


Hydroxypropionic acid


Ethylene glycol


1,3 Propanediol


Hexamethylenediamine

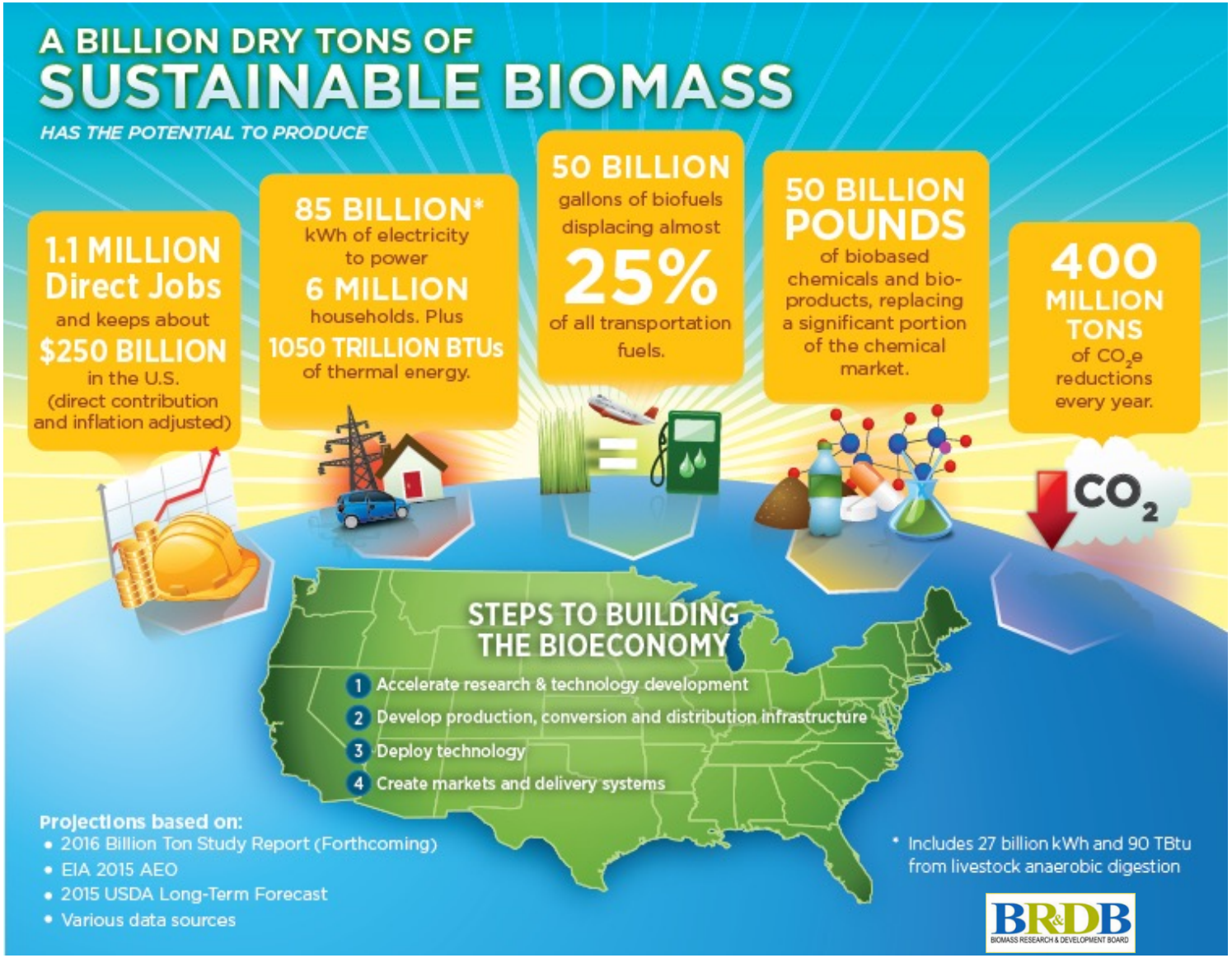

Succinic acid


1,4-Butanediol


Butadiene

Bioproducts can enhance the economics of biofuel production

Potential Impacts of a Billion Ton Bioeconomy



1 billion tons of biomass could be sustainably produced in the U.S.

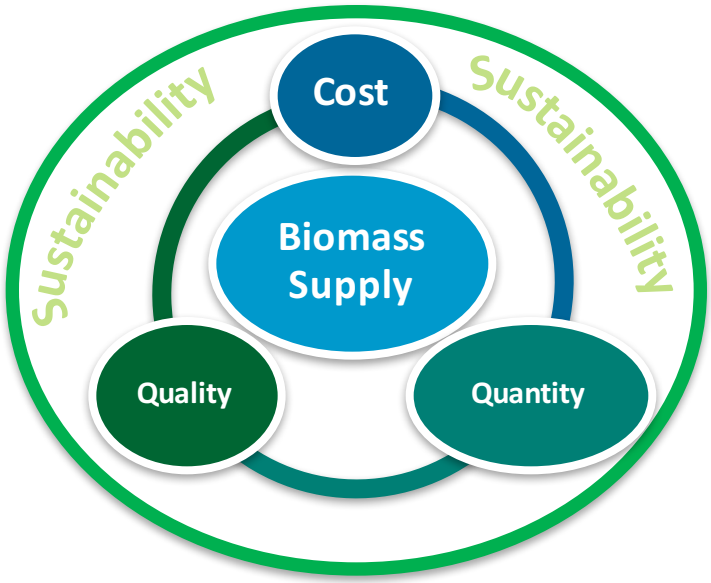
Feedstock Supply and Logistics

Focus

- Fully integrate feedstocks into supply chain (multiple interfaces)
- Reform raw biomass into high-quality feedstocks
- Use innovative technologies to ensure sustainable supply and reduce costs
- Reduce risks to enable industry expansion

Approaches

- Use basic and applied science to understand, model, and manage
- Provide nationally, but solve locally
- Meet environmental performance targets and goals while assuring sustainability
- Work with stakeholders and partners



Overcoming Demonstration and Market Transformation Challenges

Integrated Biorefineries
Validating performance at integrated pilot, demonstration, and pioneer scales is essential to de-risk technology and enable financing that will catalyze the transition to large-scale renewable fuel production.

