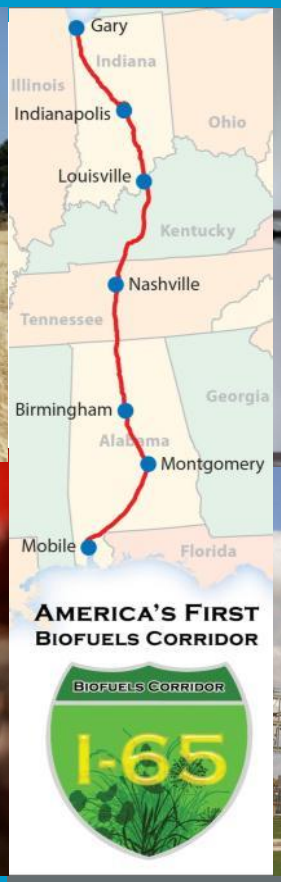
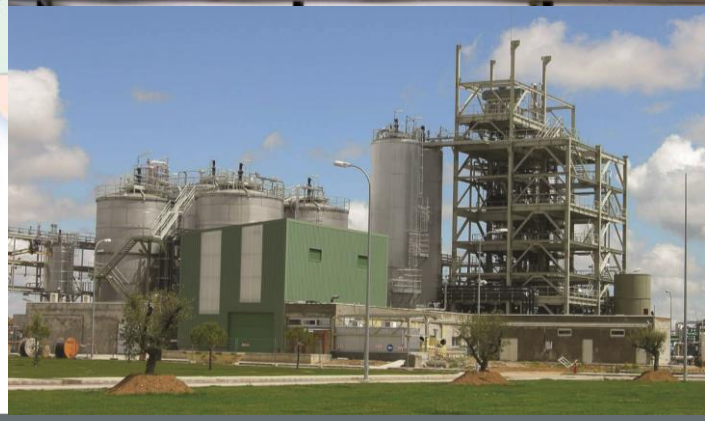




Bioproducts in the Federal Bioeconomy Portfolio

October 26, 2015

Nichole Fitzgerald

Bioenergy Technologies Office (BETO)

Agenda

- Introduction and BETO Overview
  - Erica Qiao, BCS, Incorporated
  - Nichole Fitzgerald, Technology Manager, Bioenergy Technologies Office
- Bioproducts in the Federal Bioeconomy Portfolio
  - Nichole Fitzgerald
  - Dennis Hall, Director, The Ohio State University Bioproducts Innovation Center (OBIC)
  - Kate Lewis, Deputy Program Manager, U.S. Department of Agriculture (USDA) BioPreferred

Questions and Comments

Please record any questions and comment you may have during the webinar and send them to eere_bioenergy@ee.doe.gov

As a follow-up to the webinar, the presenter(s) will provide responses to selected questions.

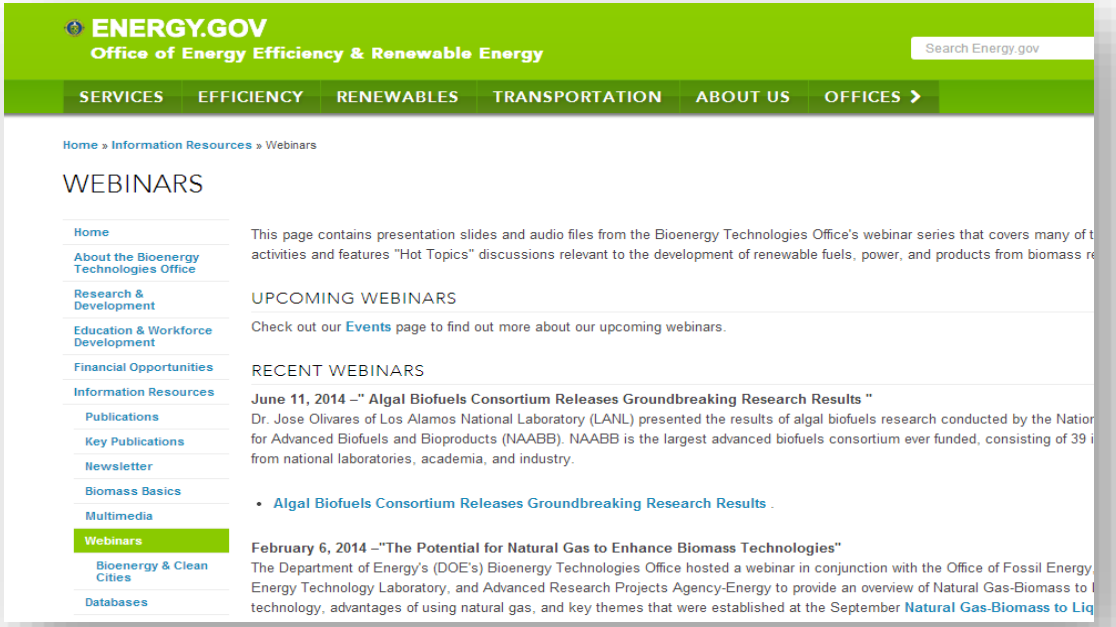
Slides from this presentation will be posted online: http://www.energy.gov/eere/bioenergy/webinars

For general questions regarding the Bioenergy Technologies Office, please email eere_bioenergy@ee.doe.gov

Bioenergy Technologies Office Webinar Series

Started in May 2010 to highlight “hot topics” in biomass and bioenergy industry.

Find past webinars and today’s slides on the Office’s website: http://www.energy.gov/eere/bioenergy/webinars



Bioenergy Technologies Office

Accelerate the commercialization of advanced biofuels and bioproducts through RD&D of new technologies supported by public-private partnerships

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

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

*Mature modeled price at pilot scale.

BETO reduces risks and costs to commercialization through RD&D

The Challenge and the Opportunity

THE CHALLENGE

- **$1 Billion** is spent each day on U.S. crude oil imports
- Transportation accounts for **2/3rds** of petroleum consumption and **1/3rd** 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 billions tons of biomass could displace 30% of U.S. petroleum use by 2030, and reduce 500M tons of CO2e annually.

America's biomass resources can help mitigate petroleum dependence

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
- Algae
- Product Logistics Preprocessing

Conversion R&D

- Biochemical
- Thermochemical
- Deconstruction
- Biointermediate
- Upgrading

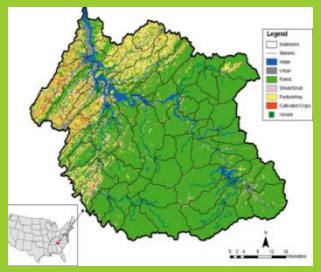
Demonstration & Market Transformation

- Integrated Biorefineries
- Biofuels Distribution Infrastructure

Cross Cutting

Sustainability

- Sustainability Analysis
- Sustainable System Design



Strategic Analysis

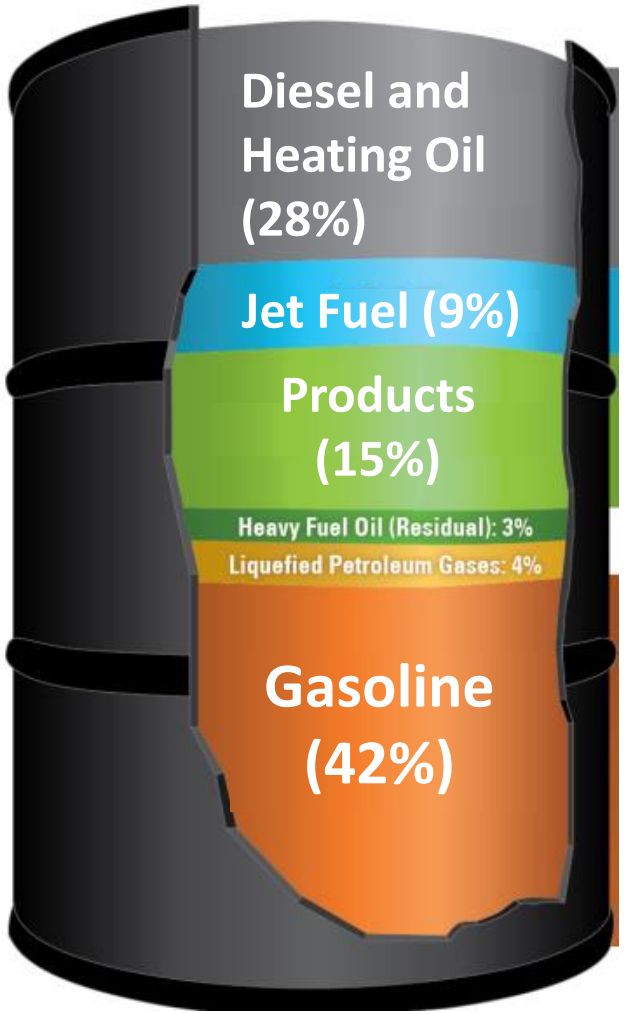
- Technology and Resource Assessment
- Market and Impact Analysis
- Model Development & Data compilation

Strategic Communications

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

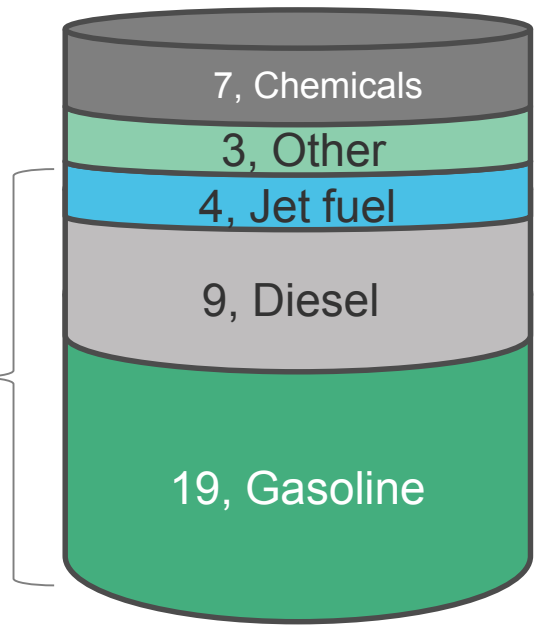
Replacing the Whole Barrel

- Only ~40% of a barrel of crude oil is used to produce petroleum gasoline
- Reducing oil dependence requires replacing diesel, jet fuel, heavy distillates, and other products
- EERE successfully achieved modeled mature cost goals for cellulosic ethanol in 2012
- EERE shifted its R&D to focus on hydrocarbon "drop-in" biofuels, jet fuels, and bio-based products



