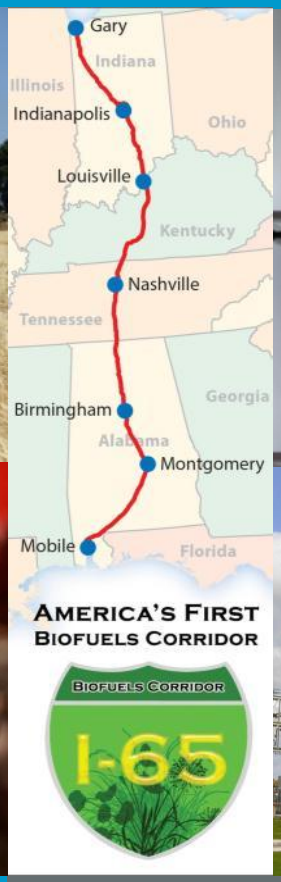
BIOENERGY TECHNOLOGIES OFFICE (BETO)

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



BETO Peer Review

3/23/2015

Jonathan L. Male

Director,
Bioenergy Technologies Office

2015 PROJECT PEER REVIEW

March 23-27, 2015, Hilton Mark Center
Alexandria, VA

Outline

I. Overview
II. BETO's Goals and Mission
III. 2015 Project Partners
IV. Review By the Numbers
V. Program Management Review
VI. Changes Implemented in Response to the 2013 Peer Review

The Challenge and the Opportunity

THE CHALLENGE

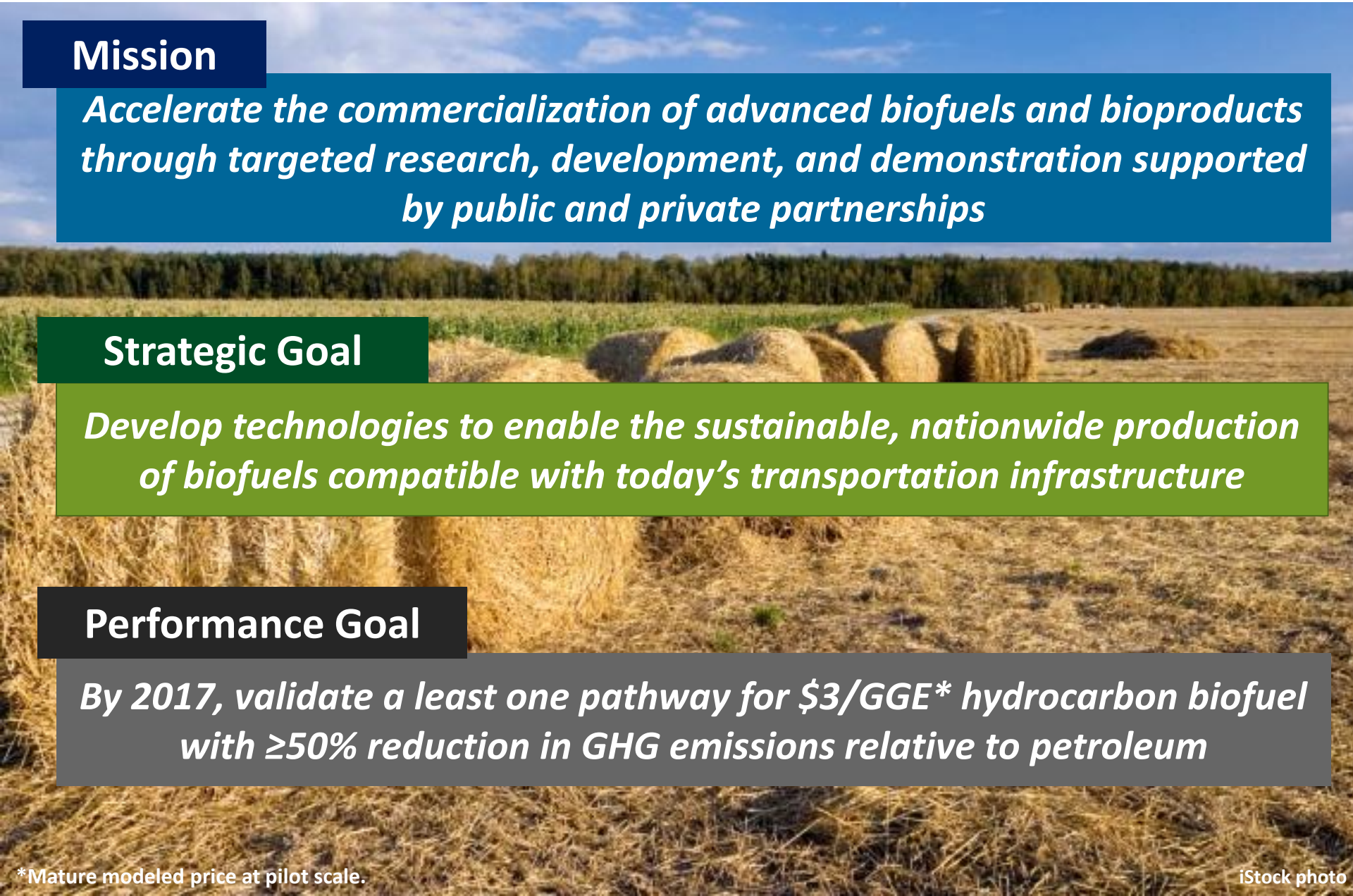
- U.S. gasoline consumption is 8.5 million barrels/day
- 67% of U.S. petroleum consumption is in the transportation sector

THE OPPORTUNITY

- More than 1 billion tons of biomass could be sustainably produced in the U.S.
- 1 billions tons of biomass could displace 30% of U.S. petroleum use by 2030

Biofuels could displace 30% of liquid transportation fuels

Bioenergy Technologies Office



Mission

Accelerate the commercialization of advanced biofuels and bioproducts through targeted research, development, and demonstration supported by public and private partnerships

Strategic Goal

Develop technologies to enable the sustainable, nationwide production of biofuels compatible with today's transportation infrastructure

Performance Goal

By 2017, validate a least one pathway for $3/GGE* hydrocarbon biofuel with ≥50% reduction in GHG emissions relative to petroleum

*Mature modeled price at pilot scale.

iStock photo

Bioenergy Technologies Office's Core Focus Areas

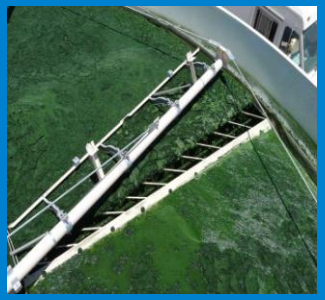
Program Portfolio Management

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

Research, Development, Demonstration, & Market Transformation

Feedstock Supply & Logistics R&D

- Terrestrial
- Algae
- Product Preprocessing



Conversion R&D

- Biochemical
- Thermochemical
- Deconstruction
- Biointermediate
- Upgrading

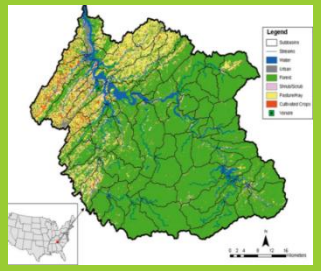
Demonstration & Market Transformation

- Integrated Biorefineries
- Biofuels Distribution Infrastructure

Cross Cutting

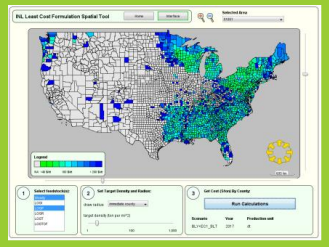
Sustainability

- Sustainability Analysis
- Sustainable System Design



Strategic Analysis

- Technology and Resource Assessment
- Market and Impact Analysis
- Model Development & Data compilation



Strategic Communications

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

Assistant Secretary Dr. David Danielson's Five Questions

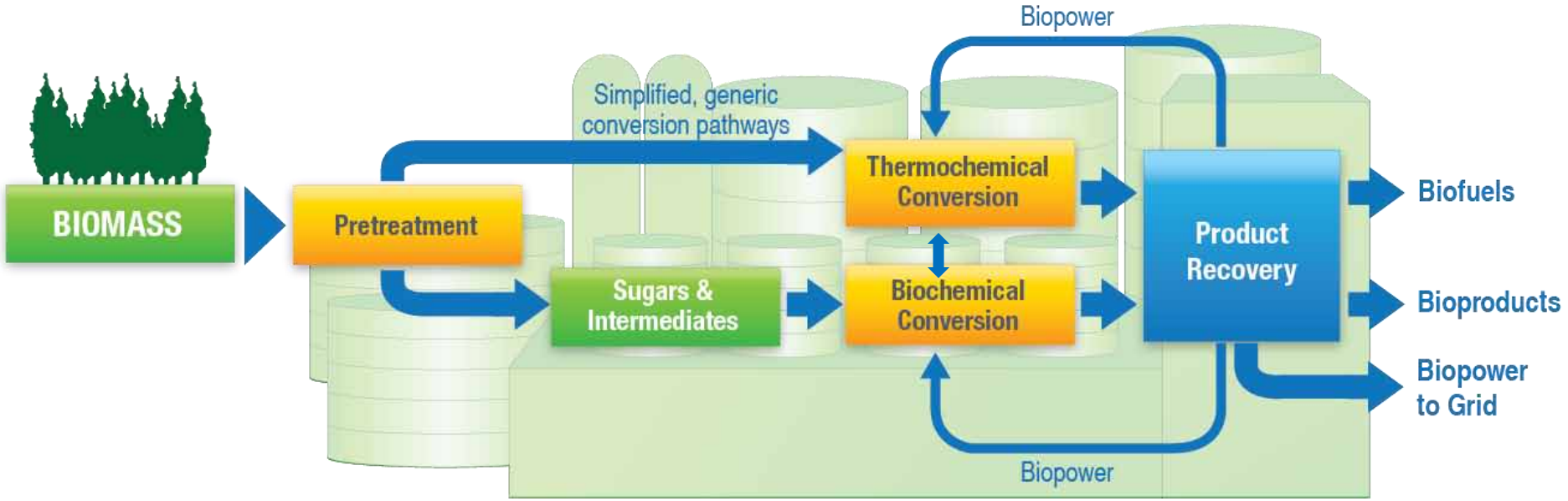
- **HIGH IMPACT:** Is this a high impact problem?
- **ADDITIONALITY:** Will the EERE funding make a large difference relative to what the private sector (or other funding entities) is already doing?
- **OPENNESS:** Have we made sure to focus on the broad problem we are trying to solve and be open to 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