Infrastructure and End Use
In addition to the significant risks involved with scaling-up new biorefinery technology, other market barriers related to infrastructure and end use also limit advanced biofuel production. Efforts in this area focus on enabling higher rates of renewable fuel usage in current markets while addressing barriers for expansion into new markets.

Feedstocks
Efforts to improve the supply and logistics system are essential for commercial operations. These activities span both terrestrial and algal feedstock systems to identify areas for improvement in feedstock supply and logistics systems and in the development of advanced feedstock logistics systems.

Technology Interface
These activities help identify (1) times when technologies are ready for piloting and scale-up, (2) entirely new feedstock logistics systems or conversion technologies, or (3) improvements to a smaller set of unit operations.

Analysis and Sustainability
Both project-specific and portfolio-wide evaluations assess progress toward objectives and sharpen the focus of DMT strategies on the areas with the highest potential impact to the industry.

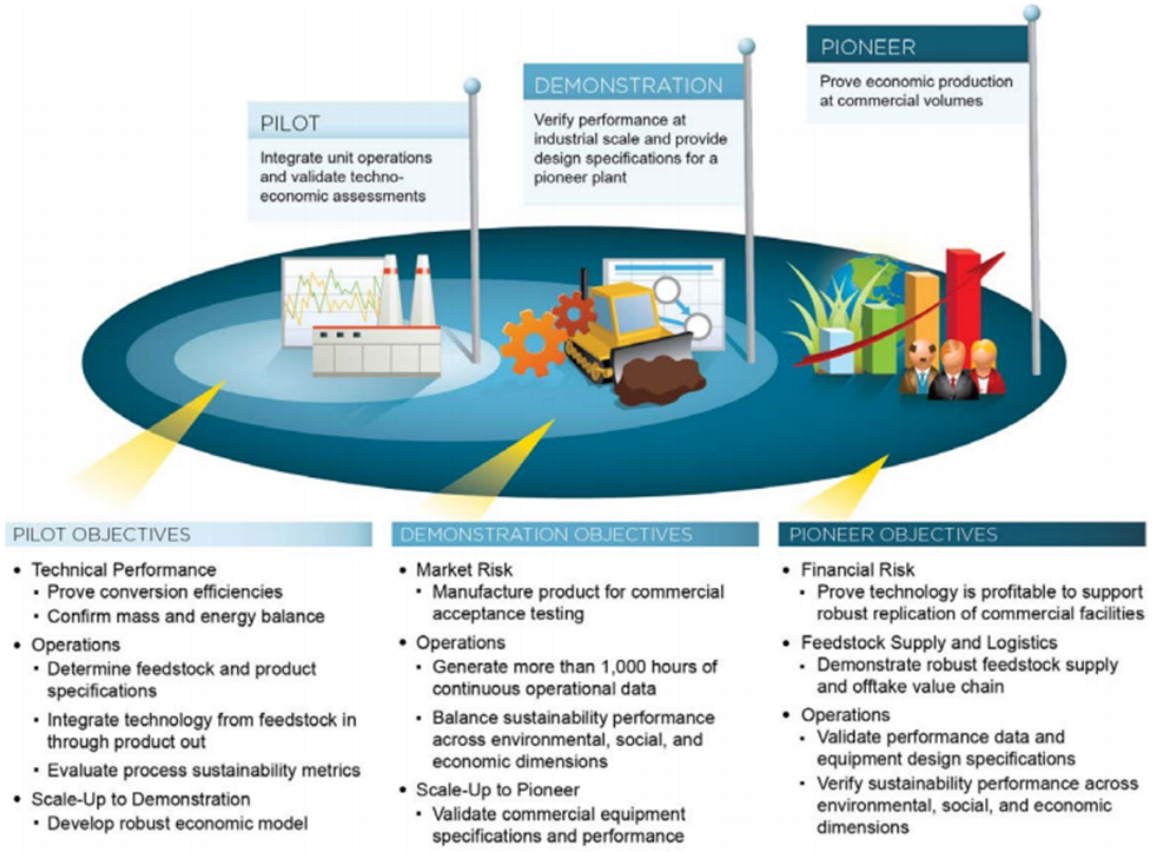


Figure 2-31: Description of key objectives at each integrated biorefinery scale

Funding Opportunity Announcements

Incubator 2

- Up to **$10 million** in funding to **advance the production of advanced biofuels**, substitutes for petroleum-based feedstocks, and **bioproducts** made from renewable, **non-food-based biomass**, such as algae, agricultural residues, and woody biomass.
- **Goal:** To make **drop-in biofuels** more **accessible** and **affordable** and meet the **cost target equivalent** of **$3 per gallon of gasoline by 2022**.
- **Closing Date:** November 13, 2015

Projects Selected:

- **Arizona State University**: Engineer cyanobacteria for the production of ethyl laurate
- **Arizona State University**: Will develop mixotrophic algae which can consume CO_2 and cellulosic sugars, and significantly improve algal biomass growth
- **Duke University**: Will enable a dramatic reduction in costs for commercial-scale biorefineries through "dynamic metabolic control"
- **Lygos, Inc.**: Will develop microbial catalysts to convert renewable cellulosic sugars into higher-value commodity and specialty chemicals.
- **White Dog Labs**: Will develop new metabolic pathways in microorganisms so that they can concurrently consume a cellulosic sugar feedstock and CO_2, thus limiting the amount of CO_2 released from the process
- **LanzaTech, Inc.**: Work on technology to enable manufacturing of the high-value industrial chemical building block, acetone, via biomass-derived syngas