BETO is working to displace the entire barrel of petroleum crude

Petroleum products in the US: the breakdown of a barrel of oil



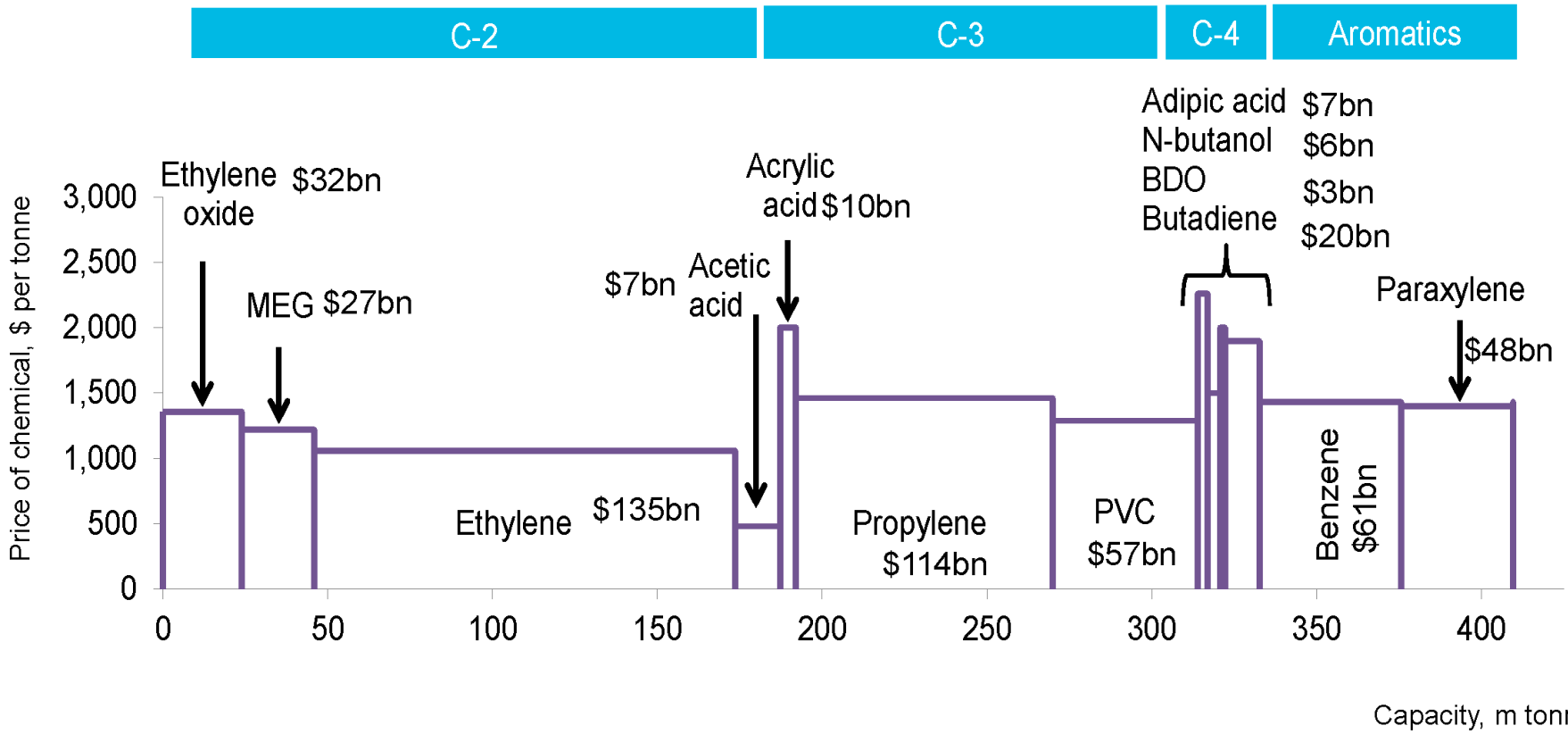
Chemicals make up 17% of the volume of US oil products and is worth $812bn

Fuel makes up 76% of the volume of US oil products and is worth $935 bn

A Barrel of U.S. Oil (by gallons)

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

Replacing the whole barrel- money in products



Source: Bloomberg New Energy Finance, ICIS and Nexant

What are Bioproducts?

The US produces 15% of global chemicals and chemicals comprise 12% of all US exports.

The US produces: ehthylene, propylene, polyethylene, butadiene, butanol, polystyrene, EO, MEG.

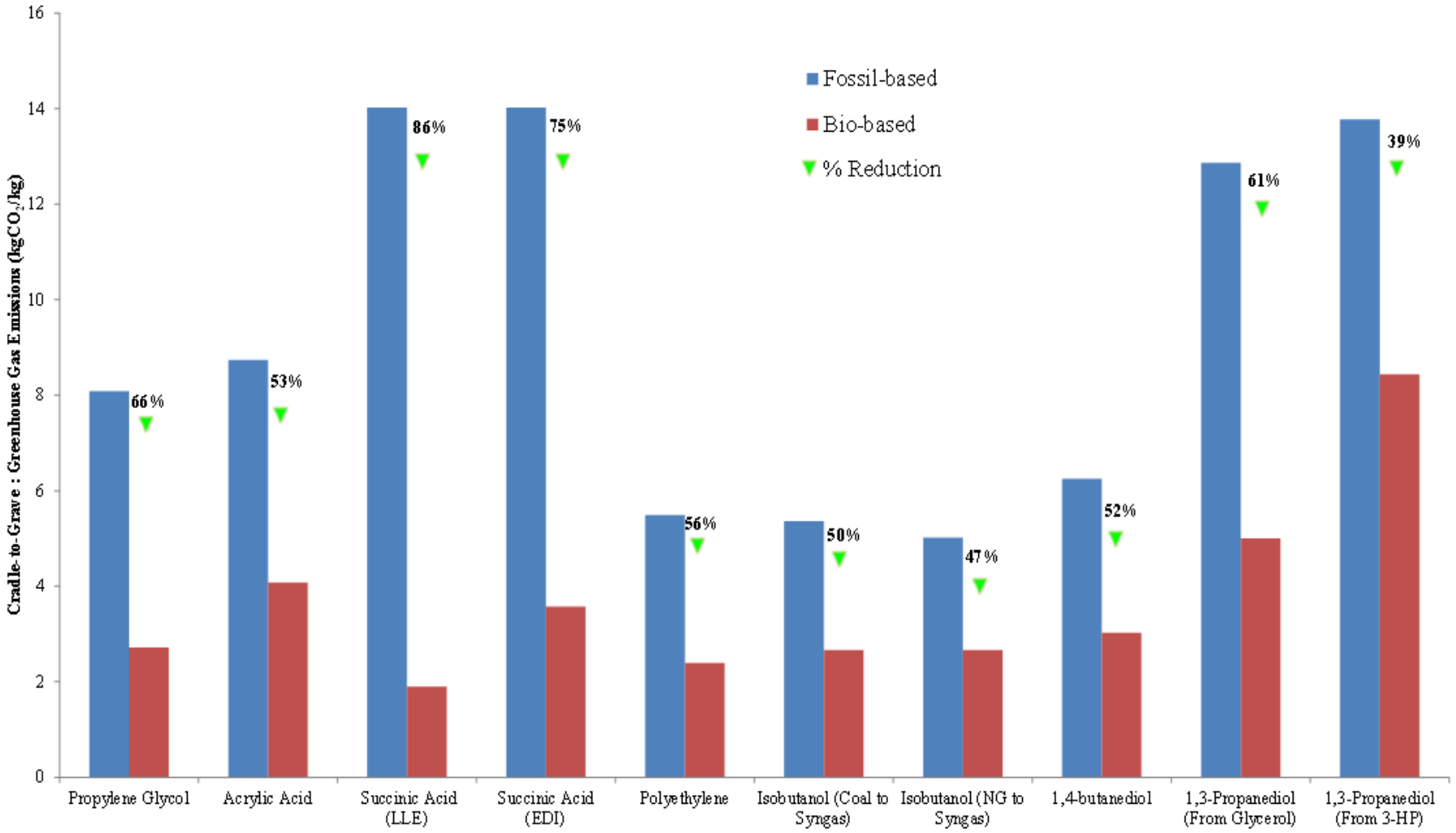
These chemicals are converted to: plastics, cosmetics, pharmaceuticals, detergents, packaging, clothing, car parts, fibers.

C&EN
CHEMICAL & ENGINEERING NEWS

Renewable Products In Use

Bomgardner Chemical & Engineering News. 92 (43) 10-14. Oct 27, 2014

Bioproducts uniformly showed emission reductions compared to their fossil-derived counterparts



Life-Cycle Fossil Energy Consumption and Greenhouse Gas Emissions of Bioderived Chemicals and Their Conventional Counterparts – Felix Adom, Jennifer Dunn, Jeongwoo Han, and Norm Sather.

BETO's Focus on Bioproducts

2013 Peer Review 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.
- TABB FOA selections were announced on July 9th.
- Bioproducts to Enable Biofuels Workshop, July 2015, Denver, CO

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

How Can Renewable Chemicals Help?