Key Challenge for Innovation Involves Lowering Risks

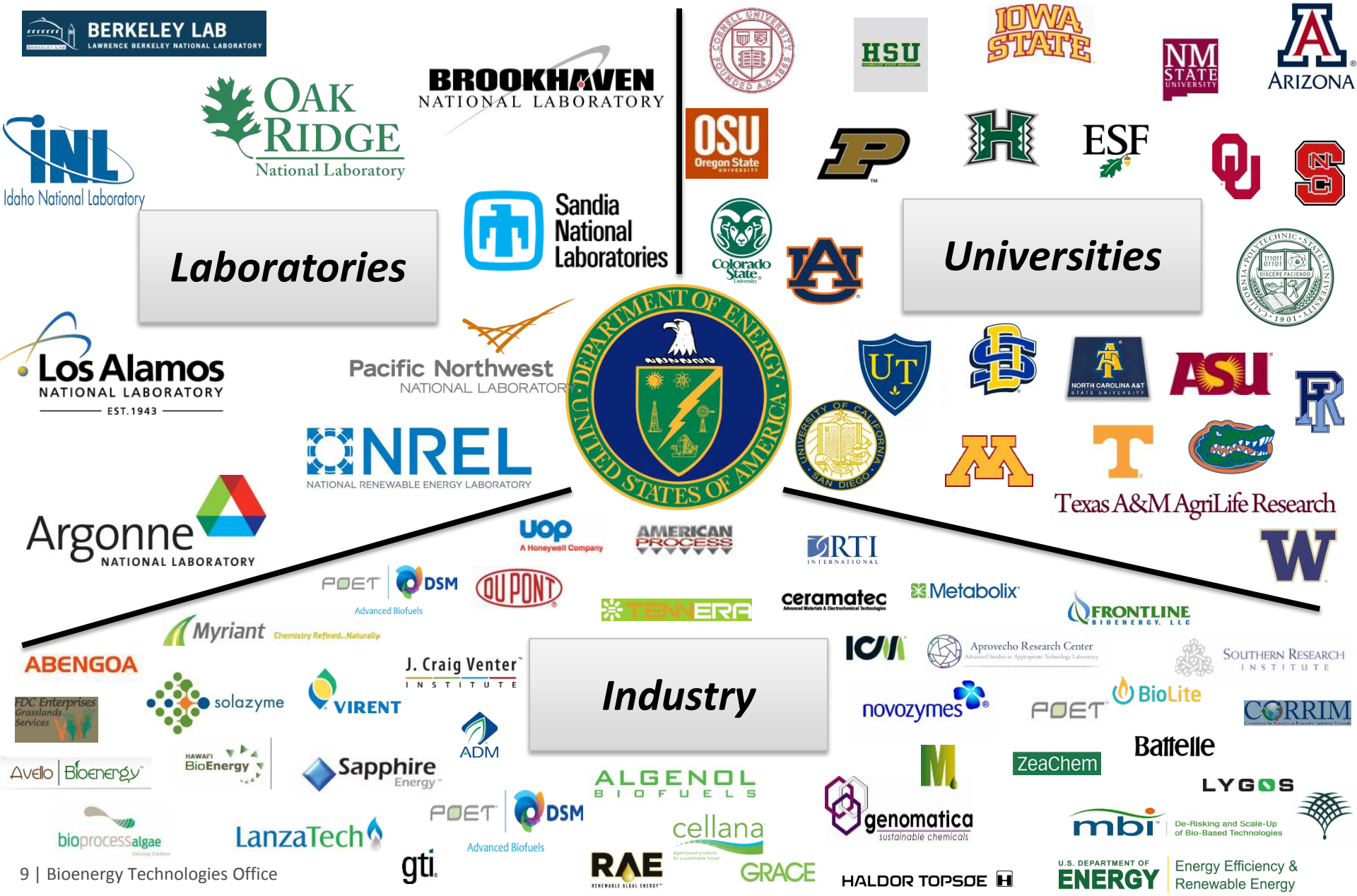
De-risking technologies is central to R&D through demonstration that addresses greater integration and scale:

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

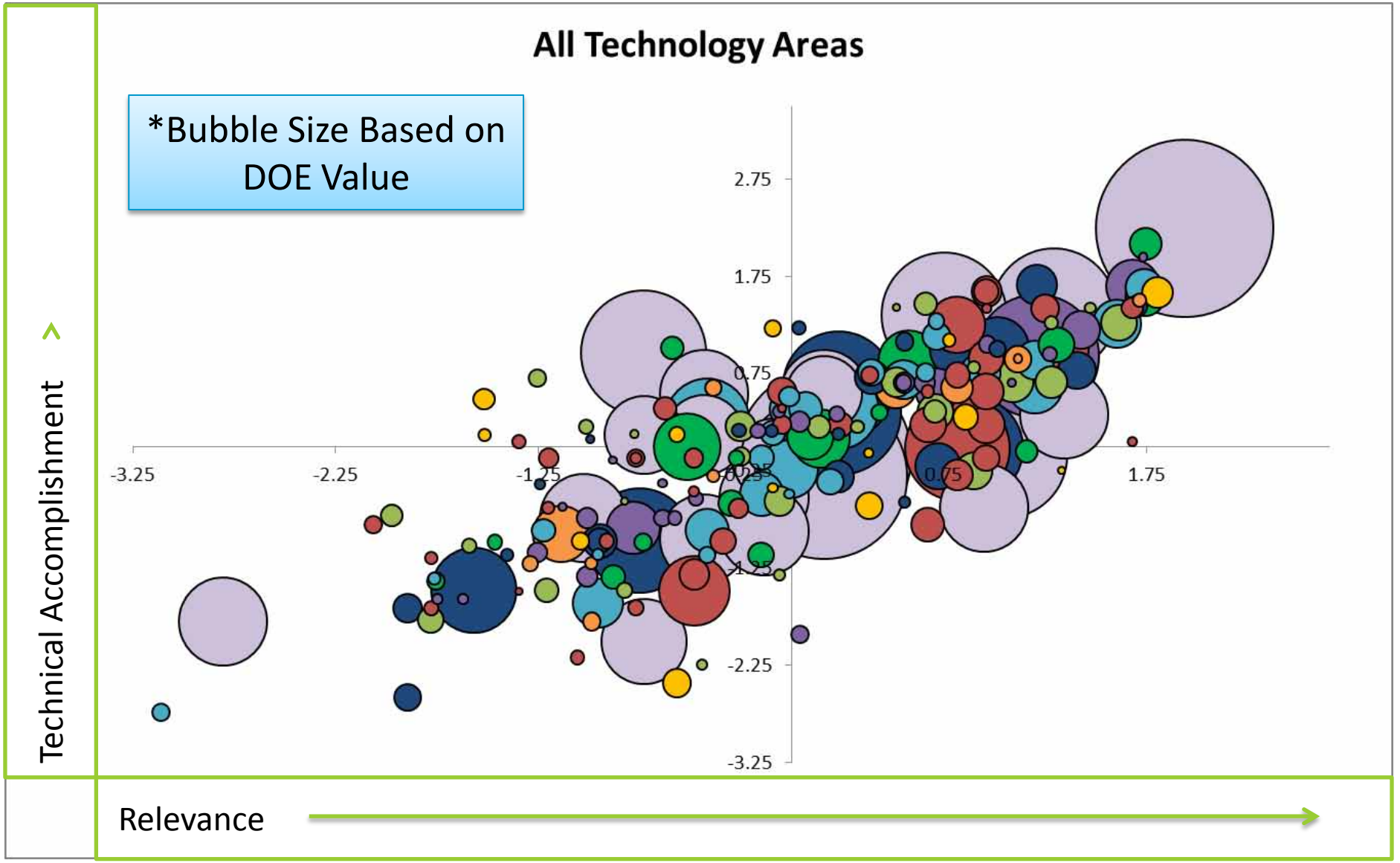


Key Challenges			
Biomass	**Pretreatment**	**Conversion**	**Product**
• Reliable supply • Consistent quality • Affordable delivery	• Biomass feeding, sizing and moisture • Solids handling • Construction materials	• Products Yields • Construction materials • Catalysts • Fermentation organisms	• Separations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

Project Partners



2013 Project Results



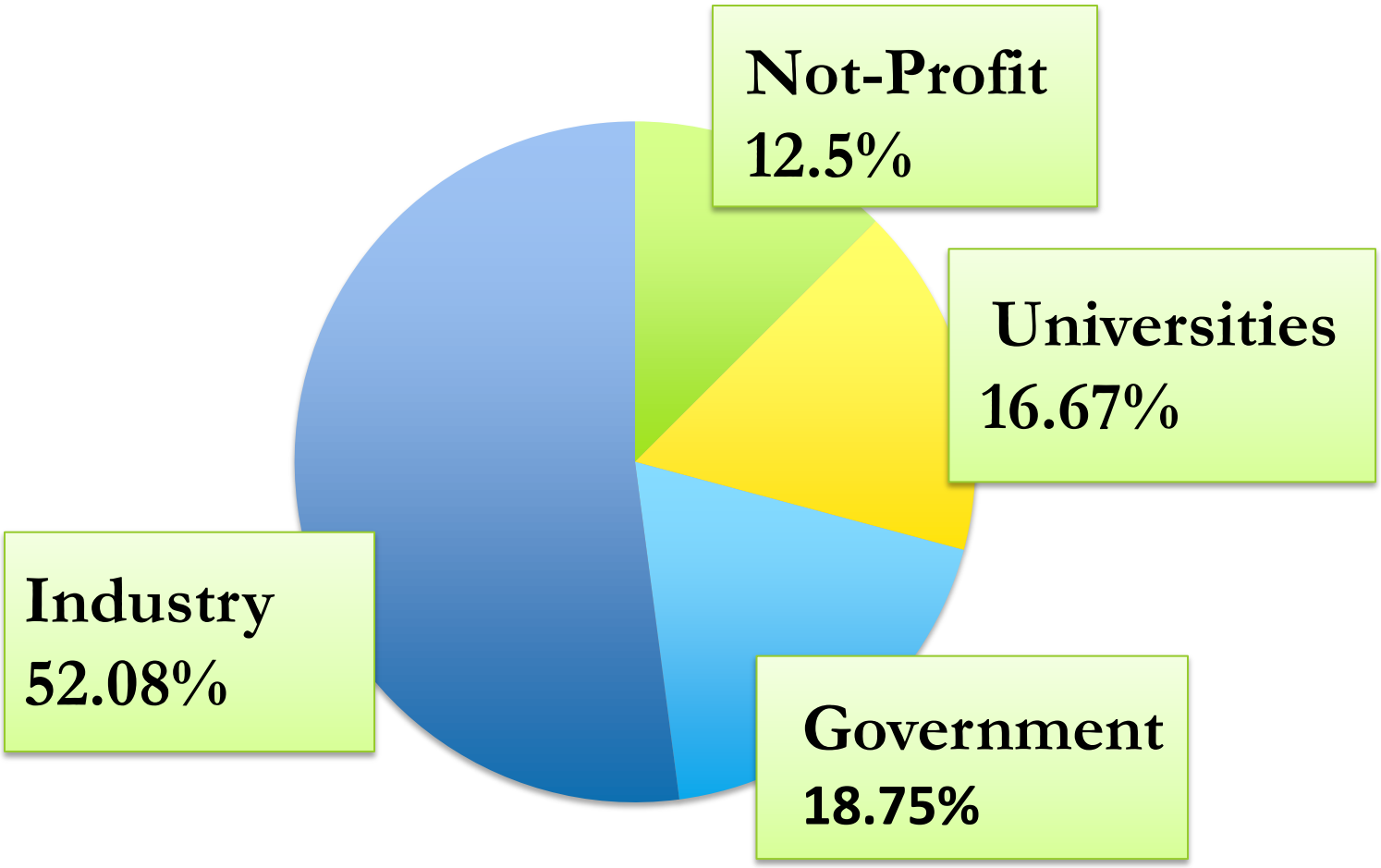
2015 Steering Committee

A special thanks to:

Peer Review Steering Committee	
Jim Dooley	Forest Concepts, LLC
Dean Draemel	ExxonMobil/University of California, Berkeley
Jim Kellis	DuPont
Mike Lakeman	Boeing and Algae Biomass Organization
Valri Lightner	DOE Loan Programs Office
Jack McDonald	Independent Contractor
Shelie Miller	University of Michigan
Carol Werner	Environmental and Energy Study Institute

Affiliation of Reviewers

BETO has recruited 48 leading experts in their field to serve as reviewers and members of the steering committee.



