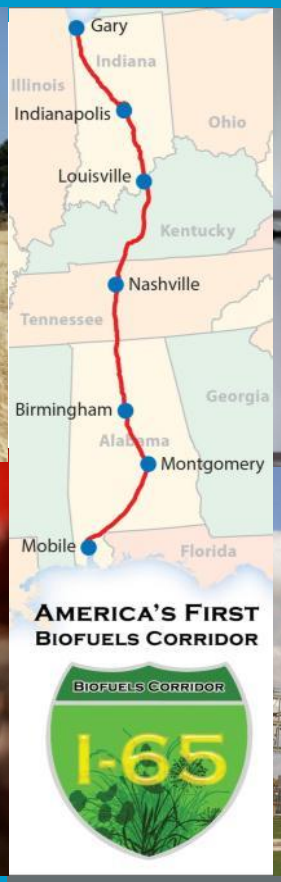
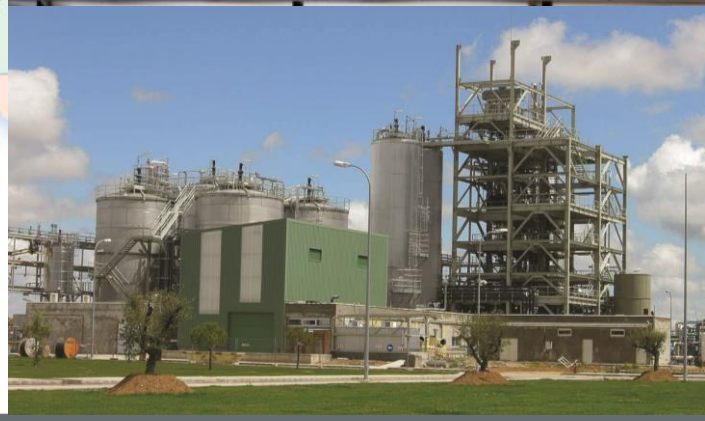


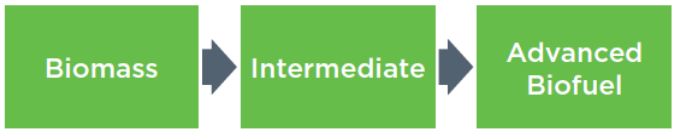


Recent Activity on Bioproducts that Enable Biofuels in the Bioenergy Technologies Office

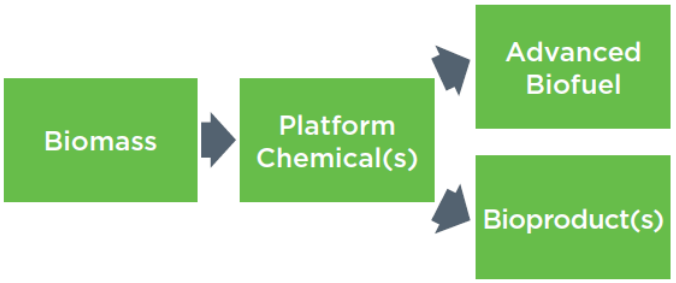
July 13, 2016

Andrea Bailey – ORISE Fellow, Conversion Technologies

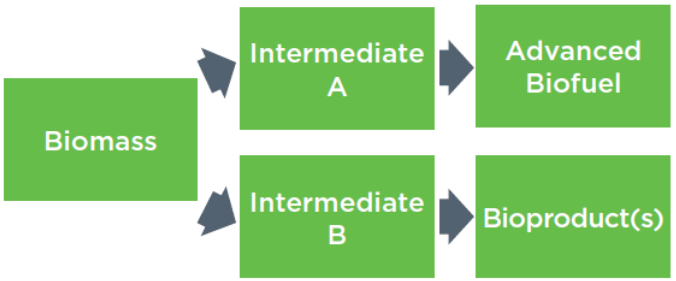
Potential Bioproduct Production Pathways



Fuel alone. Traditional approach which was highly successful for cellulosic ethanol