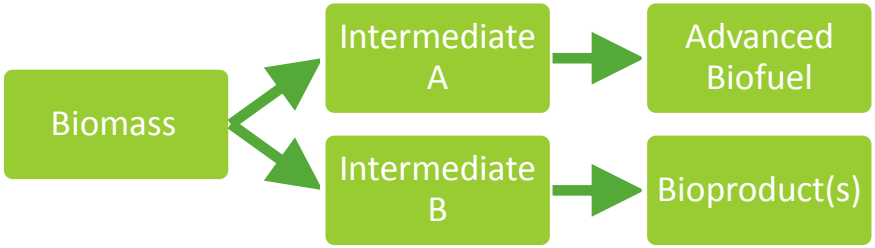
Pros:

- Bolsters the bioeconomy
  - Knowledge from bioproduct production can be transferred to biofuels production
- Market entry
  - Entry into bioproduct markets can be easier than that of fuels.
  - Profits from bioproduct production can offset current fuel-related costs
  - Corporations will support the bioeconomy through the purchase and use of sustainable bioproducts
- Critical for economic success of advanced biofuel production
  - Reduces risk by allowing biorefineries to pursue a higher value product
  - Biofuels producers are competing against fossil fuel producers with depreciated capital

Cons:

- Focus on bioproducts could detract research focus from biofuels
- Need to avoid producers abandoning biofuels entirely as bioproduct markets become highly profitable
- Spot pricing does not reflect long term issues and potential market saturation

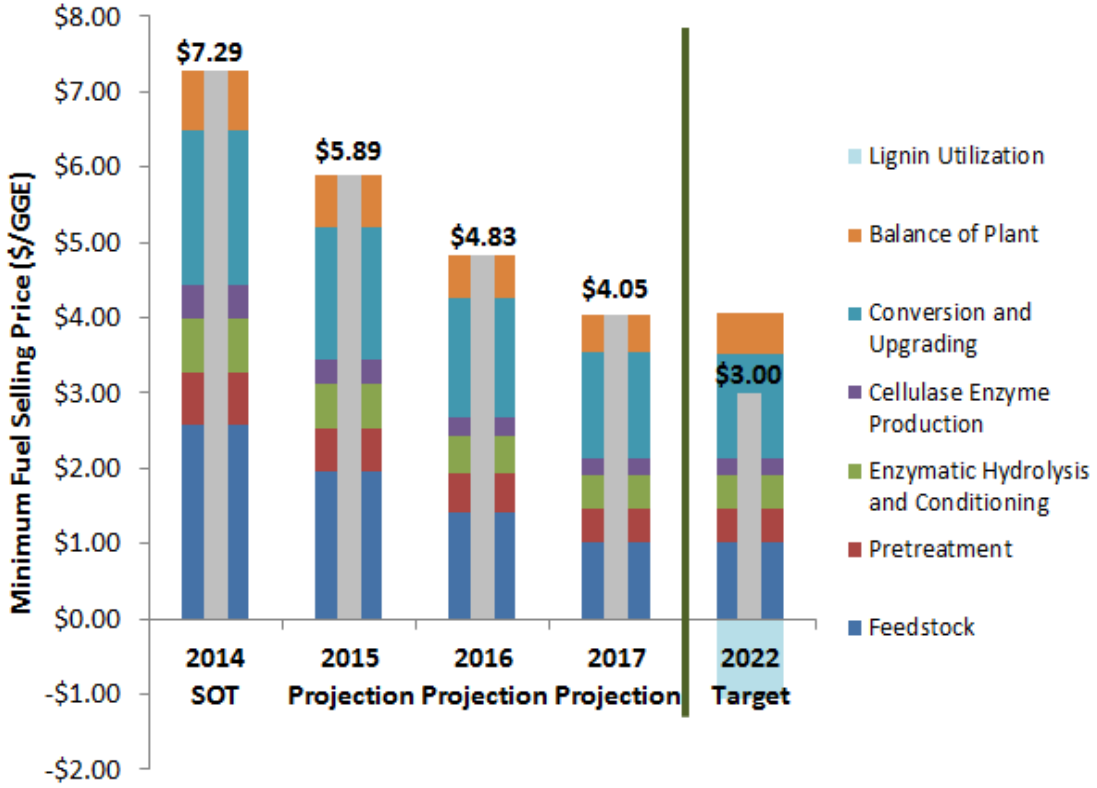
Strategies for incorporating products



Hydrocarbon/Sugar Intermediates

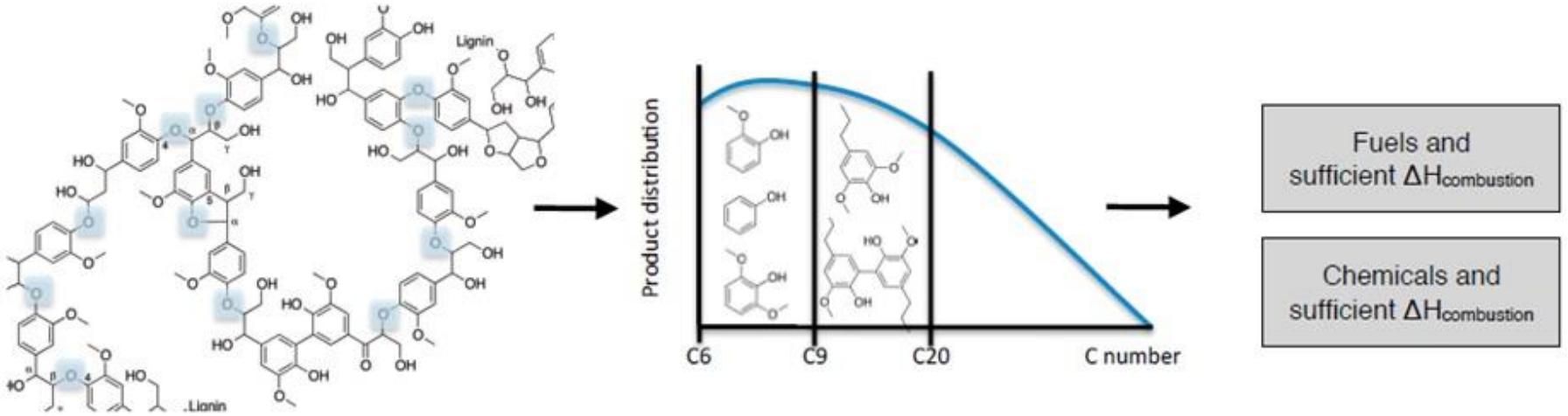
Low-Temperature Deconstruction and Catalytic Sugar Upgrading Pathway:

- Process economics and sustainability metrics were found to vary with assumptions about the source of hydrogen used for catalytic upgrading
- Includes three different scenarios which source hydrogen either externally, *in situ*, or through gasification of part of the feedstock



Lignin Valorization at NREL

TEA shows that lignin utilization is essential to meet $3/gge target in 2022 (Davis et al., 2013)



Depolymerization
- Obtain lignin in liquid phase at high yield
- Quantify/understand impact to polysaccharides

Upgrading
- Convert lignin to fuels and chemicals
- Leverage known deconstruction methods
- Develop new upgrading processes

De-polymerization and upgrading (from NREL - Lignin valorization through integrated deconstruction, biological funneling, and catalysis, Gregg T. Beckham) Linger, Vardon, Guarnieri, Karp, *et al., PNAS,* 2014

Renewable Carbon Fiber

This effort aims to reduce our dependence on foreign oil and bring more manufacturing jobs to the U.S.

- BETO and other EERE Offices are working together to produce innovative materials from biomass.
  - Utilize biorefinery products (sugars, lignins, other chemicals).
  - Enhance biorefinery economics.
  - New materials
    - Application for multiple markets.

TABB FOA

The Targeted Algal Biofuels and Bioproducts (TABB) FOA: 6 projects will receive up to $18M in funding to reduce the modeled price of algae-based biofuels to less than $5/gge by 2019.

The projects selected include:

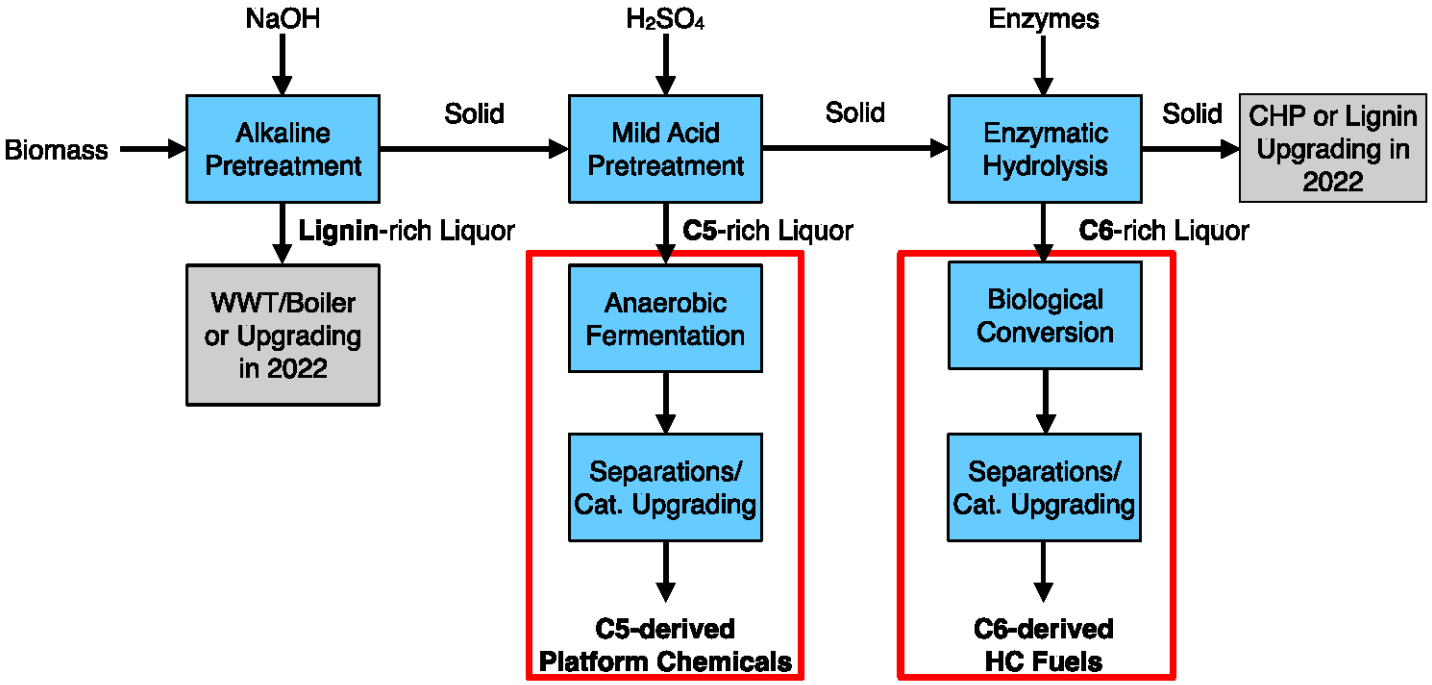
- Producing Algae and Coprducts for Energy (PACE), Colorado School of Mines, Golden, CO.
  - In collaboration with Los Alamos National Laboratory, Reliance Industries Ltd., and others, will receive up to $9 million to enhance overall algal biofuels sustainability by maximizing CO2, nutrient, and water recovery and recycling, as well as bio-power co-generation, and will produce green chemicals along with hydrocarbon fuels.
- Marine Algae Industrialization Consortium (MAGIC), Duke University, Durham, NC
  - Leading a consortium including University of Hawaii, Cornell University, Cellana and others, will receive up to $5.2 million to produce protein-based human, salmon, and poultry nutritional products along with hydrotreated algal oil extract at Cellana's demonstration facility in Kona, HI.

Photo credits NREL and Arizona State University

Biological Upgrading of Sugars

Goal: develop strains to produce fuels and co-products for the 2017 and 2022 Biochemical Conversion Platform cost target goals of $5/gge and $3/gge

- Fatty acids as fuel precursors, succinic acid as an *example* product, both aligned with TEA targets
- "Bioproducts are on the Critical Path" – DOE BETO



HC fuels alongside co-products will be a major benefit to the US biorefinery infrastructure

- Conduct TEA/LCA to identify cost drivers and data gaps and to refine process options
- Collaborate with industry and academics for joint development of strains and process demonstrations
- **Outcome**: demonstrated, robust strains for producing HC fuels and co-products in the biorefinery

Green Chemistry Awards

EPA's Green Chemistry Awards were announced on July 13th. Two of the recipients currently have projects with BETO.

DOE partner recipients:

- **Greener Synthetic Pathways:** Algenol in Fort Myers, Florida for their development of a blue-green algae to produce ethanol and other fuels.
  - Algenol is also working with PNNL, NREL, and Georgia Tech on development of higher-value green chemical production concepts.
- **Specific Environmental Benefits:** LanzaTech in Skokie, Illinois for their development of a process that uses waste gas to produce fuels and chemicals, reducing companies' carbon footprint.
  - This method utilizes gas streams with a range of CO and H_2 compositions to produce fuels such as ethanol and chemicals such as 2,3-butanediol at high selectivities and yields.

Other Green Chemistry award recipients:

- Renmatix, Soltex, Hybrid Coating Technologies, Nanotech Industries, and Professor Eugen Y.-X. Chen of Colorado State University.

These companies/individuals are recognized for the landmark green chemistry technologies that turn climate risk and other environmental problems into business opportunities, spurring innovation and economic development.

Conclusion

- BETO is focused on fuels
- Products can play an important role in enabling biofuels development
  - Can help improve the ROI for biorefineries/biofuels producers
  - Offer a route to improving biofuels-related technologies
  - Provide a venue for improving bio-based infrastructure
- There are many strategies for products to enable fuels
- Next steps for BETO are:
  - Joint Agency “Billion Ton Bioeconomy” Initiative
  - Upcoming funding opportunities in early and late TRLs

THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Towards Sustainability and The Biobased Promise

OBIC

agriculture

OBIC

polymers & specialty chemicals

OBIC, the Bioproducts Innovation Center located at The Ohio State University, was created in 2005 to integrate academia and industry linking expertise from two major industries, agriculture and polymers/specialty chemicals.

The Biobased Promise

Biobased innovations offer consumers intelligent, sustainable choices because they use renewable materials derived from plants.

"Smart for Tomorrow…
Even Smarter for Today"

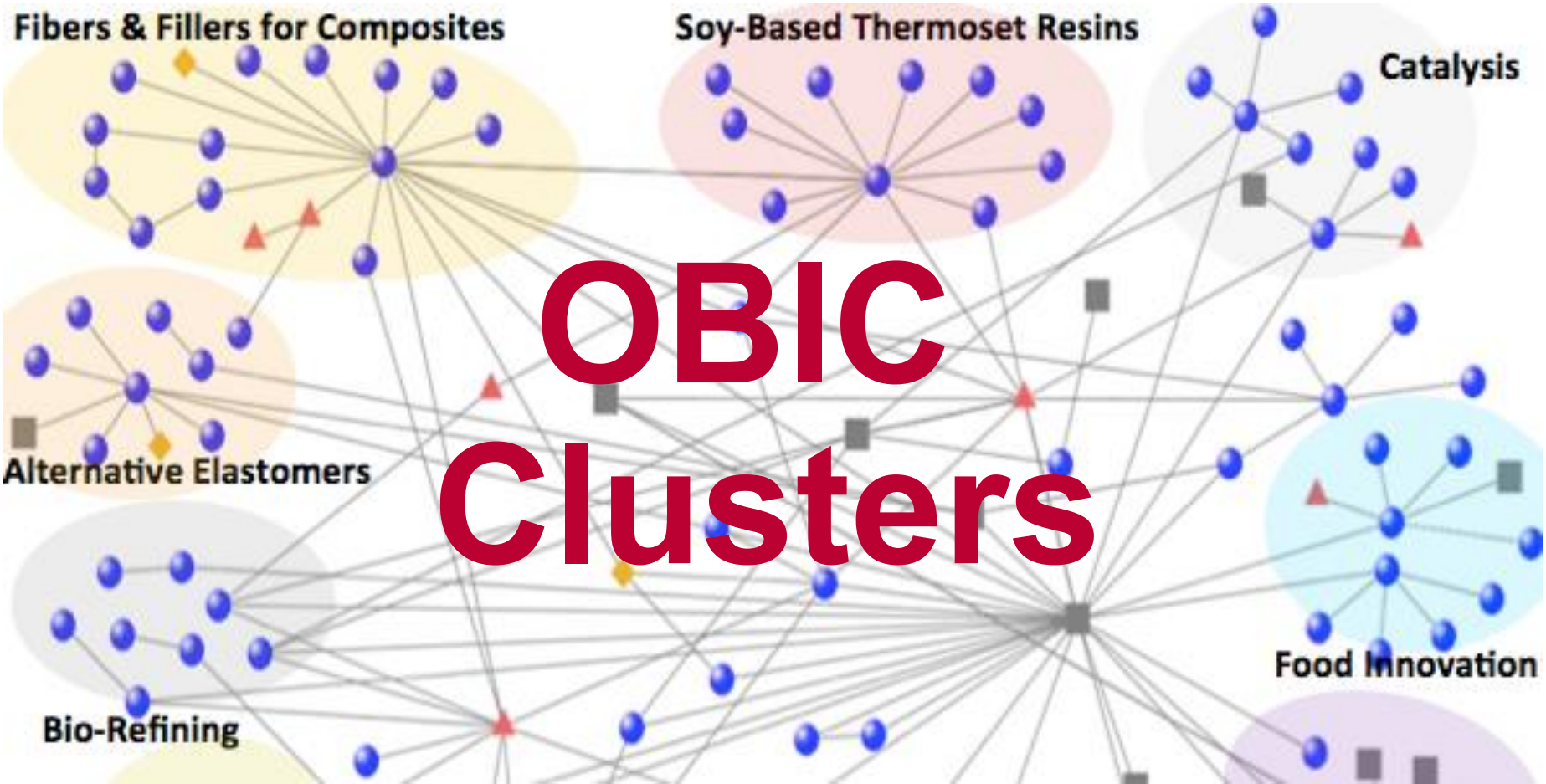
"Cell to Sell"®

Bioproducts represent an important economic development opportunity.

"Cell to Sell"® Innovation Pipeline

Policy Point #1

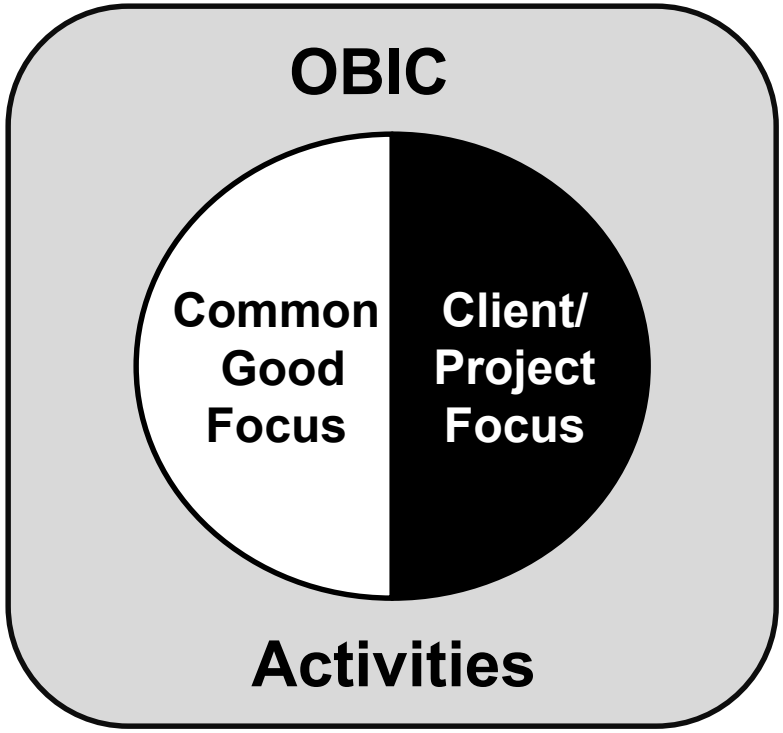
Bioproduct commercialization is not something that you do alone.