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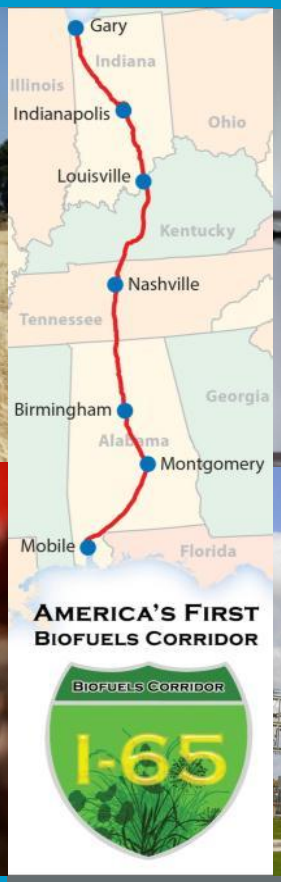

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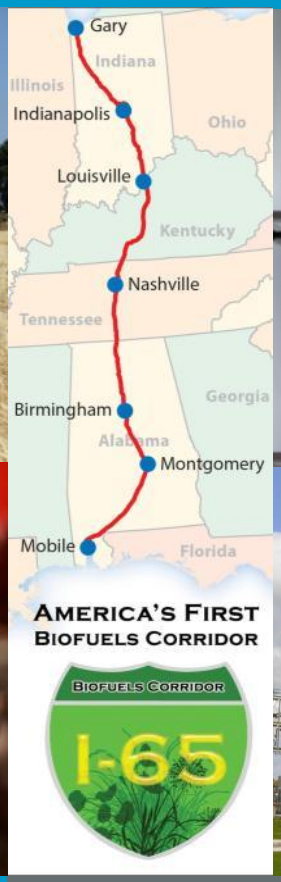
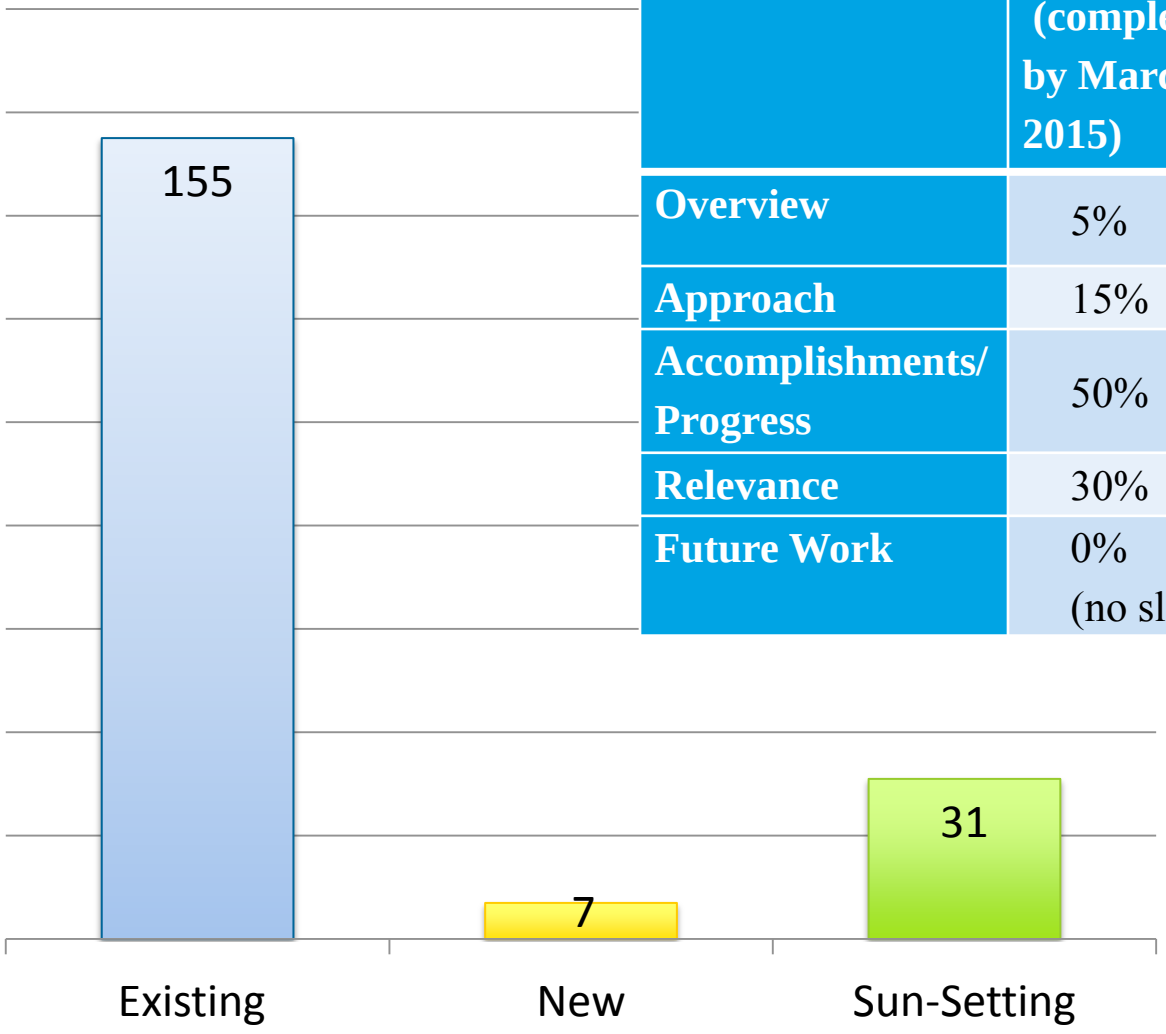


Projects by Review Category



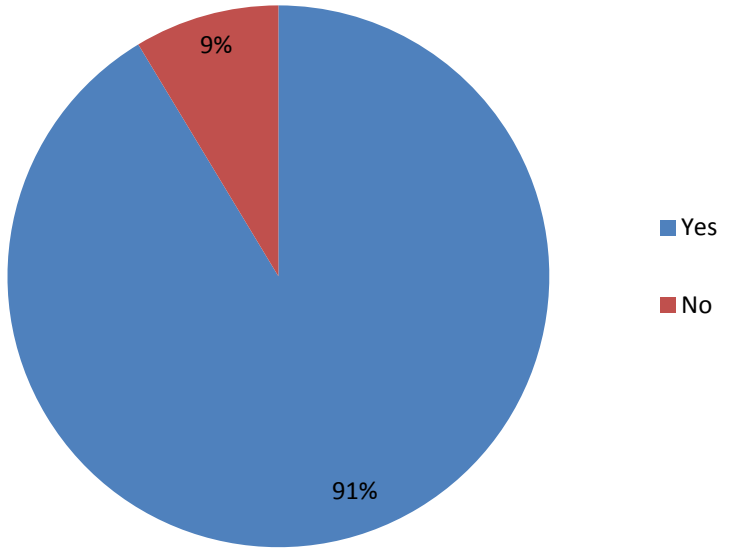
Scored Criteria	Sun-Setting Projects (completed by March 2015)	New Projects (since April 2014)	Existing Projects (everything else)
Overview	5%	5%	5%
Approach	15%	25%	20%
Accomplishments/ Progress	50%	10%	30%
Relevance	30%	25%	25%
Future Work	0% (no slide)	35% (2–3 slides)	20%

Reviewed Projects as Percentage of the Portfolio

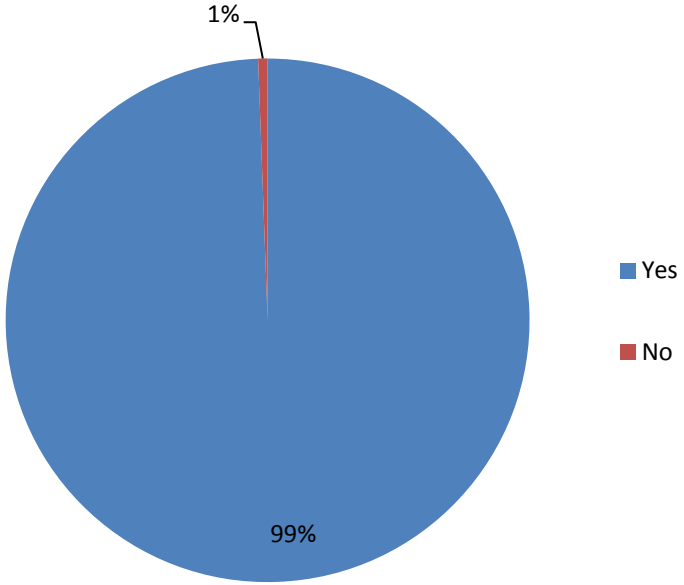
This review will cover 91% of the projects in BETO's portfolio, which represents 99% of project funding.