Integrated Biorefinery Tiger Team

- Since 2006, BETO has been substantially involved in the development of first-of-a-kind integrated biorefinery projects.
- The BETO Demonstration and Market Transformation (DMT) program created the Integrated Biorefinery (IBR) Tiger Team to understand lessons learned and key stakeholder issues and to inform how BETO can provide the support to the industry.
- Site visits and in-person tours were conducted at the following facilities:
  - Abengoa Bioenergy Biomass of Kansas in Hugoton, KS on February 25-26, 2016
  - INEOS in Vero Beach, FL on March 8, 2016
  - POET-DSM in Emmetsburg, IA on March 15, 2016
  - DuPont in Nevada, IA on March 17, 2016

Prominent Feedstock Issues Identified by the Tiger Team

- Use of equipment that was originally designed for different feedstock types (grain, pulpwood chips, etc.)
- Insufficient piloting of feedstock handling or pretreatment equipment using the actual feedstock
- Lack of understanding of feedstock characteristics (viz. bulk density, angle of repose, effect of moisture, abrasiveness, regional soil composition, inert materials and ash content, etc.) and their effect on equipment and conversion processes
- Inability to produce and maintain a consistent particle size distribution that allow for optimized operations
- Inadequate removal of dirt and rock from the feedstock leading to equipment erosion, breakage, and fouling
- Process interruption due feedstock bridging, bird-nesting, binding or plugging;
- Creation of fines and/or the inability to remove fines resulting in yield loss, inhibitor creation, and fouling
- Need for improvements in feedstock logistics (collection methods, moving bales, clean storage of bales, fire detection/suppression, etc.)

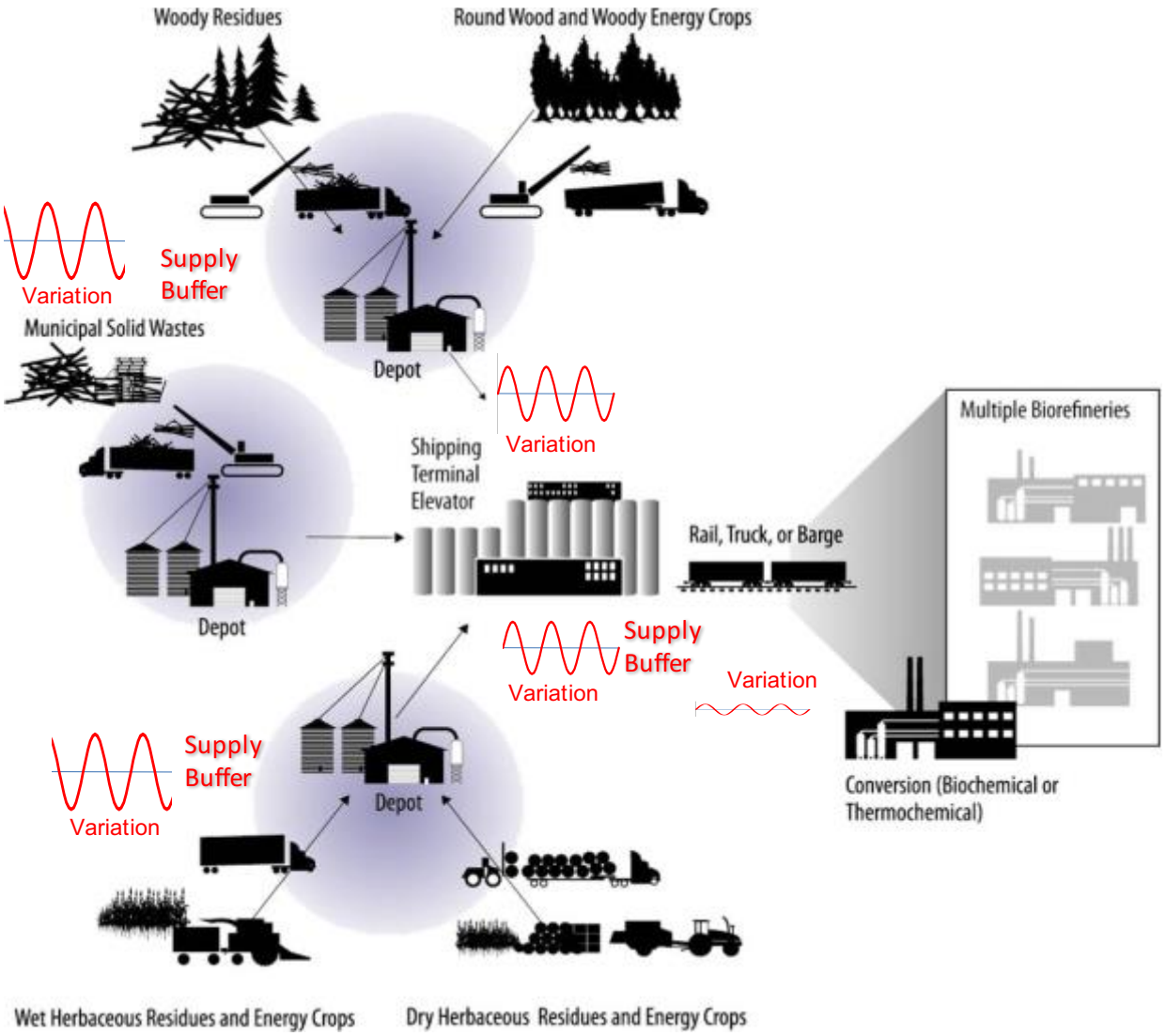
Industry Feed Handling Challenges

- Moisture
  - Grinder throughput
  - Particle size variability
  - Variation causes inconsistent mass and heat transfer in conversion
- Particle Size
  - Large particles (aka pin chips)
    - Cause plugging problems in bins, augers
    - Do not fully cook – plugging in downstream equipment, microbial contamination
  - Fine particles
    - High in ash
    - Dust-fire, explosion, and health hazards
    - Plugging of weep holes in digesters
    - Buffering capacity, increase chemical usage
  - Variation causes inconsistent mass and heat transfer in conversion
- Foreign material (dirt, metal)
  - Plugging, equipment wear

How Has the Biofuels Industry Responded?