Cluster Agent Activities

- **Prospecting**
  - Market Data
  - Needs & Opportunities
  - Technology & Feedstock Assets
  - Resources
- **Networking**
  - Industry Outreach
  - Collaborator Input & Ideation
- **Assessment**
  - Technical & Economic Analysis
  - Application & Market Analysis
  - Value Proposition/Business Case
- **Leverage Resources**
  - Talent – Public & Corporate
  - Facilities
  - Strategic Investments
  - Grant Proposal Development
- **Program Oversight**
  - Partnerships & Agreements
  - Project Development
  - Project Deployment

Goal: Increase probability of success

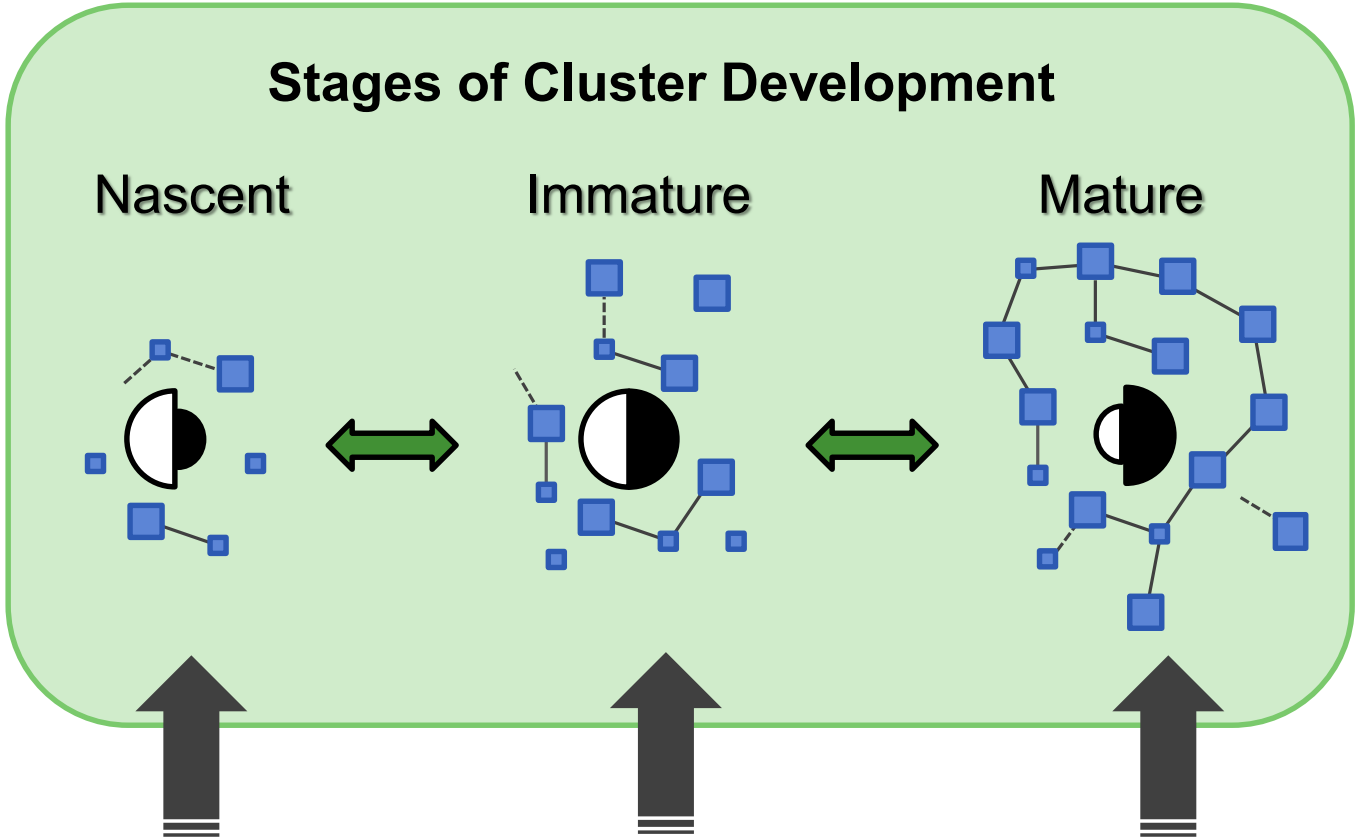


Catalyzing Cluster Formation

ELEMENTS

Assets
- Feedstocks
- Facilities
- Technology
- Talent
- Fund$

Drivers
- Industry
- Markets
- Policy



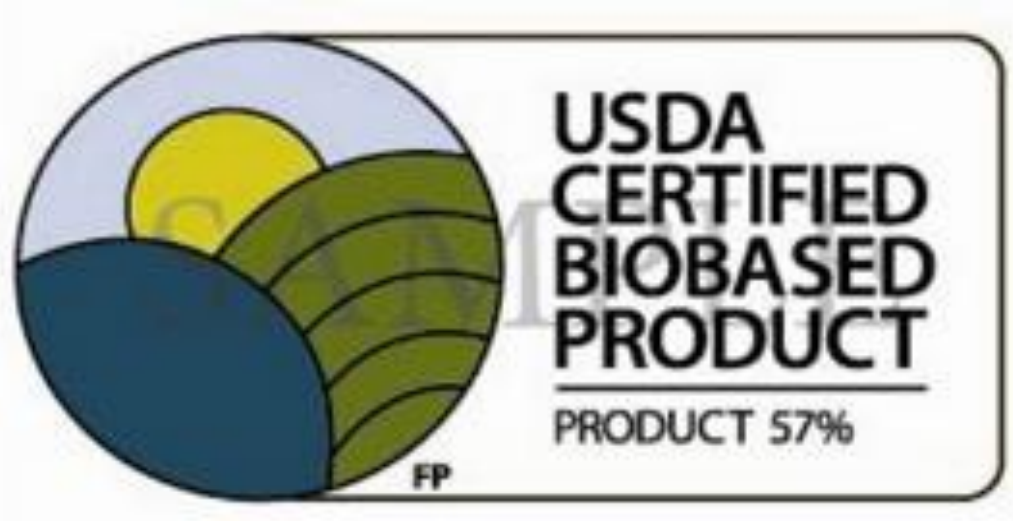
Public Private

OBIC

Discover	***Connect***	***Assess***
Assist		***Steward***

Policy Point #2

A consortium effort is needed to increase market pull.