Project Reviewed		
Yes	190	$ 404,361,287
No	18	$ 2,350,764
Total	208	$ 406,712,051

Projects Reviewed by #



Projects Reviewed by Funding



FY16 Budget Request to Congress

Program Area	FY 2014 Enacted*	FY 2015 Enacted*	FY 2016 Request*	FY 2016 vs. FY 2015*
Feedstocks	46,972	32,000	38,800	+6,800
Conversion Technologies	101,384	95,800	99,186	+3,386
Demonstration and Market Transformation	64,790	79,700	87,514	+7,814
Strategic Analysis and Cross-Cutting Sustainability	12,146	11,000	14,000	+3,000
Biopower	1,998	0	0	0
NREL Site-Wide Facility Support	5,000	6,500	6,500	0
Total, Bioenergy Technologies	232,290	225,000	246,000	+21,000

*Dollars in thousands

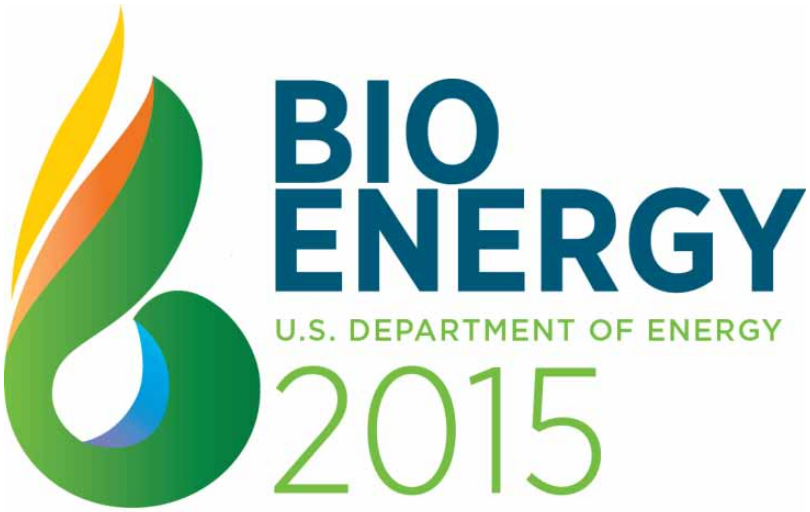
Bioenergy 2015 and Program Management Review

The 2015 Program Management Review

- Will be held June 25th at the Washington Convention Center
- Results of the Project Peer Review will be presented by Lead Reviewers, along with an overall assessment of BETO's portfolio presented by the Steering Committee.
- The Program Management Review will take place the day after BETO's annual conference, Bioenergy 2015

Bioenergy 2015

- Will be held June 23-24, 2015 at the Washington Convention Center.
- Convene key representatives from across the bioenergy supply chain, including industry, federal agencies, and Congress.



Results of the 2013 BETO Peer Review

What changes has BETO made based on the results of the 2013 Peer Review?

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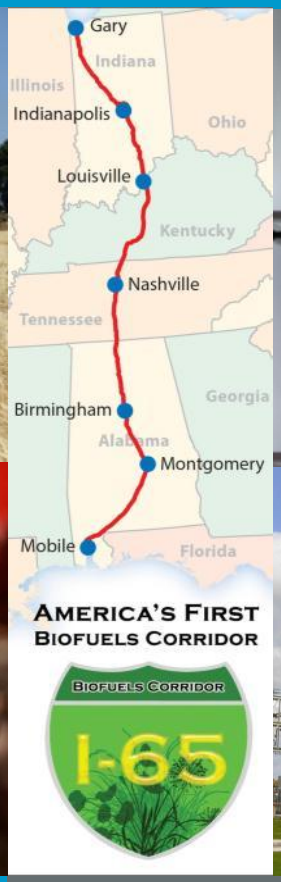


Support for the Incubator Program

2013 Steering Committee Final Report

"An incubator program may help the Office explore new areas… competitive solicitations would be the most effective way to identify these technologies"

Actions to date

- BETO issued an Incubator FOA for "off roadmap" technologies in February 2014.
- In March 2015, BETO announced awards of up to $10M in 7 projects.

Plans moving forward

- BETO plans to issue another Incubator FOA in FY2015
- Future Incubator FOAs may be modified based on the outcomes of this award.

2015 Incubator Awards

Entity	Location	Award Amount
Metabolix Inc.	Cambridge, MA	$2 M
PNNL	Richland, WA	$0.9 M
Ohio State University	Columbus, OH	$1.2 M
University of California Riverside	Riverside, CA	$1 M
OPX Biotechnologies	Boulder, CO	$2 M
Kiverdi, Inc.	Berkeley, CA	$2 M
Gas Technology Institute	Des Plaines, IL	$1.4 M

Publish a Lessons Learned on BETO Demonstration Projects

2013 Steering Committee Final Report

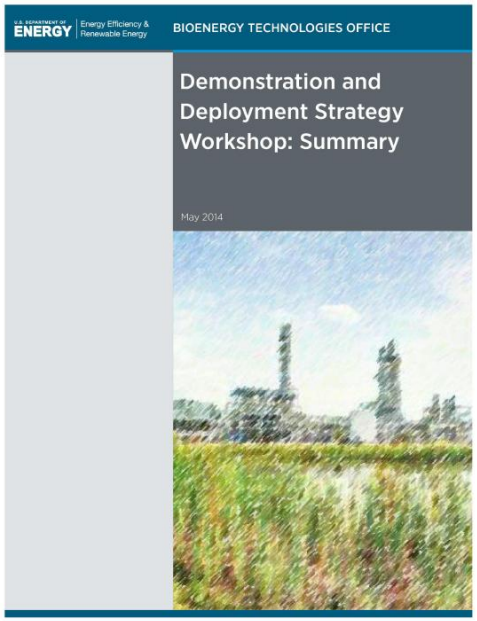
"There is an opportunity for DOE to conduct/publish a 'lessons learned' or post-mortem for projects that are being closed."

Actions to date

- BETO has implemented numerous workshops/reports to assess the progress of the demonstration portfolio and examine lessons learned.

Plans moving forward

1. Greater emphasis needs to be placed on **scale up risks** where data validation and piloting efforts should be seriously considered prior to design of an integrated facility.
2. **Fully integrated pilot plant tests** are essential.
3. Projects without **fully developed designs** that were sent out for bid resulted in inaccurate cost estimates, schedule slip, and large cost overruns….
8. **Feeding solid biomass to reactors** continues to be a challenge.



More on this during today's final morning Plenary

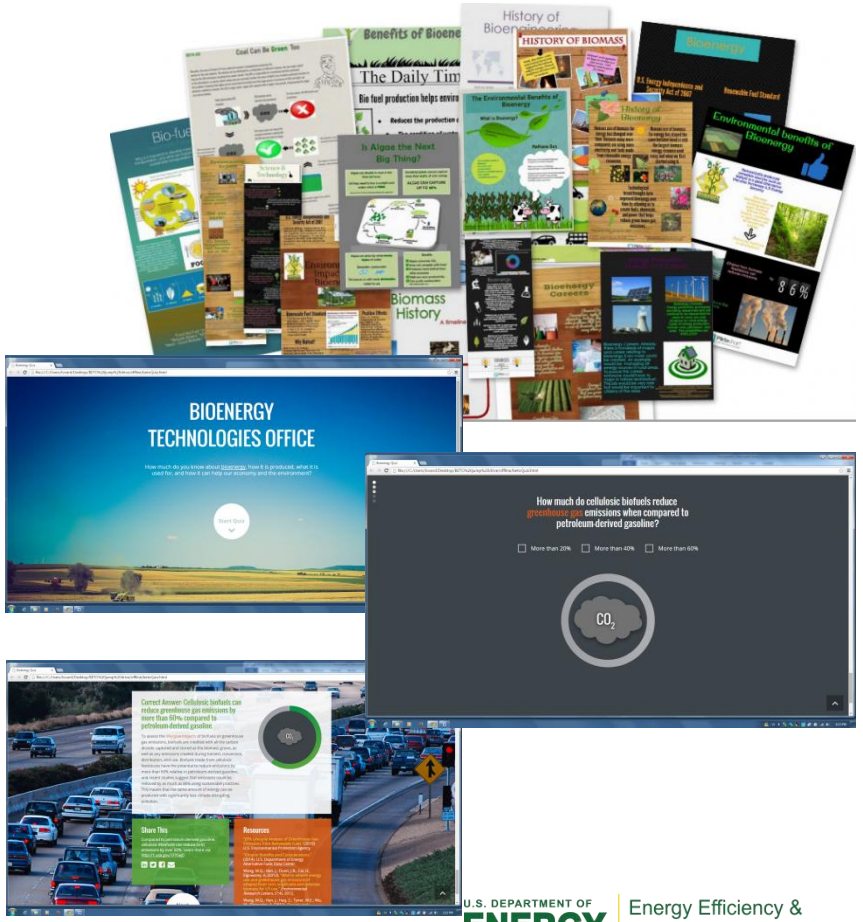
Improve/Expand BETO Communications Strategy

2013 Steering Committee Final Report

"Develop messaging for both the general public and Congress to clearly communicate the bioenergy message to the public."

Actions to date

- New outreach initiatives have included:
  - **BioenergizeME** – Improve bioenergy literacy (i.e., Infographic Challenge)
  - **BioComms** – Coordinated outreach, BETO and labs, nationwide messaging.
  - **Mythbusters** – Engaging tools to encourage science-based bioenergy discussions (i.e., Bioenergy Game)
- Consistent messaging: "American technologies, production, jobs; reduced carbon emissions."



Better Understand Integration with Petroleum Refineries

2013 Steering Committee Final Report

"DOE should look at the ways to process fuel as it goes into a refinery; understand how the process works and educate stakeholders."

Actions to date

- BETO held a workshop on refinery integration in New Orleans, LA in April 2014 .
- Attendance at the workshop represented all points in the supply chain.
- BETO has also conducted an internal training course with a petroleum industry expert to better understand the refining sector.

Fuel Certification for New Hydrocarbon Fuels

2013 Steering Committee Final Report

DOE should "engage with ASTM and the DOE to ensure certification of new biofuel products."

Actions to date

- BETO joined USDA and the FAA to support Farm-to-Fly 2.0.
- Supporting FAA's Center of Excellence in alternative jet fuels led by Washington State University/MIT
- Working with the Commercial Alternative Aviation Fuels Initiative (CAAFI) to produce 1 billion gallons of aviation biofuel by 2018.
- Increasing technical work at DOE National Laboratories to enable achievement of alternative jet fuel goals.