- Two choices given the lack of theoretical understanding of particle processes
  - Duplicate existing designs & technology
  - Pilot plant experience
- Investigation of today's demonstration and commercial cellulosic ethanol plants will show
  - Though they piloted their conversion technology, the integrated feed processing and handling was not piloted
  - Most (if not all) have attempted to duplicate existing designs
  - Most probably conducted vendor testing as a substitute for piloting

Decoupling Feed Processing from Conversion



- Wide-spread, interconnected supply network
- Stable, flowable, consitent, and ***conversion-ready*** feedstocks
- Reduced feedstock variability in quantity, quality, cost

Decoupling does not solve the feed handling problem, but it does reduce conversion plant downtime.

Request for Information (RFI) – Biomass Supply Systems

Revolutionary Biomass Supply Systems Supporting a Billion Ton Bioeconomy Vision

- **Duration:** June 8 – June 30, 2016
- **Audience:** Industry, academia, research laboratories, government agencies, and other stakeholders
- **Purpose:** Identify information about current high-technology operations, improved equipment and processes, as well as barriers and solutions associated with the collection/harvest, storage, preprocessing, and transportation of increasing volumes of biomass
- **Categories:**
  1. Preprocessing Technologies
  2. Quality Management
  3. Strategies for Mobilizing a Billion Tons of Biomass

Funding Opportunity Announcements

MEGABio: Bioproducts to Enable Biofuels

- **$11.3 million** in funding to **develop flexible biomass-to-hydrocarbon biofuels** conversion pathways that can be modified to produce advanced fuels and/or products based on external factors, such as market demand.
- **Goal:** **Meet the 2022 cost target** of **$3/gasoline gallon equivalent** (gge) for the production of renewable hydrocarbon fuels from lignocellulosic biomass and other types.
- **Closing Date:** April 15, 2016

Stakeholder feedback on bioproducts solicited in a July 2015 workshop. Workshop report can be found here or on the BETO website under Information Resources -> Publications.

Funding Opportunity Announcements

Advancements in Algal Biomass Yield Phase II (ABY2)

- Up to **$15 million** in funding to **develop technologies** that are likely to succeed in **producing 3,700 gallons of algal biofuel intermediate** (or equivalent dry weight basis) **per acre per year** (gal/acre/yr.) on an annualized average basis (not peak or projected) through multiple batch campaigns or on a semi-continuous or continuous basis, in an outdoor test environment.
- **Goal:** Achieve **3,700 gallons of algal biofuel per acre by 2020.**
- **Closing Date:** March 25, 2016

DOE-Supported Cellulosic Ethanol Biorefineries

DuPont

- Nevada, Iowa
- Opened October 2015
- 30 MGY of cellulosic ethanol from corn stover

POET-DSM Project Liberty

- Emmetsburg, Iowa
- Opened September 2014
- 25 MGY of cellulosic ethanol from corn stover

INEOS

- Vero Beach, Florida
- Opened July 2013
- 8 MGY of cellulosic ethanol from vegetative waste

Abengoa

- Hugoton, Kansas
- Opened October 2014
- 25 MGY of cellulosic Ethanol from corn stover

1993	2003	2007	2009	2013	2014	2015
INEOS wins DOE-SBIR Grant	Abengoa builds DOE-supported pilot plant in York, Nebraska	Abengoa and POET win awards funded under EPACT05	INEOS wins ARRA Grant	INEOS Opens	POET and Abengoa Open	***DuPont Opens***

After decades of DOE partnerships, 4 commercial scale biorefineries have begun production

Defense Production Act (DPA) Initiative

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

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

Company	Location	Feedstock	Capacity	Groundbreaking	Off-Take Agreements
Emerald Biofuels	Gulf Coast	Fats and Greases	82 MM g/y	TBA	TBD
Fulcrum Bioenergy	McCarran, NV	MSW	10 MM g/y	Spring of 2016	United, Cathay Pacific
Red Rock Biofuels	Lakeview, OR	Woody Biomass	12 MM g/y	TBA	Southwest Airlines

Interagency initiative to produce more than 100 MM g/y of advanced biofuels

Federal Activities Report on the Bioeconomy

- On February 18th, the Biomass R&D Board released the Federal Activities Report on the Bioeconomy (FARB).
- This report aims to educate the public on the wide-ranging, federally funded activities that are helping to bolster the bioeconomy.
- The FARB details a vision for a Billion Ton Bioeconomy—tripling the size of today's bioeconomy by 2030.
- Achieving this vision would provide economic, environmental, and social benefits, including a considerable reduction in GHG emissions.
- The FARB has been promoted through USDA and DOE blogs and social media, and has been picked up by leading bioenergy digests and websites including Biofuels Digest, Renewable Energy World, and Bioenergy Industrial Organization.