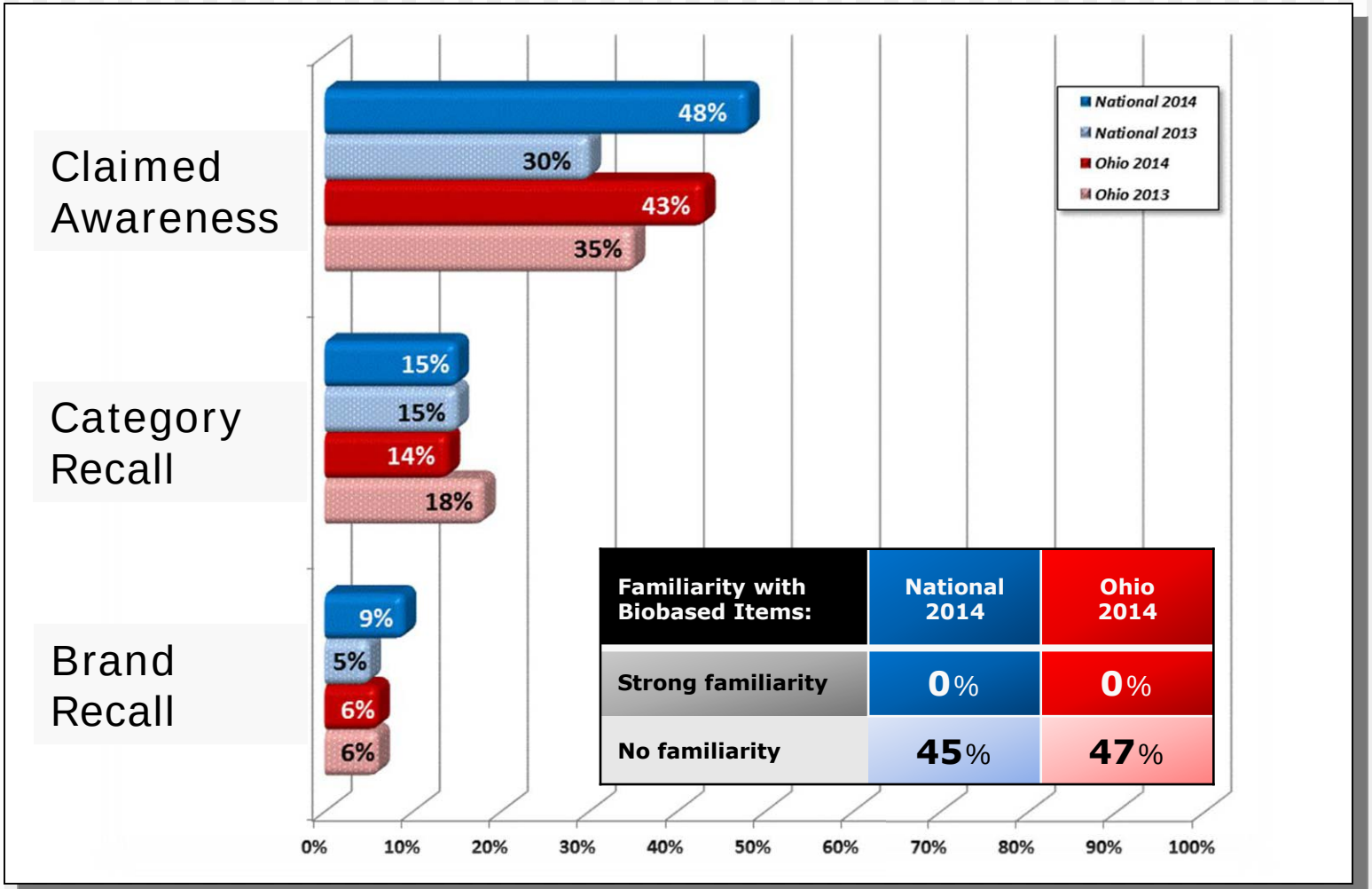


B4 Branding:
Survey of Biobased Market

- *A total of **800** respondents completed the online survey that was conducted during the second half of 2014:*
  - ✓ ***600** Nationally representative respondents*
  - ✓ ***200** Ohio-specific respondents*
- *Respondents met the following criteria:*
  - ✓ *Adults 18 – 74 years old*
  - ✓ *Target of 50% male / 50% female*
  - ✓ *Made purchases from a grocery store or mass-merchandise retailer within the past 30-days*

Unaided Awareness of Biobased Products

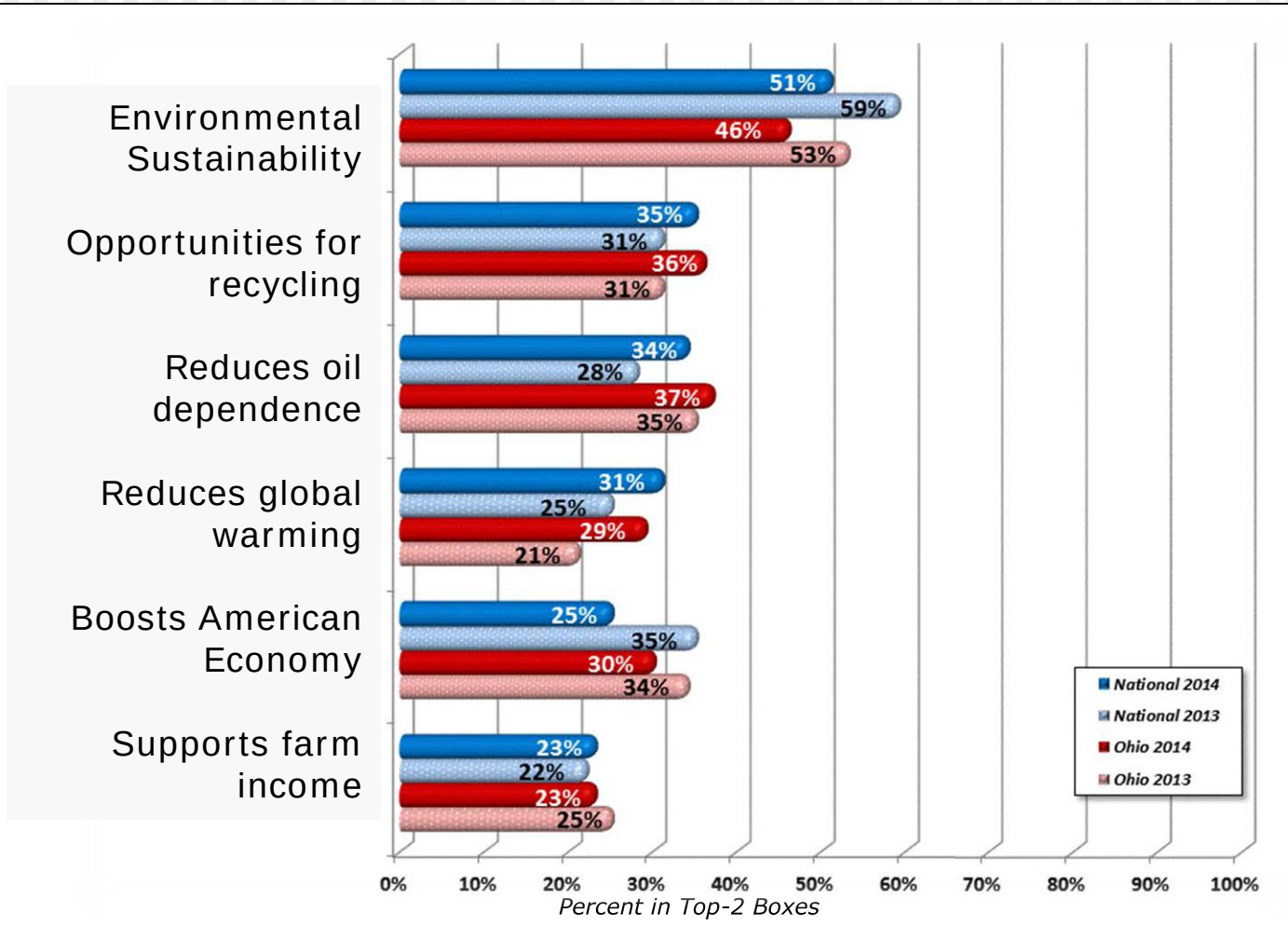
Are you aware of any biobased products? What biobased products are you aware of? You may list up to three such products in the blanks below:



Familiarity with Biobased Items:	National 2014	Ohio 2014
Strong familiarity	0%	0%
No familiarity	45%	47%

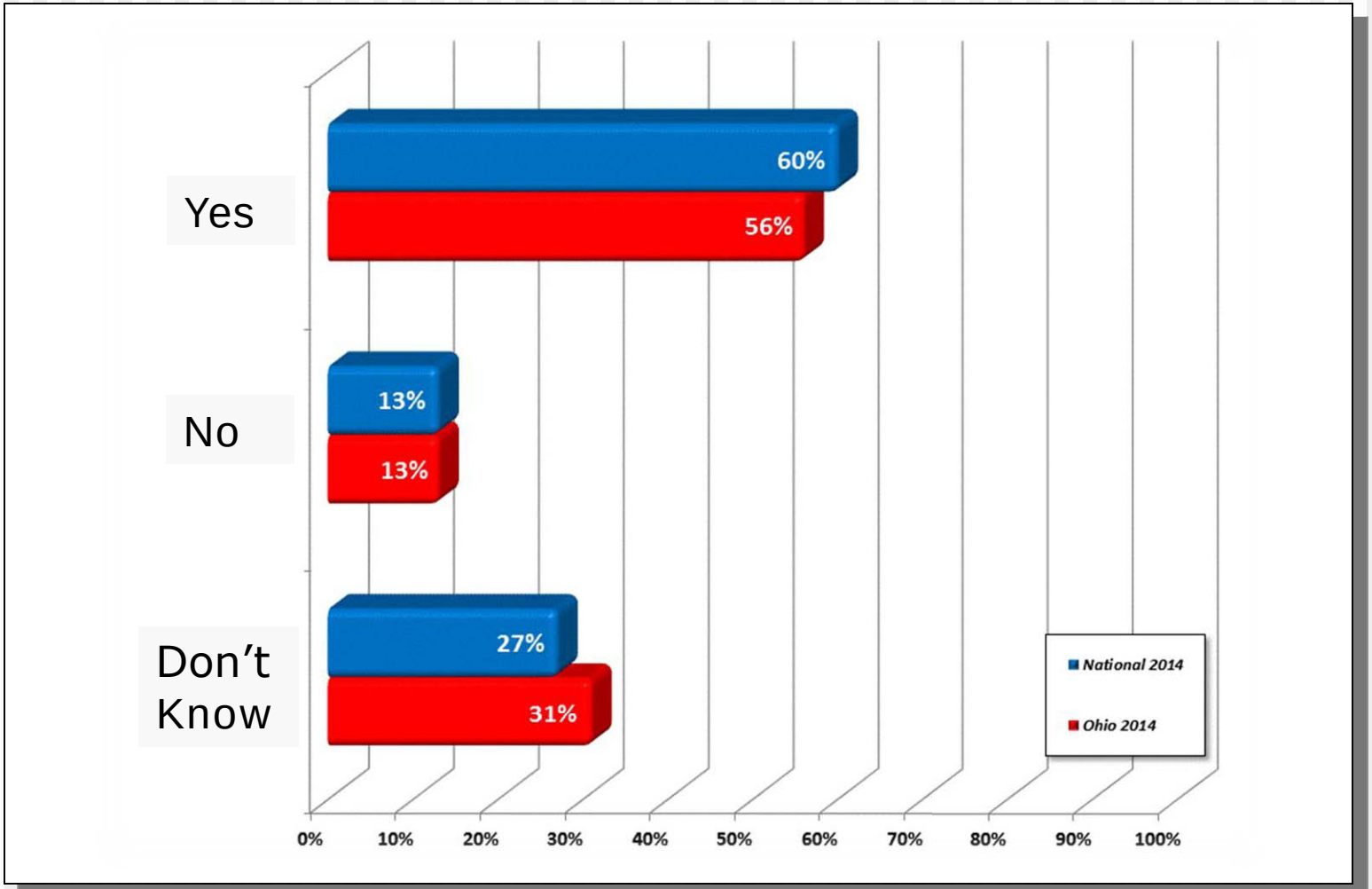
Benefits Influencing Purchase of Biobased Products

Please rank the following benefits as to their importance in influencing your purchase consideration of biobased products or biobased packaging:



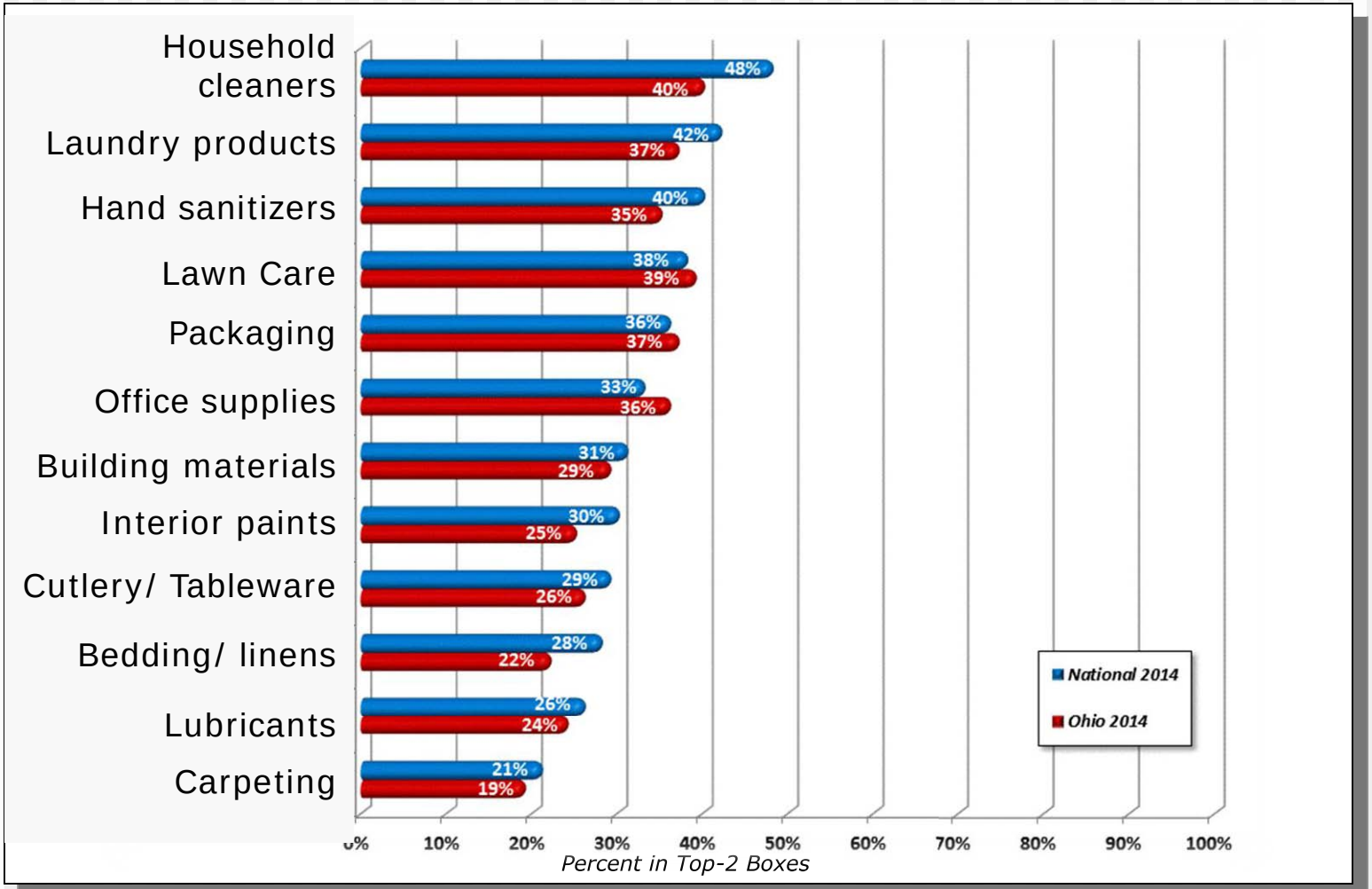
Biobased Products Making a Difference

Do you believe that buying biobased products or products using biobased packaging make a difference? (Coded open-ended responses)



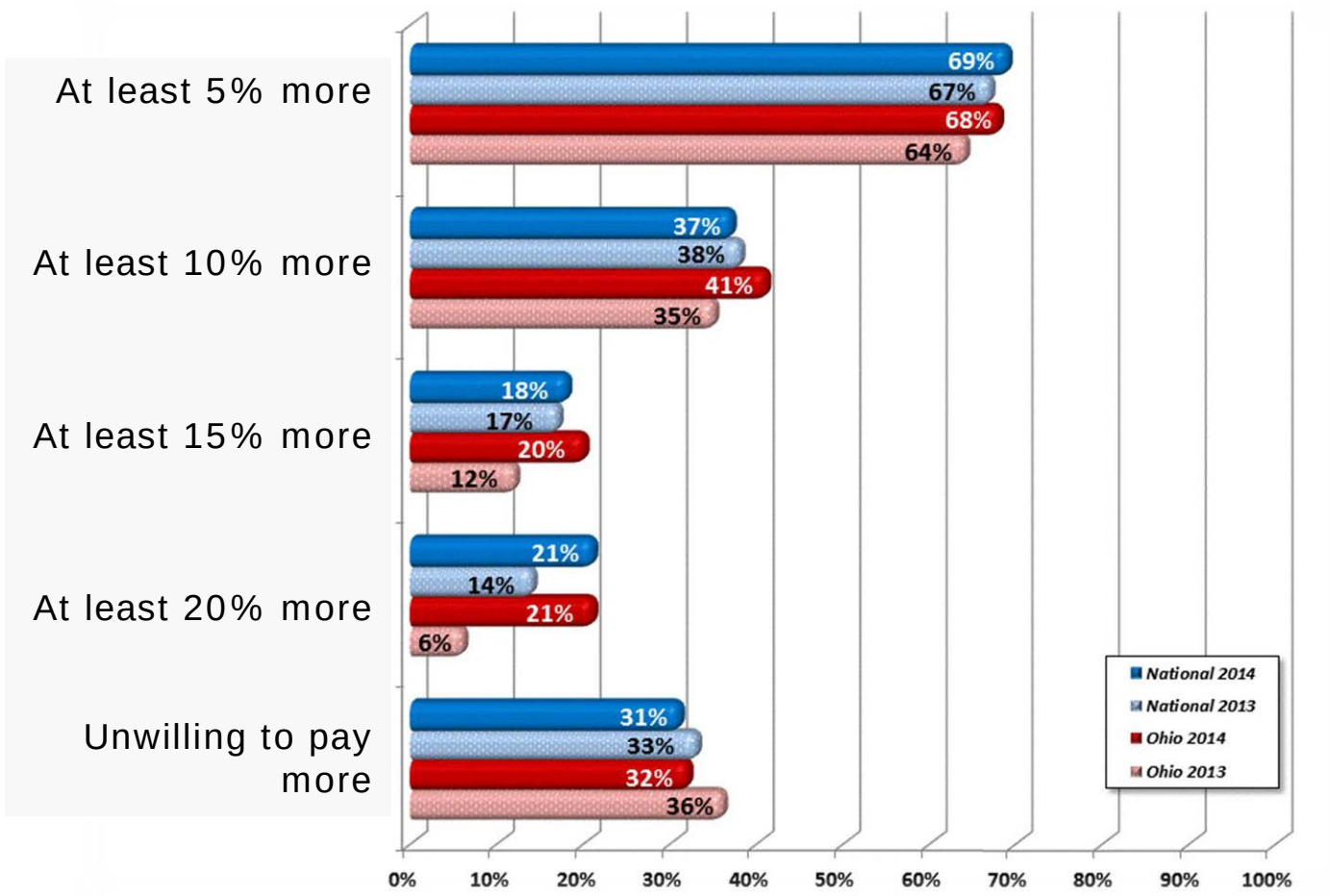
Interest in Purchasing Biobased Categories

Please rate your level of interest in buying biobased products in the following categories: (Rating based upon 7-point scale)



Price Sensitivity to Biobased Products

Assuming comparable performance to its petroleum-based equivalent, how much more would you be willing to pay for a biobased product?