More on this during Tuesday's morning Plenary

New Work in Waste-to-Energy

2013 Steering Committee Final Report

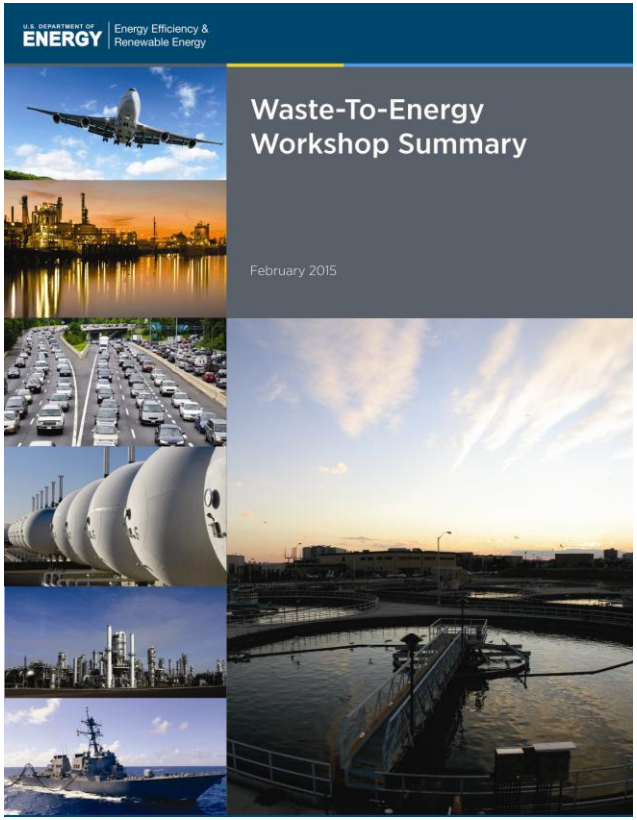
"There was also general agreement that the Office has productive 'waste-to-energy' projects within its portfolio."

Actions to date

- Two workshops held to develop a better understanding of the feasibility of producing transportation fuels and co-products from "wet" waste streams.

Plans moving forward

- Continued development of the need to understand "wet" waste streams.
- On October 9th, 2014 DOE announced the Biological and Chemical Upgrading awardees to develop advanced biofuels and bioproducts including:
  - NatureWorks LLC ($2.5M) biogas to lactic acid
  - National Renewable Energy L ab. ($2.5M) biogas to muconic acid



Bioproducts

2013 Steering Committee Final Report

"Given the wide array of potential co-products, it will be critical for the Office to focus on co-products that match specific biofuels pathways."

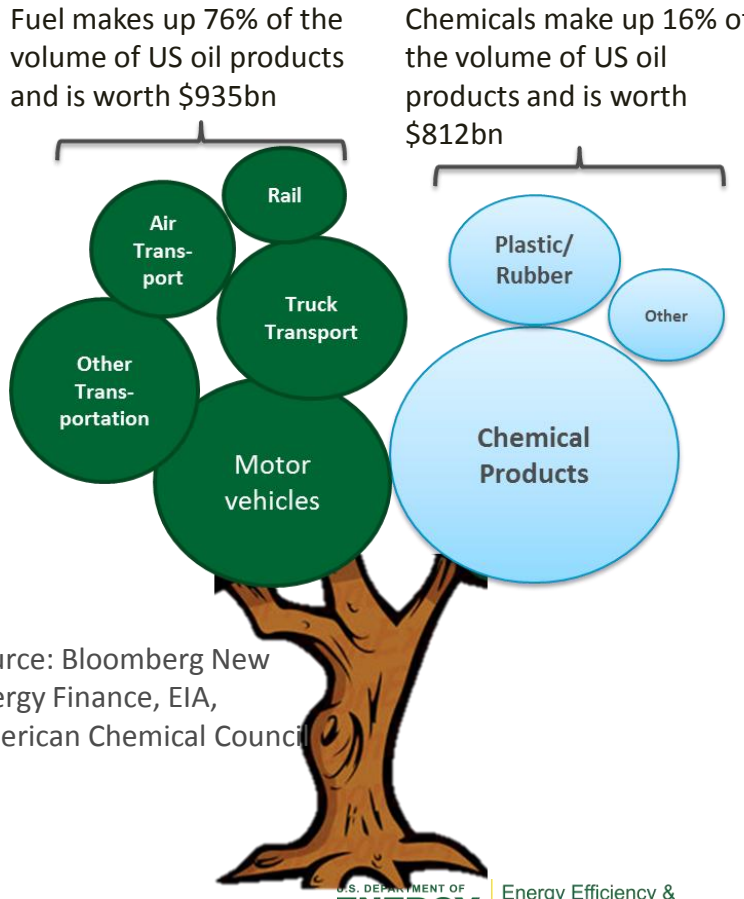
Actions to date

- Broadened portfolio scope to look at different products that better enable fuel.
- Working with partners at USDA and OECD to develop a workshop on renewable chemicals.
- BCU FOA announced in October 2014

Plans moving forward

- Targeted Algal Biofuels and Bioproducts FOA will be announced in June 2015

Bioproducts provide much higher value-added margins, relative to transportation fuels.



Source: Bloomberg New Energy Finance, EIA, American Chemical Council

Impacts – DMT FOA

2013 Steering Committee Final Report

"Assistance to support the first few demonstration systems is critical… as such, there exists a need for government to step in and correct this market failure"

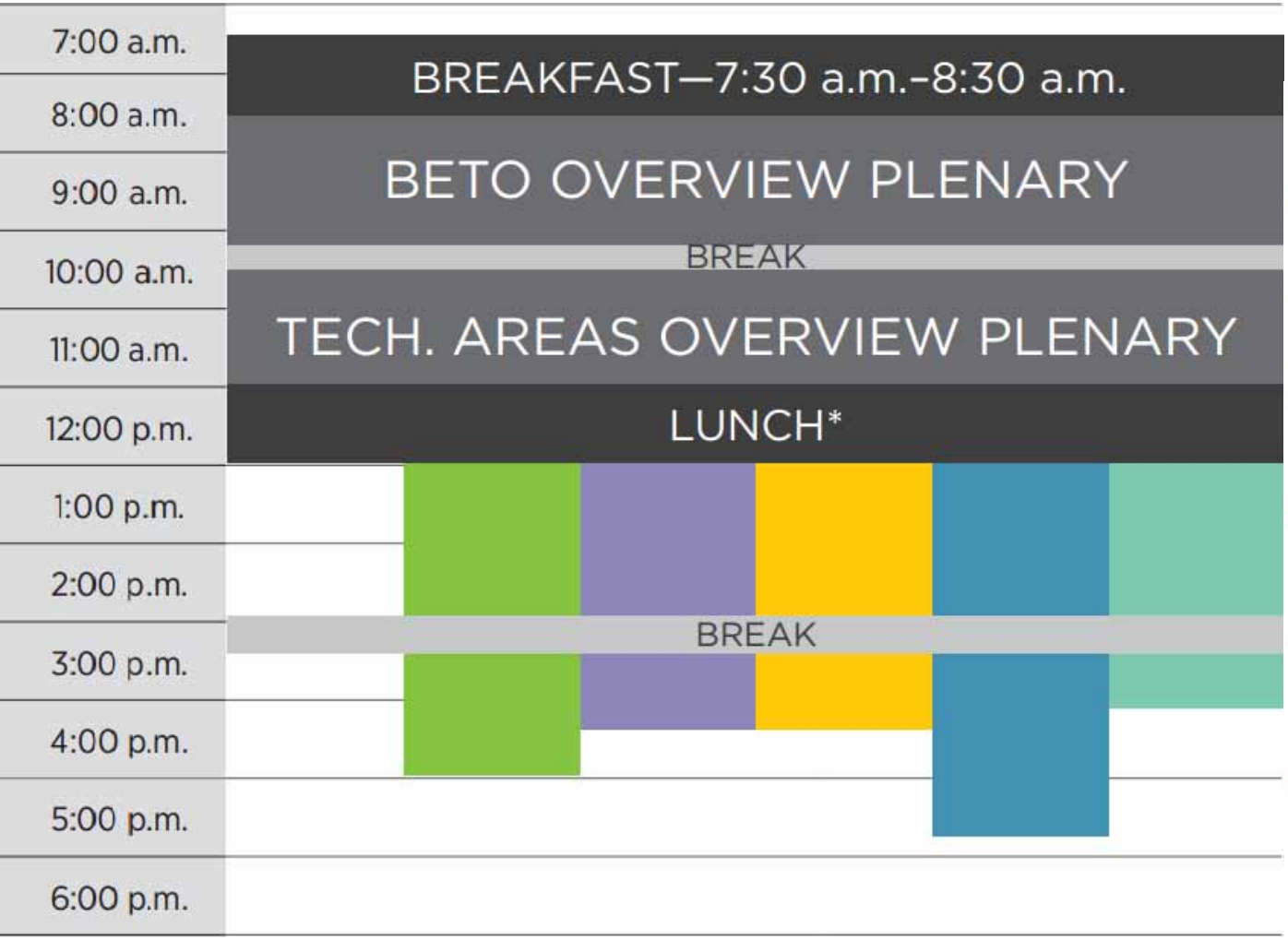
Actions to date

- Innovative Pilot (iPilot) FOA was released in 2013.
- In September 2014, 3 projects were down-selected under the DPA initiative to enter Phase II

Plans moving forward

- A new Demonstration at Increasing Scale FOA is planned for release in 2015.

Review Opening



- TERRESTRIAL FEEDSTOCKS
  Juniper Room
- ALGAL FEEDSTOCKS
  Aspen Room
- BIOCHEMICAL CONVERSION
  Arbors Room
- THERMOCHEMICAL CONVERSION
  Plaza II & III
- DEMONSTRATION AND MARKET TRANSFORMATION
  Plaza I
- SUSTAINABILITY AND STRATEGIC ANALYSIS
  Beech Room
- COOKSTOVES
  Plaza I

Extra Slides

2013 Peer Review - Key Findings and Impacts

Notable Gaps

- Cost of biomass feedstocks
- Capital + Operational expenditures for commercial scale plants.

New Areas of Focus

- Incubator
- Waste to Energy
- Carbon Fiber
- Natural Gas

Recommendations

- Develop a hydrocarbon fuels strategy
- Encourage data sharing across portfolio
- Amend contracts to require peer review
- Require IBR disclosure on economic performance
- Ensure Biofuels Certification (DoD / ASTM)
- Develop Congressional / public messaging
- Address regional impacts on feedstocks
- TEA / LCA for all projects

Biofuels and Falling Oil Prices

At Biomass 2011, then-Secretary Chu delivered the opening address, saying that:

- ***'…policy makers and politicians hit the "panic button" on developing alternative energy whenever oil prices rise, and the "snooze button" whenever oil prices fall.'***

If this is where we are today, we must heed what the Secretary said next:

- **"… like hockey great Wayne Gretzky used to say we need to 'skate where the puck is going to be."**

Impacts – Waste to Energy

Actions to date

- Two workshops held to develop a better understanding of the techno-economic feasibility of producing transportation fuels and co-products from “wet” waste streams.
  - Workshops held on Anaerobic Digestion, Hydrothermal Liquefaction as well as AnMBRS, MxCs, and combinations thereof to produce hydrogen and higher hydrocarbons.

Plans moving forward

- Continued development of the understand of “wet” waste streams.
  - Workshop Sessions to come later this year: Energy-Positive Water Resource Recovery, Water Environment Federation Water-Energy Conference, Renewable Gaseous Fuels, and Challenges for Wet Wate-to-Energy.