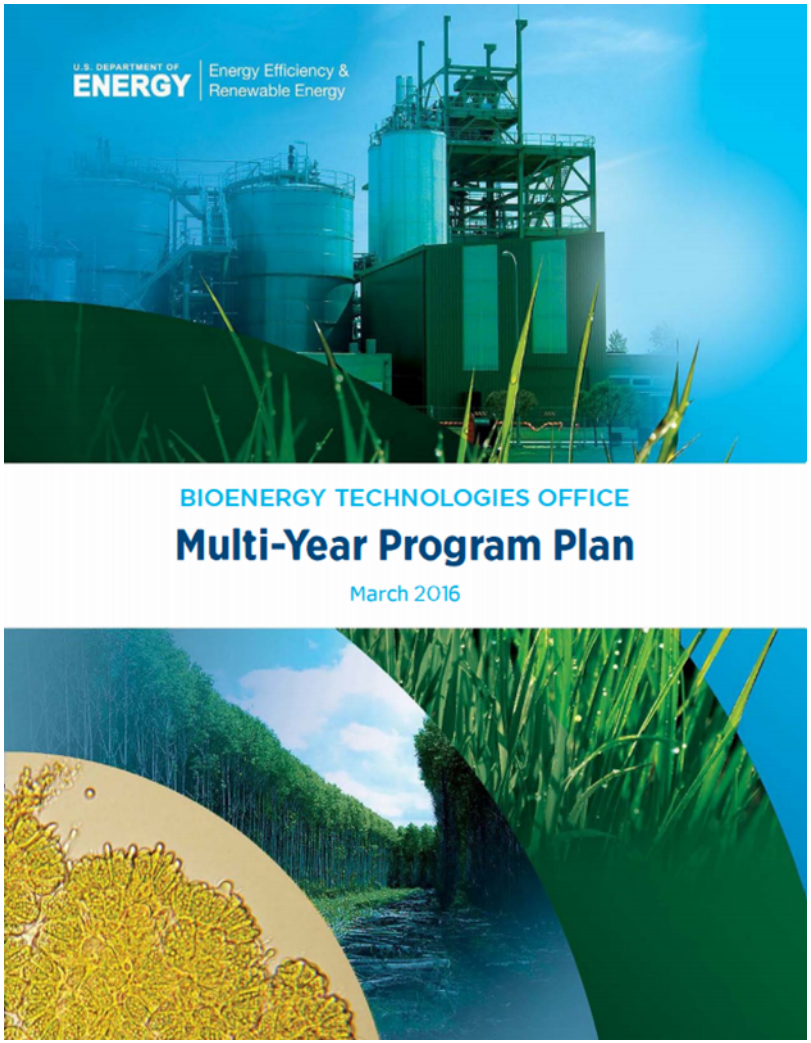
BR&DB
BIOMASS RESEARCH & DEVELOPMENT BOARD

Multi Year Program Plan (MYPP) March 2016 Update

Key Changes:

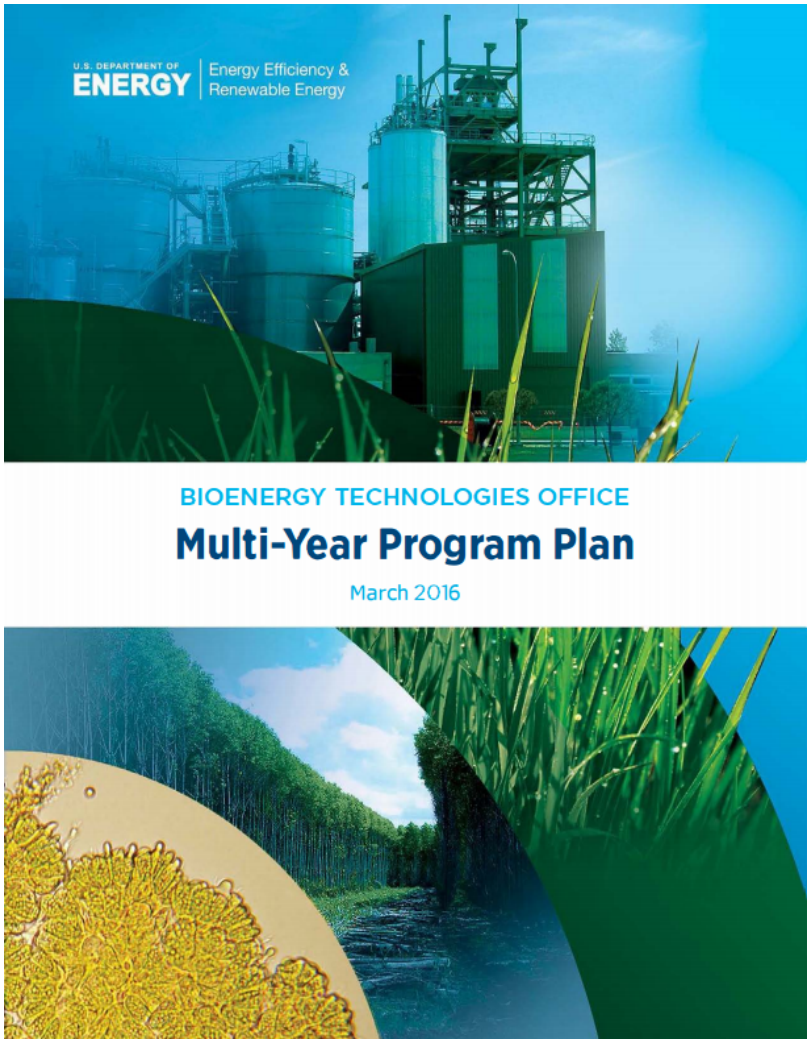
- ✓ Revised BETO vision and mission
- ✓ Added Algae Farm design case
- ✓ Added new IBR strategy & related analysis results
- ✓ Added and updated program milestones
- ✓ Updated costs to 2014$