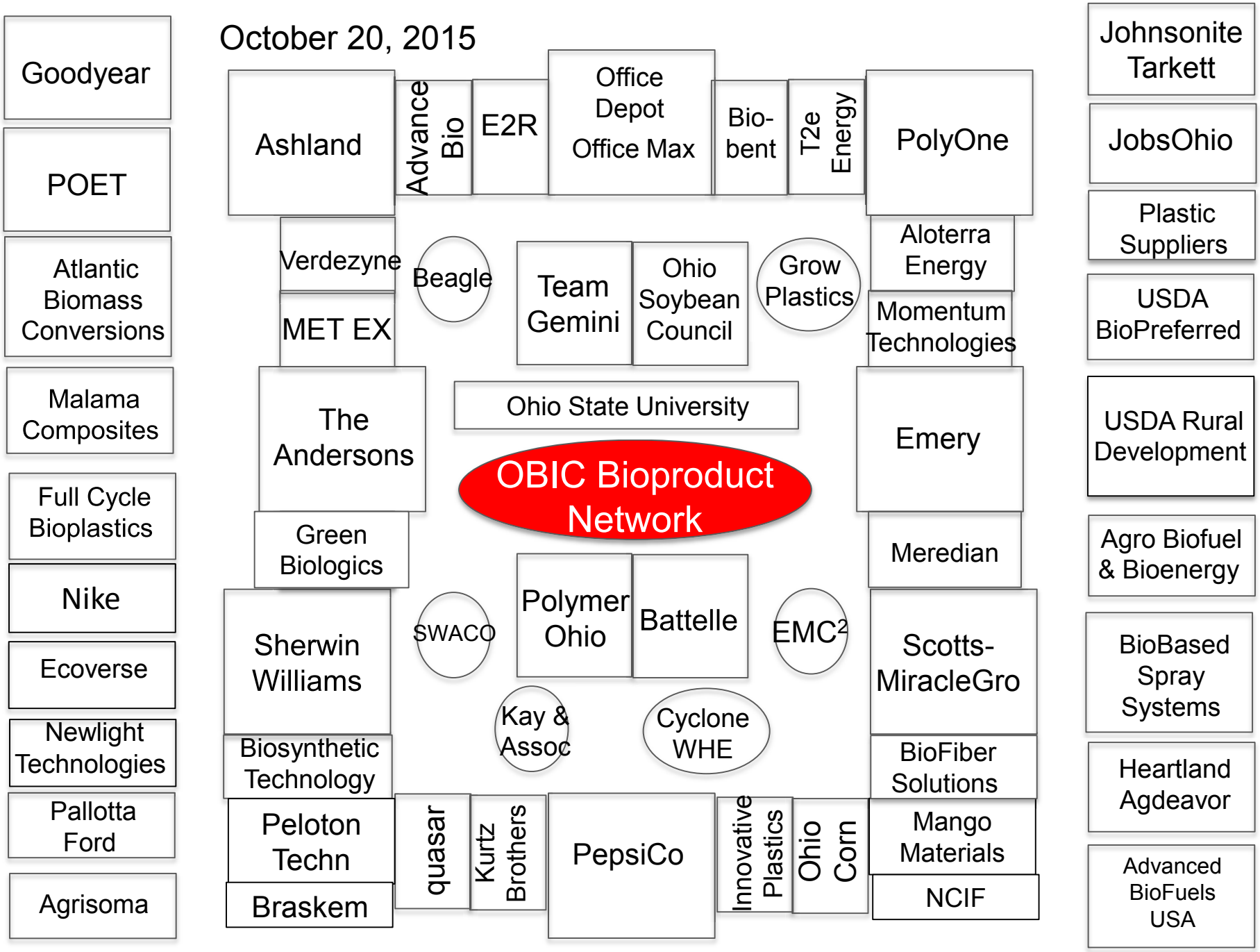
THE OHIO STATE UNIVERSITY

OBIC Sustainable World Tour

Bioproducts World 2014

"We can virtually make everything and anything from biobased materials. It's a new economy. It's a new way of doing business."

Secretary of Agriculture, Tom Vilsack


October 20, 2015
Goodyear
POET
Atlantic Biomass Conversions
Malama Composites
Full Cycle Bioplastics
Nike
Ecoverse
Newlight Technologies
Pallotta Ford
Agrisoma
Ashland
Advance Bio
E2R
Office Depot
Office Max
Bio-bent
T2e Energy
PolyOne
Verdezyne
Beagle
Team Gemini
Ohio Soybean Council
Grow Plastics
Aloterra Energy
MET EX
Momentum Technologies
The Andersons
Ohio State University
OBIC Bioproduct Network
Emery
Green Biologics
Meredian
Sherwin Williams
SWACO
Polymer Ohio
Battelle
EMC²
Scotts-MiracleGro
Kay & Assoc
Cyclone WHE
Biosynthetic Technology
BioFiber Solutions
Peloton Techn
Braskem
quasar
Kurtz Brothers
PepsiCo
Innovative Plastics
Ohio Corn
Mango Materials
NCIF
Johnsonite Tarkett
JobsOhio
Plastic Suppliers
USDA BioPreferred
USDA Rural Development
Agro Biofuel & Bioenergy
BioBased Spray Systems
Heartland Agdeavor
Advanced BioFuels USA

Thank you for your work to advance our Bioeconomy

Denny Hall, OBIC Director
Hall.16@osu.edu
614-292-4188

BioPreferred®

An End-User Market Tool for Bioproduct Transformation

USDA

United States Department of Agriculture

BioPreferred in USDA Portfolio







Feedstock Production	Feedstock Logistics	Conversion	Conversion Process Scale-up/Integration	Product Testing/Approval		Enable Production	End User Markets
				Performance	Environment Assmt		

Farm Bill Mandated

- Agricultural Act of 2014
- Title IX, Section 9002
- Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Program (9003)
  - www.rd.usda.gov/programs-services/biorefinery-assistance-program
- Review BCAP, REAP, BRDI

BioPreferred Program Goals

- Identifies and seeks new markets for biobased products
- Two major program elements:
  - Mandatory federal government procurement preference
  - Voluntary biobased product certification/labeling

Federal Govt. Bioproduct Purchasing

- USDA identifies and qualifies product categories (with minimum biobased contents) by rule
- Federal agencies must show biobased products in qualified categories a procurement preference one year after rule is final

- Requirement applies to Federal agencies and contractors

Executive Order 13693 Overview

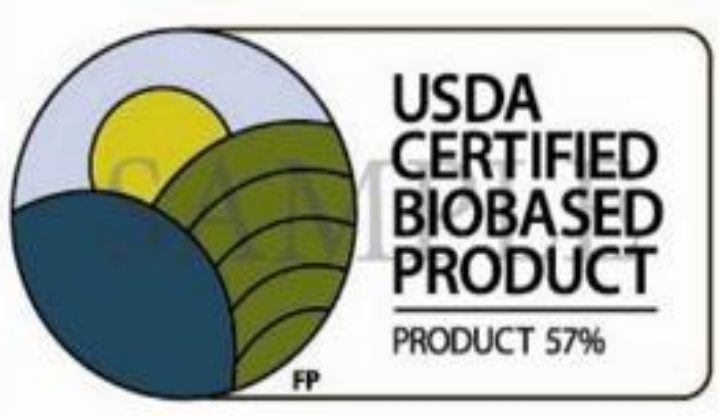
- "Planning for Federal Sustainability in the Next Decade"
- "Promote sustainable acquisition and procurement by ensuring that environmental performance and sustainability factors are included for all applicable procurements…"
  - Meet statutory mandates that require purchase preference
- Signed March 2015

Product Certification and Labeling

- Expand purchases of biobased products in commercial and consumer markets
- Increase availability of information
- Help manufacturers market biobased products

"USDA Certified Biobased Product" Label

- Launched February 2011
- Serves as an unbiased indicator of biobased content
- On-line paperless application process
- Minimum biobased content
  - Same as qualified category for products associated with a category
  - 25% for all other products
- Independent third party certification partnership with ASTM International



USDA Certified Biobased Products

Activity	Number
Applications Received [●]	2600
Review/Testing in Process	400
Certified [●]	2200
Failed [○]	100

(As of Oct 2015)

US Companies Registered with BioPreferred

Stakeholder Feedback

"Being in the USDA Biobased Market Program catalog has been the catalyst for our receiving both civilian business and inquirers from the US Army concerning our product."

"…we are a willing partner and see the BioPreferred program as being absolutely vital to our success."

"Yellowstone [National Park] was an 'early adopter' of a number of biobased products such as hydraulic fluids, bar oil, and other machinery lubricants."

"We have received a good response from downstream customers about USDA's biobased product certification and label…" [The label] has led to a few new opportunities for us to pursue…it has led to some potential new business for us… The benefit gained from product certification far outweigh the companies investment and time."

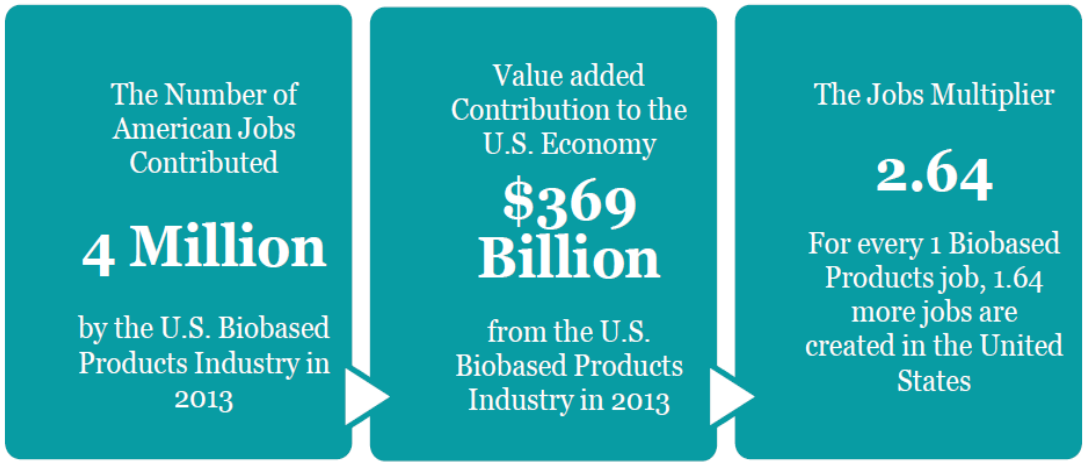
Secretary Vilsack's Comments on BioPreferred

"USDA is continuing to support growth of a new biobased economy, creating a 'USDA Certified Biobased Product' label that links manufacturers of more than 25,000 plant-based products with buyers."

"Rural America holds tremendous promise today, thanks in large part to innovation taking place in the biobased economy. Since 2009, USDA has made tremendous investments in the research necessary to develop the next generation of biobased products." -- January 11, 2013

Program Next Steps 2016-2017

- Economic Impact Report, Part II
- Complex Assemblies
- Additional Product Qualification for Federal Procurement



Thank You!

- Kate Lewis, Deputy Program Manager
- 202-720-0811
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Summary of Webinar

The creation of a robust, next -generation domestic bioenergy industry is one of the important pathways for providing Americans with sustainable, renewable energy alternatives. Through research, development, and commercialization to produce renewable fuels and products sustainably and affordably, we can provide home-grown alternatives for the transportation, energy, and bioproducts sectors.

Questions?

Email eere_bioenergy@ee.doe.gov

Please include “Bioproducts Webinar” in the Subject Line

Thank you!