FY15 Funding Opportunities and Awards

Upcoming Award Announcements

- **Targeted Algal Biofuels and Bioproducts FOA**
  - The FOA seeks to reduce the cost of algal biofuels from $7 per gallon – the current projected state of technology for 2019 – to less than $5 per gallon algal biofuel by 2019.
  - **STATUS:** Awards anticipated June 2015
- **Landscape Design for Sustainable Bioenergy Systems FOA**
  - DOE announced up to $14 million to support landscape design approaches that enhance the environmental and socio-economic sustainability of cellulosic bioenergy through the improvement of feedstock production and logistics systems.
  - **STATUS:** Awards anticipated April 2015

Potential Funding Opportunities

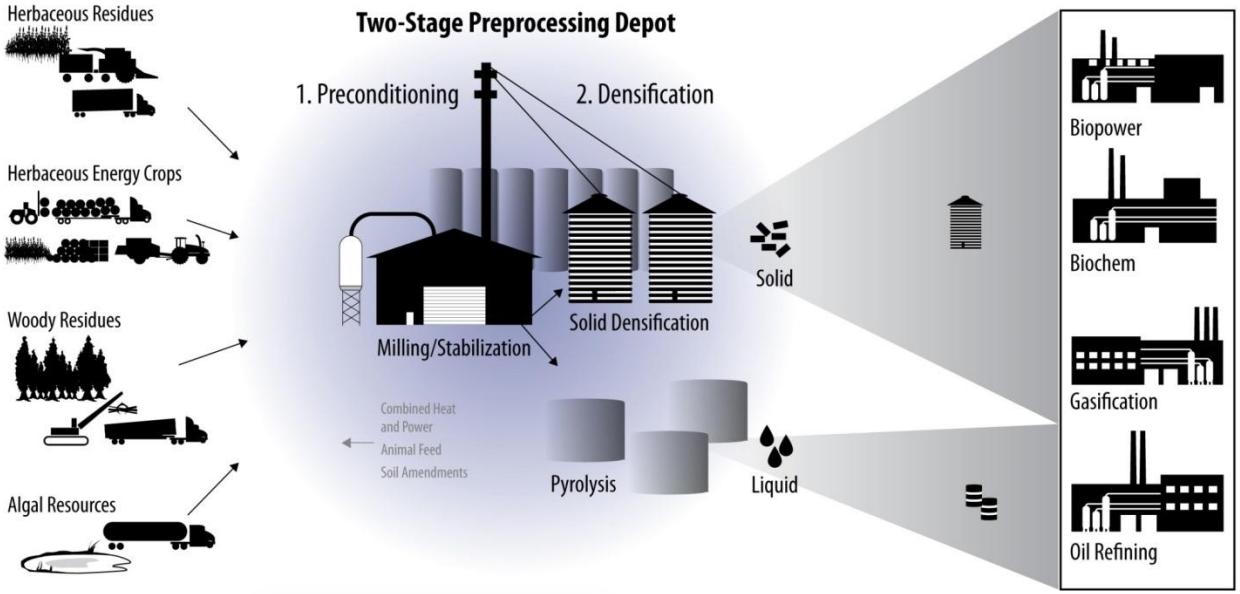
- USDA/DOE Biomass Research and Development Initiation (BRDI)
- Manufacturing Biofuels at Increasing Scale
- Fuel Testing and Engine Development for High Octane Fuels
- 2015 BETO Incubator

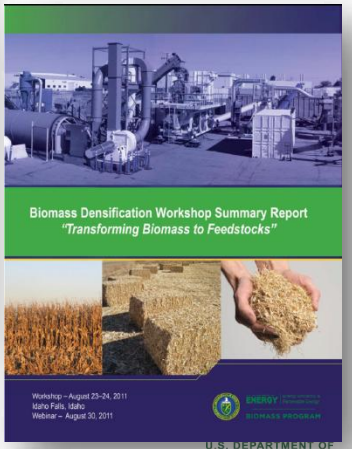
Advanced Supply System Design

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

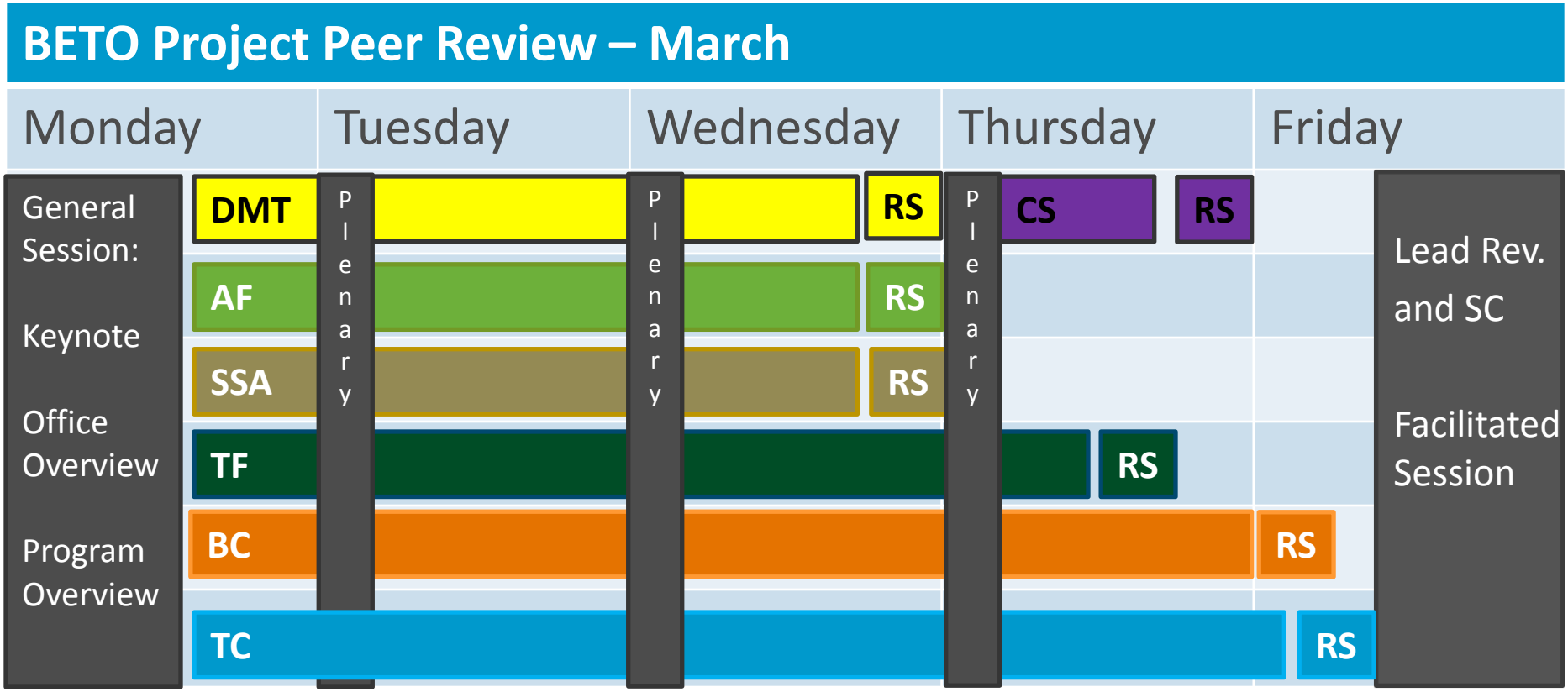
- Actively manage feedstock variability and supply uncertainty
- Feedstock specifications and conversion performance drive logistics and preprocessing
- Advanced preprocessing accesses low-grade and diffuse resources (i.e., use any and all available resources)

Approach: Advanced preprocessing and formulation of multiple raw biomass resources into least cost/performance-based feedstocks





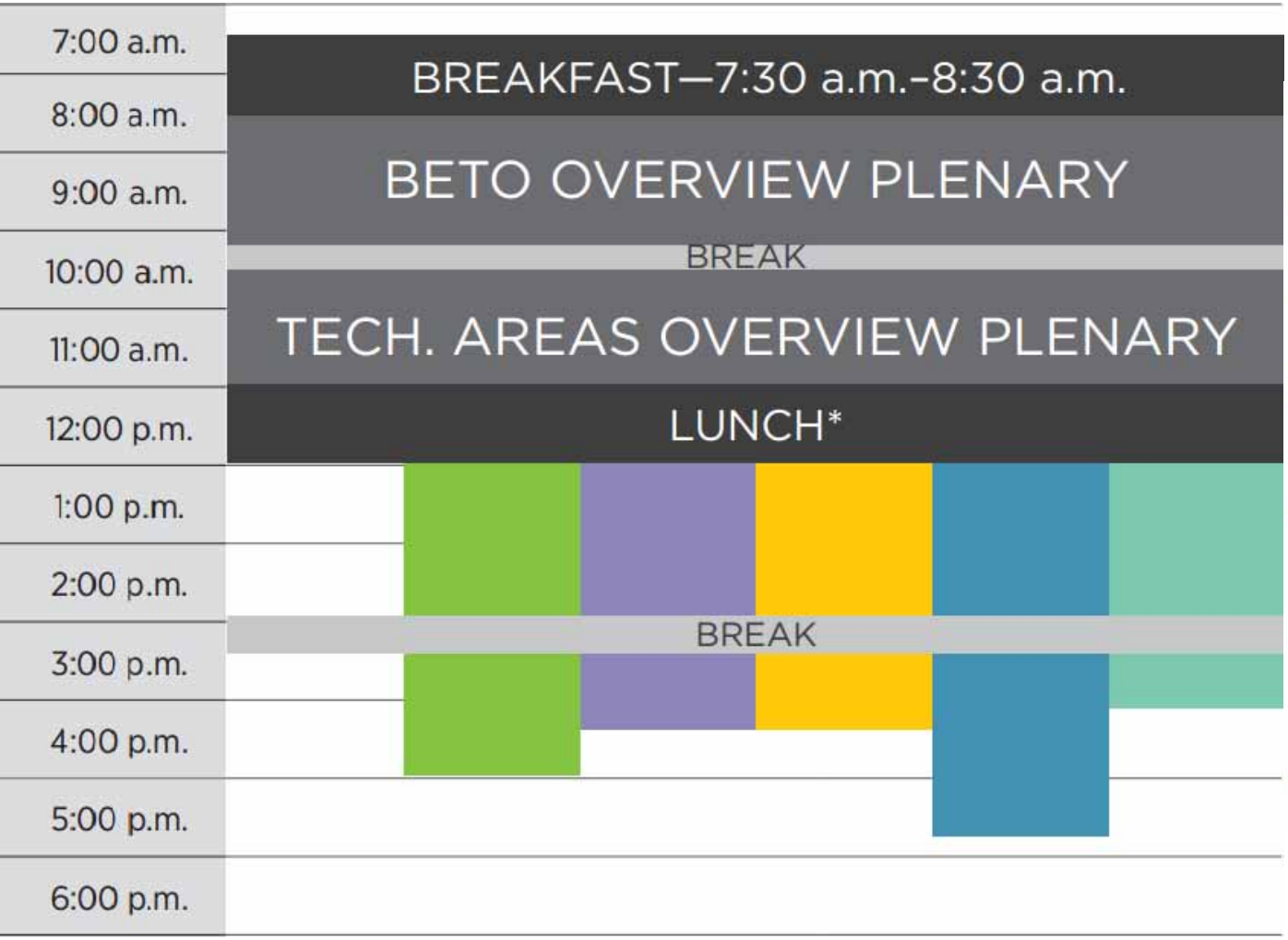
High Level Agenda



Agenda Legend:

* DMT: Demonstration and Market Transformation
* TC: Thermochemical Conversion
* SSA: Sustainability and Strategic Analysis
* AF: Algal Feedstocks
* TF: Terrestrial Feedstocks
* BC: Biochemical Conversion
* CS: Cookstoves
* RS: Review Session

Day 1: Monday, March 23



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  Beech Room
- COOKSTOVES
  Plaza I

Wet Waste-to-Energy Workshop Stream

Develop a better understanding of the techno-economic feasibility of producing transportation fuels and co-products from "wet" waste streams.