The MYPP 2016 Update is available at:
energy.gov/sites/prod/files/2016/03/f30/mypp_beto_march2016_2.pdf



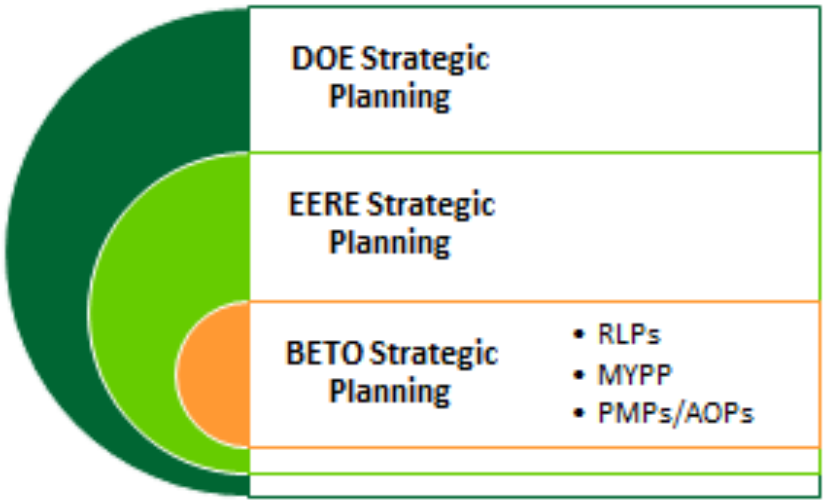
Purpose of Multi Year Program Plan (MYPP)

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

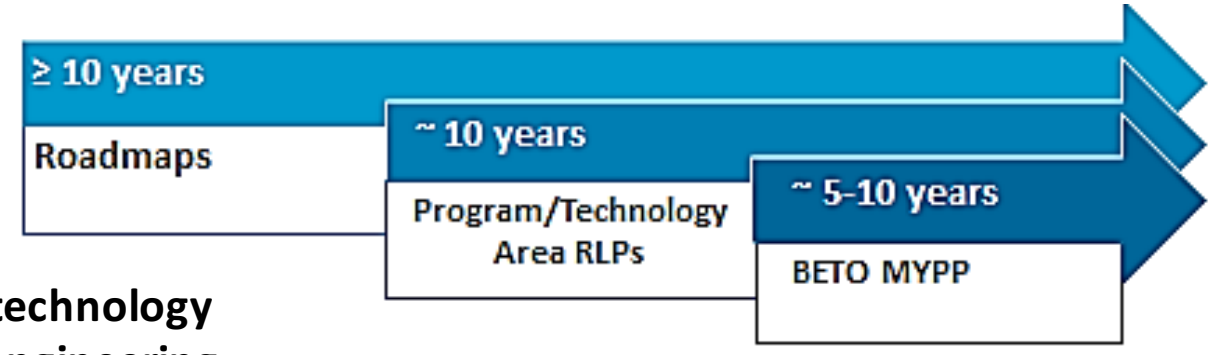


BETO Strategic Planning – Overview

- **Continuous process**
- **Provides framework**
  - Alignment with EERE/DOE/Federal goals
  - Interactions with stakeholders
  - Inter- and intra-office collaborations/discussions across technology areas
  - Alignment of Office activities from project level to multi-year goal horizons



- **Purpose**
  - Align objectives and activities across multiple stakeholders and interests
  - Document goals, current state of technology, and strategic plans
  - Inform budget processes
  - Track progress
  - Integrate learning

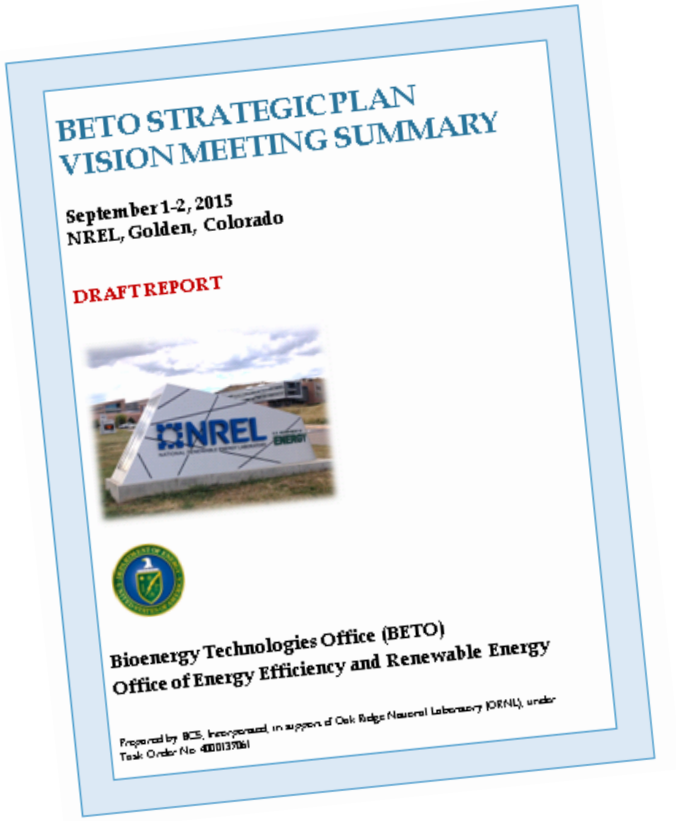


- **Based on best practices for technology R&D planning and systems engineering**

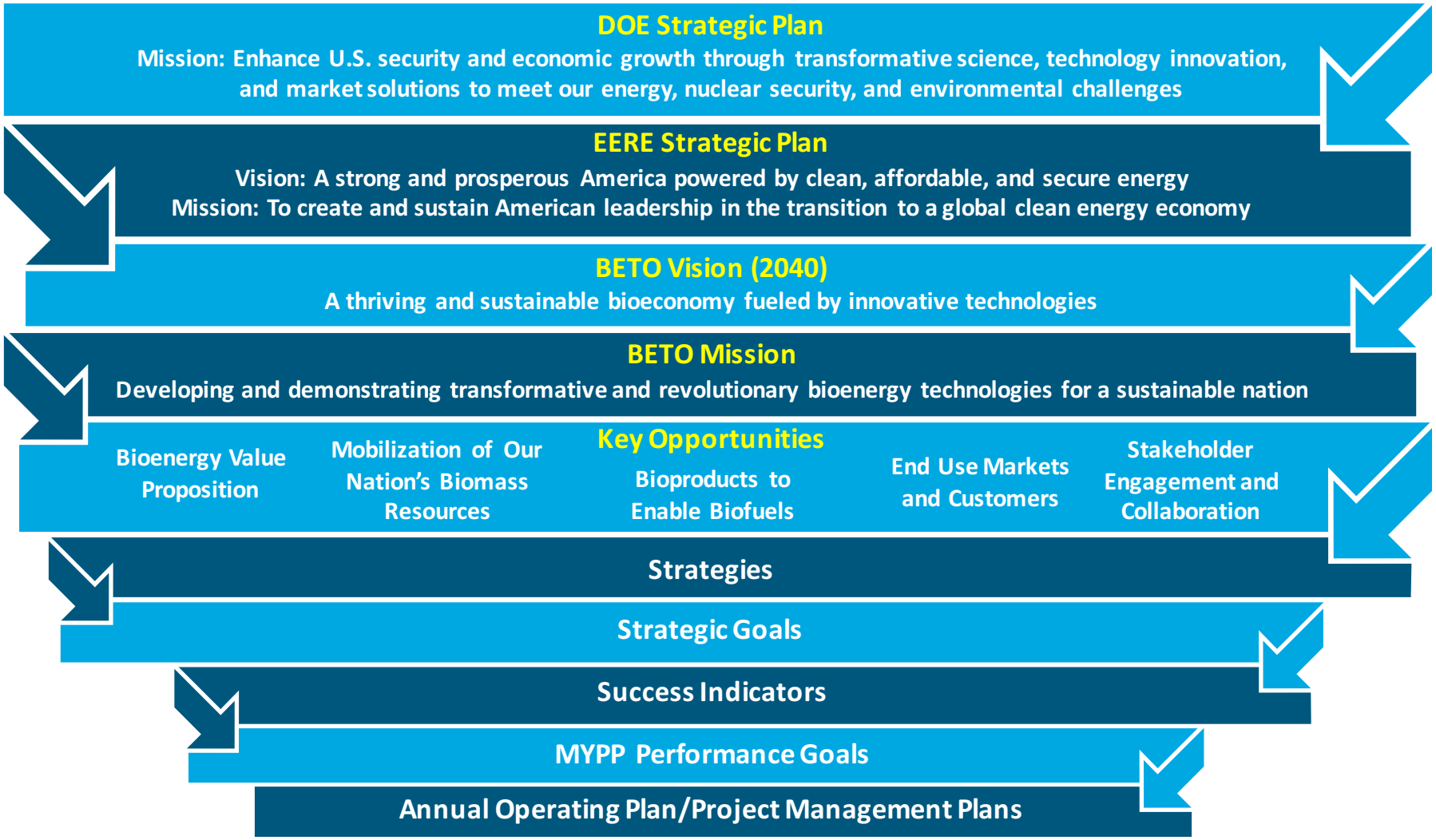
BETO Strategic Plan

Strategic Planning in Process

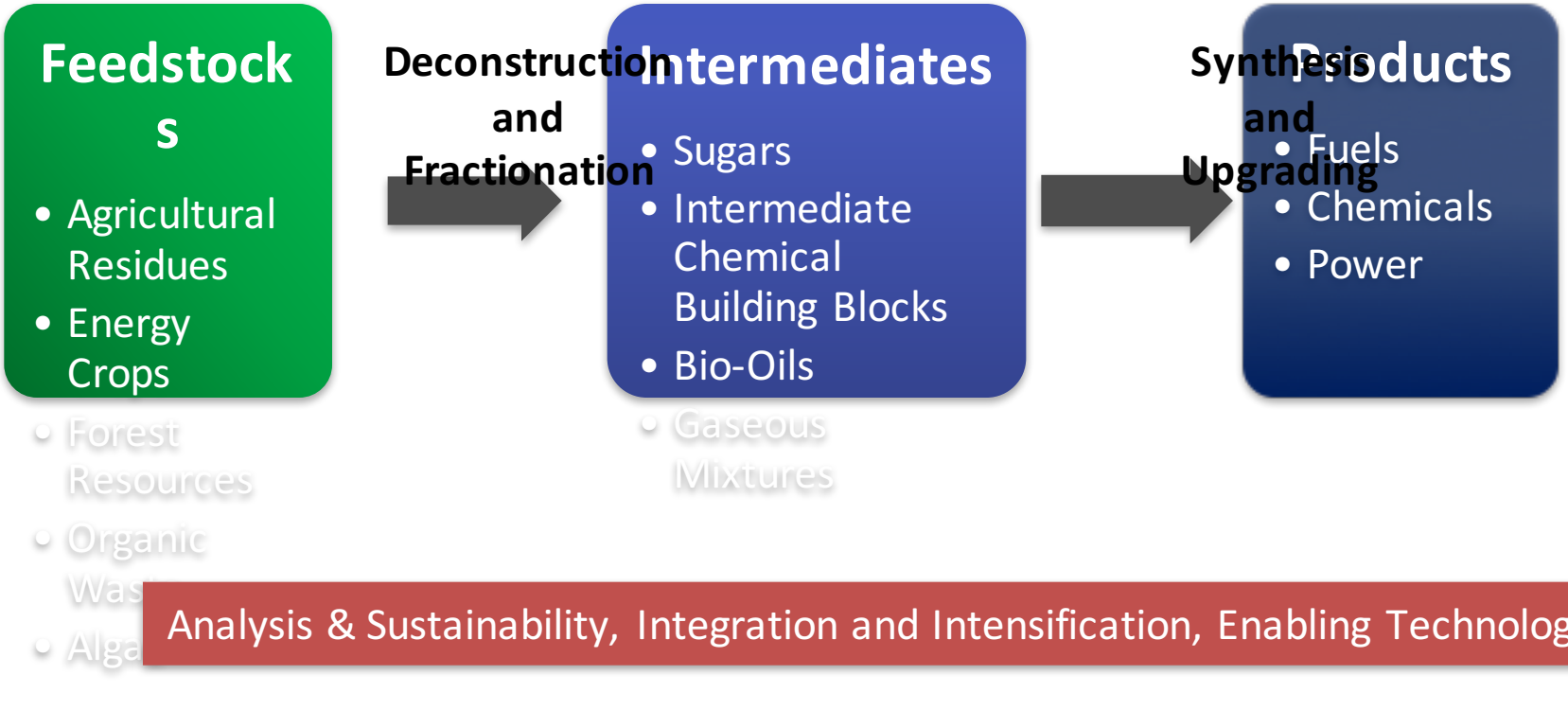
- Numerous focus group meetings held March – October 2015
- Visioning Meeting held September 1-2 in Golden, Colorado to outline new vision and mission statements
- Produced a draft Visioning Report to outline boundaries, visioning process, and SWOT analysis
- Strategic Goal Setting Meeting held December 8, in Arlington, VA, with BETO and external stakeholders to establish objectives and goals
- Now, taking this input and crafting the framework for the draft Strategic Plan report.



BETO Strategic Plan Linkages



Overview of Conversion Research & Development



Strategic Goal: Develop commercially viable technologies for converting biomass feedstocks via biological and chemical routes into energy-dense, fungible, finished liquid transportation fuels such as renewable gasoline, diesel, and jet fuel, as well as bioproducts or chemical intermediates and biopower.

FY15 DOE BRDI Selections

- **Announced on May 9, 2016 by Dr. Danielson; with total DOE funding of $3M**
- **DOE Selections**
  - **The Ohio State University (OSU)** – The OSU project is titled "Biomass Gasification for Chemicals Production Using Chemical Looping Techniques." OSU proposes to develop the biomass to syngas (BTS) chemical looping process for efficient production of value-added chemicals and liquid fuels from biomass. This BTS process is expected to deliver high quality syngas from biomass in a single step, with a potential to reduce capital costs for syngas production by 44% compared to conventional processes.
  - **Massachusetts Institute of Technology (MIT)** – The MIT project is titled "Improving Tolerance of Yeast to Lignocellulose-derived Feedstocks and Products." The primary goal of this research is to enhance production of cellulosic ethanol by improving tolerance towards three common inhibitors during cellulosic ethanol production. This same tolerance mechanism is expected to also enhance production of products beyond ethanol, such as monoethylene glycol, an important precursor material used in the production of bottling, fabrics, and anti-freeze.