- November, 2014: Anaerobic Digestion, Hydrothermal Liquefaction, and other possibilities. Report forthcoming shortly.
- March, 2015 (This workshop, joint with DOE Fuel Cells Office): AnMBRs, MxCs, and combinations thereof to produce hydrogen and higher hydrocarbons.
- April, 2015 (together with EPA, NSF, and DOE Water-Energy Tech Team): Energy-Positive Water Resource Recovery.
- Mid-June, 2015: Water Environment Federation Water-Energy Conference.
- Late June, 2015: Bioenergy 2015, with sessions on Renewable Gaseous Fuels and Challenges for Wet Waste-to-Energy.

Current vision is for a joint report from March and April workshops.

All of this will inform BETO, DOE, EPA, and NSF activities for FY 16 and beyond.

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

FY15 Program Activities and Goals

Feedstocks: Demonstrate a modeled mature delivered feedstock cost of $115 per dry matter ton (including both grower payment and logistics).

Algae: Demonstrate integrated protein and carbohydrate conversion with target of 80% of theoretical yield from proteins and carbohydrates. Demonstrate an increase in algal intermediate yields (1,500 gallons/acre/yield).

Demonstration and Market Transformation: Increase portfolio to include 3 novel technology demonstrations to reduce risk of scale up of emerging bioenergy pathways.

Biochemical Conversion: Reduce modeled conversion cost via a biochemical (hydrolysis) conversion route to hydrocarbon fuel blendstocks in support of the 2022 programmatic goal of $3/gal for drop-in fuels such as renewable gasoline, diesel, and jet fuel [$6.40/gallon of gasoline equivalent (gge)].

Thermochemical Conversion: Reduce the modeled conversion cost contribution via fast pyrolysis for converting biomass to a hydrocarbon fuel blendstock in a mature commercial-scale plant. [$3.70/gallon of gasoline equivalent (gge)].

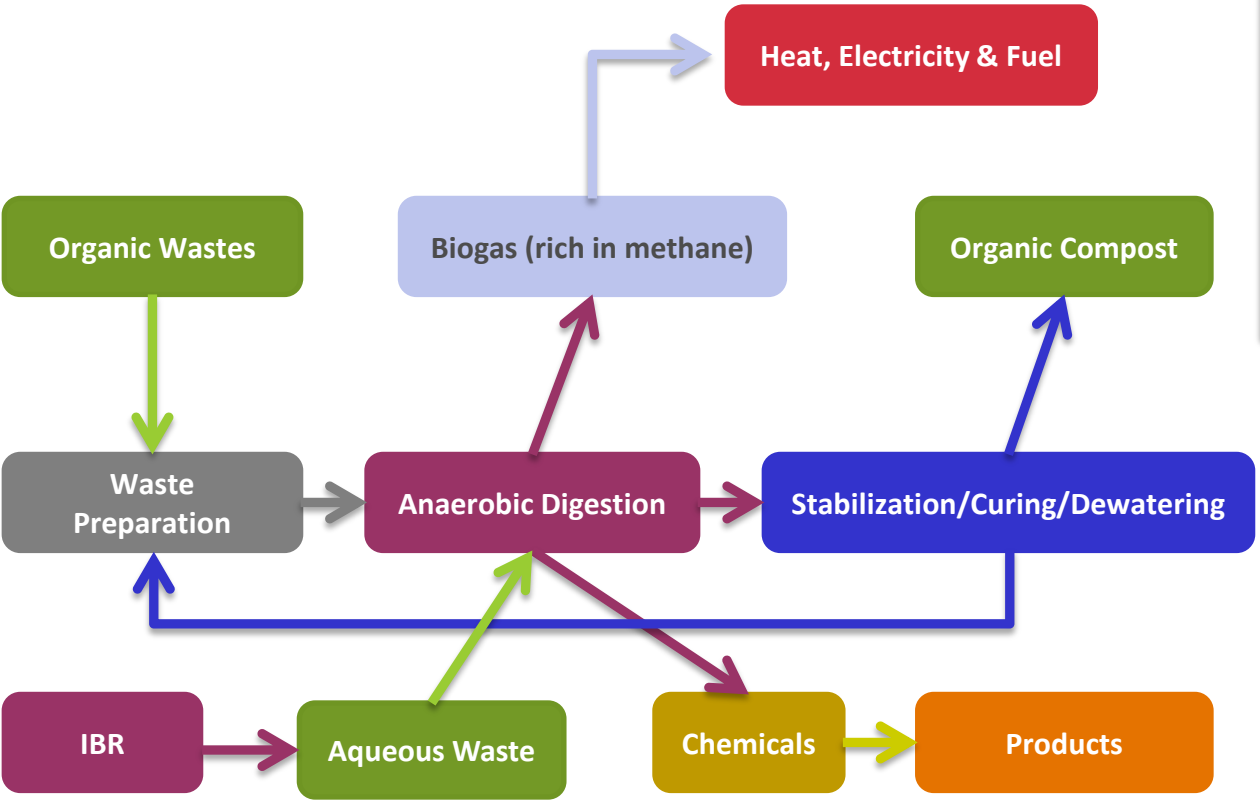
Sustainability: Identify practices that improve sustainability and environmental performance of advanced bioenergy, including results from a comprehensive case study of environmental, social, and economic sustainability indicators for a cellulosic feedstock production and biorefinery system.

Collaborations with the Vehicle Technologies Office: Test fuels and develop better engines for high octane fuels.

BETO's Waste-to-Energy (WTE) Efforts

There is a significant near-term market entry opportunity to deploy WTE technologies in the U.S., specifically with regard to anaerobic digestion at landfills to recycle organic waste biomass into renewable energy, thereby enabling a national network of distributed power and biofuel production sites.

Waste-to-Energy Cycle



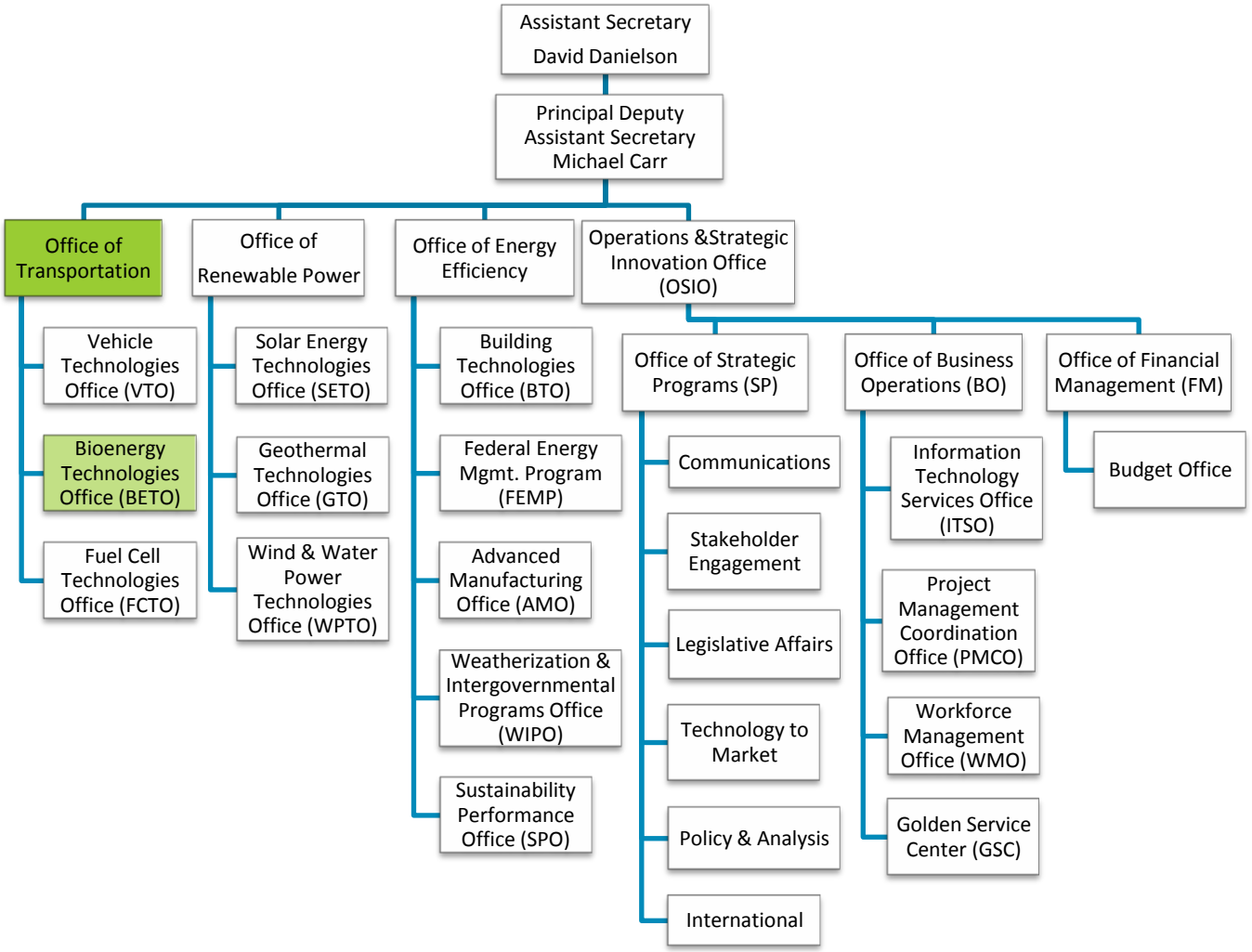
Waste streams that could be considered for use include:

- Municipal solid waste
- Landfill gas
- Waste streams from waste water treatment plants (WWTPs)
- Bio-solids (from thermochemical or biochemical biofuel pathways)

The DOE Loan Guarantee Office released a Renewable Energy and Energy Efficiency Solicitation for a public comment period. The solicitation is expected to provide as much as $2.5 billion in loan guarantees for commercial financing of technologies that avoid, reduce, or sequester GHG emissions. "Waste-to-Energy" is included in the list of eligible project types to be considered.