FY15 USDA BRDI Selections

Feedstock Development	
North Carolina Biotechnology Center	Mid-Atlantic Biomass Sorghum Collaborative to Optimize Agronomic Production and Grower Profitability
University of Montana	Forest Bioenergy and Biofuels Integration: Sustainability, Energy Balance, and Emissions from Forest Restoration in the Southern Rocky Mountains
Biofuels and Biobased Products Development	
Dartmouth College	Cotreatment of Low-Cost Fermentation of Cellulosic Biomass
University of California-Riverside	Integrated Biorefinery to Produce Ethanol, High Value Polymers, and Chemicals from Lignocellulosic Biomass
Biofuels and Biobased Products Development Analysis	
SUNY-ESF	Development of Stochastic Techno-Economic and Life Cycle Models for Quantifying the Economic and Environmental Costs of Cellulosic Bioenergy Pathways

FY16 Release 2 Phase I SBIR/STTR BETO Selections

Design and Fabrication of Solids Handling for Biomass Conversion Systems	
Altex Technologies Corporation, Sunnyvale, CA	Innovative Feeding System (IFS) for Biomass
Shockwave, LLC, Des Moines, IA	Fractionation and Dehydration of Existing Feedstock for Biomass and Biopower Production
Liquefaction of Wet Organic Waste Streams using Sub- and Supercritical Fluids	
CF Technologies, Inc., Hyde Park, MA	Supercritical transesterification of brown grease to produce biodiesel
Dynaflow, Inc., Jessup, MD	Enhanced Subcritical Water Extraction of Biomass From Wet Organic Wastes using Hydrodynamic Cavitation
Mainstream Eng. Corp, Rockledge, FL	Hydrothermal Liquefaction of Food Waste to Produce Biocrude
Co-utilization of CO_2 and CH_4 to Produce Biofuel and Bioproduct Precursors	
Microvi Biotech Inc., Hayward, CA	Consortium-Based Conversion of CO_2 and CH_4 from Biogas into Butyric Acid
MOgene Green Chemicals, Saint Louis, MO	Engineered Methanotrophs to Convert CO_2 and CH_4 from Biogas into Bioproducts
Nexceris, LLC. Lewis Center, OH	Thermochemical Conversion of CO_2 and CH_4 from Biogas to Liquid Fuels Using Superior Catalysts