Image courtesy of Iona Capital

EERE Organization Chart



Bioenergy Technologies Office

Mission

Accelerate the commercialization of advanced biofuels and bioproducts through targeted research, development, and demonstration supported by public and private partnerships

Strategic Goal

Develop technologies to enable the sustainable, nationwide production of biofuels compatible with today's transportation infrastructure

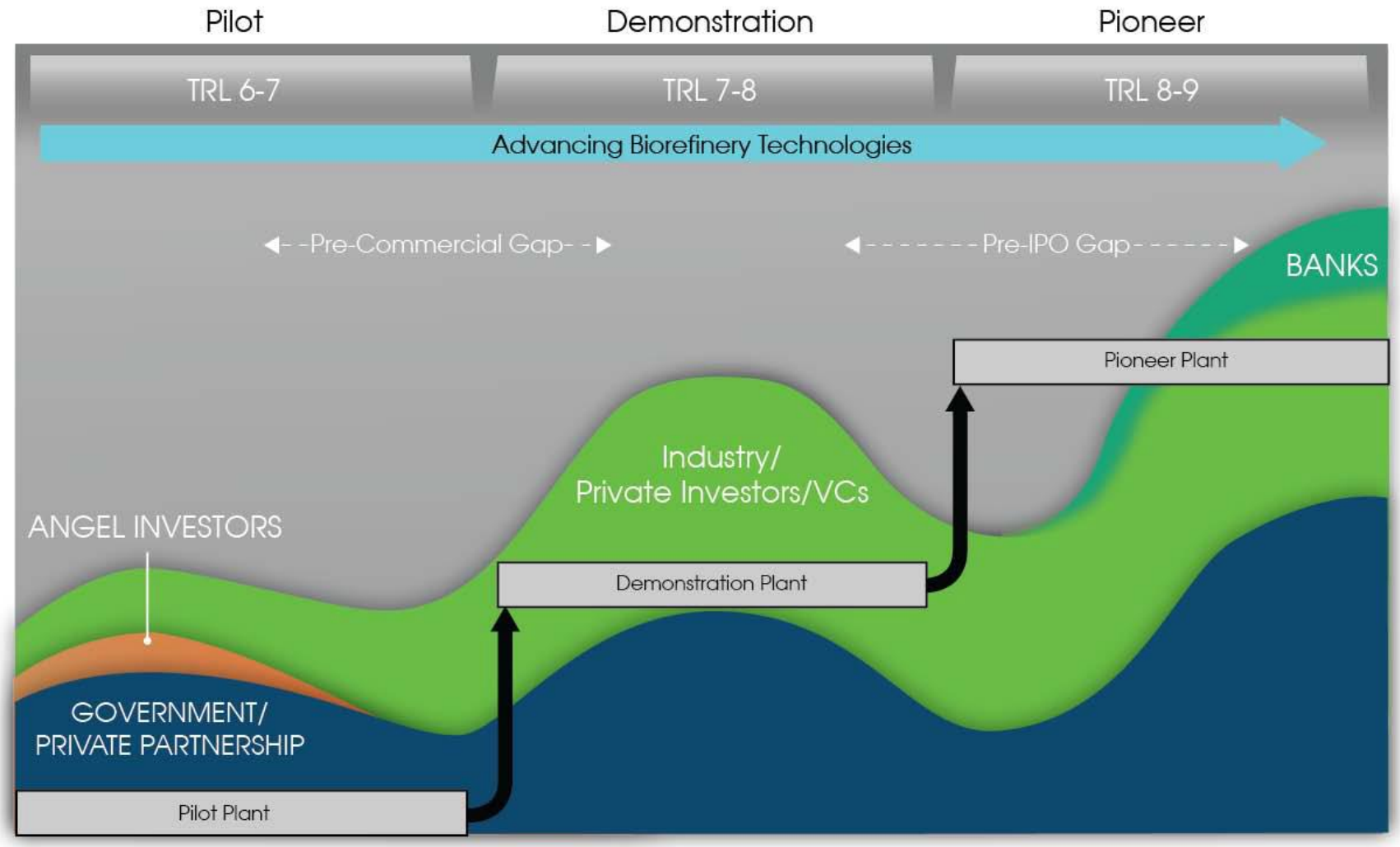
Performance Goal

By 2017, validate a least one pathway for $3/GGE* hydrocarbon biofuel (with ≥50% reduction in GHG emissions relative to petroleum)

*Mature modeled price at pilot scale.

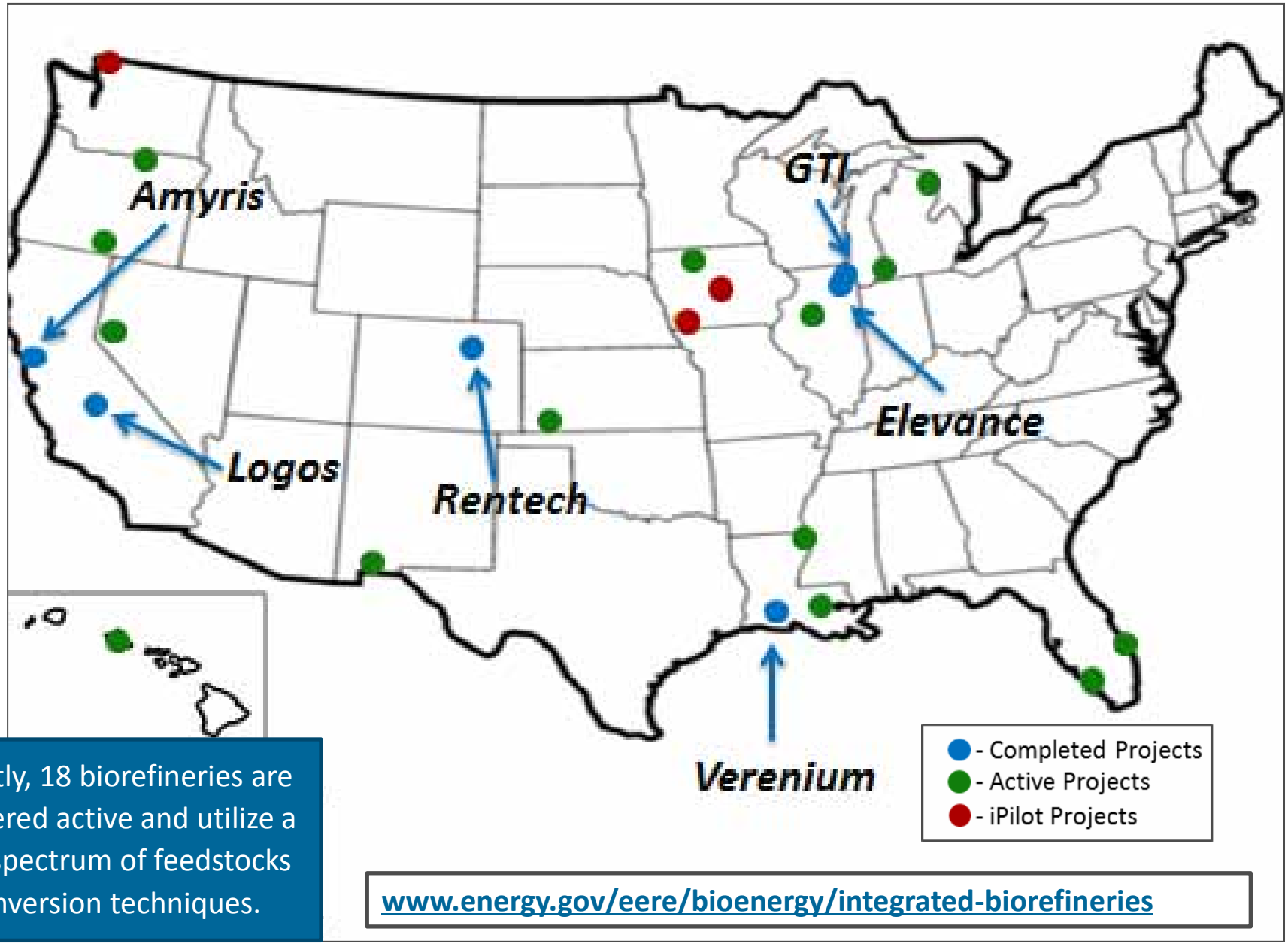
Through RD&D, BETO reduces risks and costs to commercialization

Valley of Death



BETO supports cost shared first-of-its-kind facilities to de-risk new technologies and bring industry past the valley of death.

Demonstration Portfolio (Active and Completed Projects)



Currently, 18 biorefineries are considered active and utilize a broad spectrum of feedstocks and conversion techniques.

www.energy.gov/eere/bioenergy/integrated-biorefineries

Major Commercial-scale Cellulosic Ethanol Projects

POET-DSM's Project LIBERTY

- Grand opening on September 3, 2014, in Emmetsburg, Iowa.
- Once operating at full, commercial-scale, the plant will produce 25 million gallons of cellulosic ethanol per year – enough to avoid approximately 210,000 tons of CO_2 emissions annually.
- Developed with the support of approximately $100 million in investments and research from DOE.

Abengoa Bioenergy Biomass of Kansas

- Grand opening on October 17, 2014, in Hugoton, Kansas.
- The plant will produce cellulosic ethanol from non-edible corn stalks, stems, and leaves harvested within a 50-mile radius of the plant.

Demonstration Portfolio – Selected Pilot Projects

American Process, Inc., Alpena, MI

- Feedstock: waste stream from hardboard manufacturing Capacity: 894,200 gal/yr of cellulosic ethanol (from C6 sugars) and 696,000 gal/yr of aqueous potassium acetate (De-Icer) (from C5 sugars).
- Accomplishments:
- First batch of cellulosic ethanol produced in FY14
- The project's capacity is 800,000 gallons per year.
- DOE share: $22,481,523; Cost share: $8,459,327.

Benefits, Impact, and the DOE Role

- “Over ten years, it could be expected that ten new 2000 ton/day units would create 20,000 new jobs and produce 560 million gallons per year of drop-in gasoline and diesel fuels from biomass”

- "cost and risk of further scale up severely inhibits the participation of individual private or corporate investors“

- "assistance to support the first few demonstration systems is critical, since private capital has not been willing to take this risk"

- "traditional financing vehicles are not available for innovative energy technology due to externalities associated with the energy industry not being factored into energy costs. As such, there exists a need for government to step in and correct this market failure“