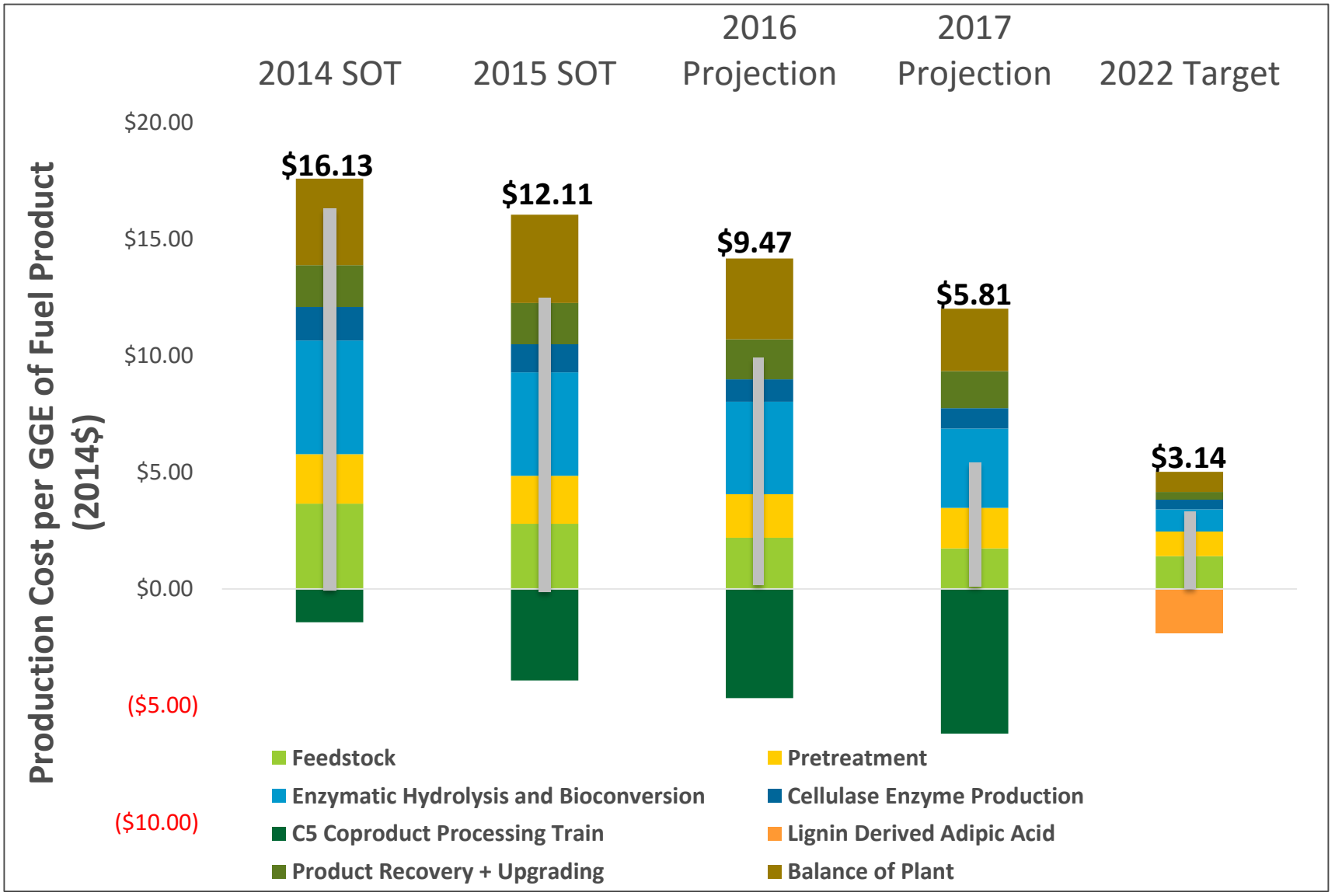
Platform chemical. (e.g. Vertimass EtOH to jet, levulinic acid)



Coproduction. May utilize waste stream/slip stream conversion
(e.g. C5 to succinic, lignin utilization, starch ethanol, etc.)

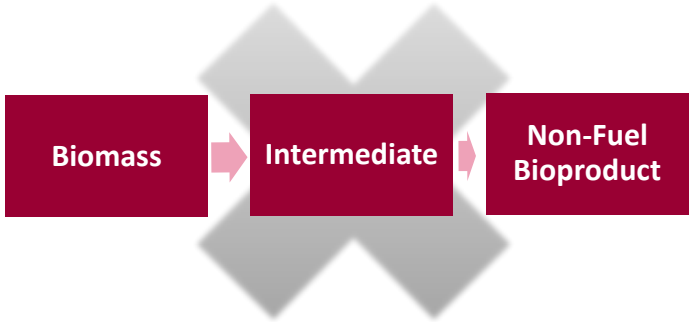
Variety of potential setups for bioproducts enabling biofuels

Design Case - Low-Temperature Deconstruction and Fermentation



High value co-products a necessity for some configurations

Potential Bioproduct Production Pathways



Product alone. Not of interest to DOE with out a fuel component.

Pathways not of interest to DOE

Bioproducts to Enable Biofuels Workshop – July 2015

94 stakeholders convened to address the following major questions:

- How can the production of bioproducts enable the production of biofuels?
- Are products necessary for economically feasible biofuels?
- Are there common intermediates that are best suited for making products and fuels?
- Are there platform technologies that are best for making products and fuels?

Bioproducts to Enable Biofuels Workshop – July 2015

Pros

- Lessons learned from bioproducts production can be transferred to biofuels
- Higher profit margin on bioproducts helps de-risk investments into refineries
- Entry into bioproduct markets may be easier

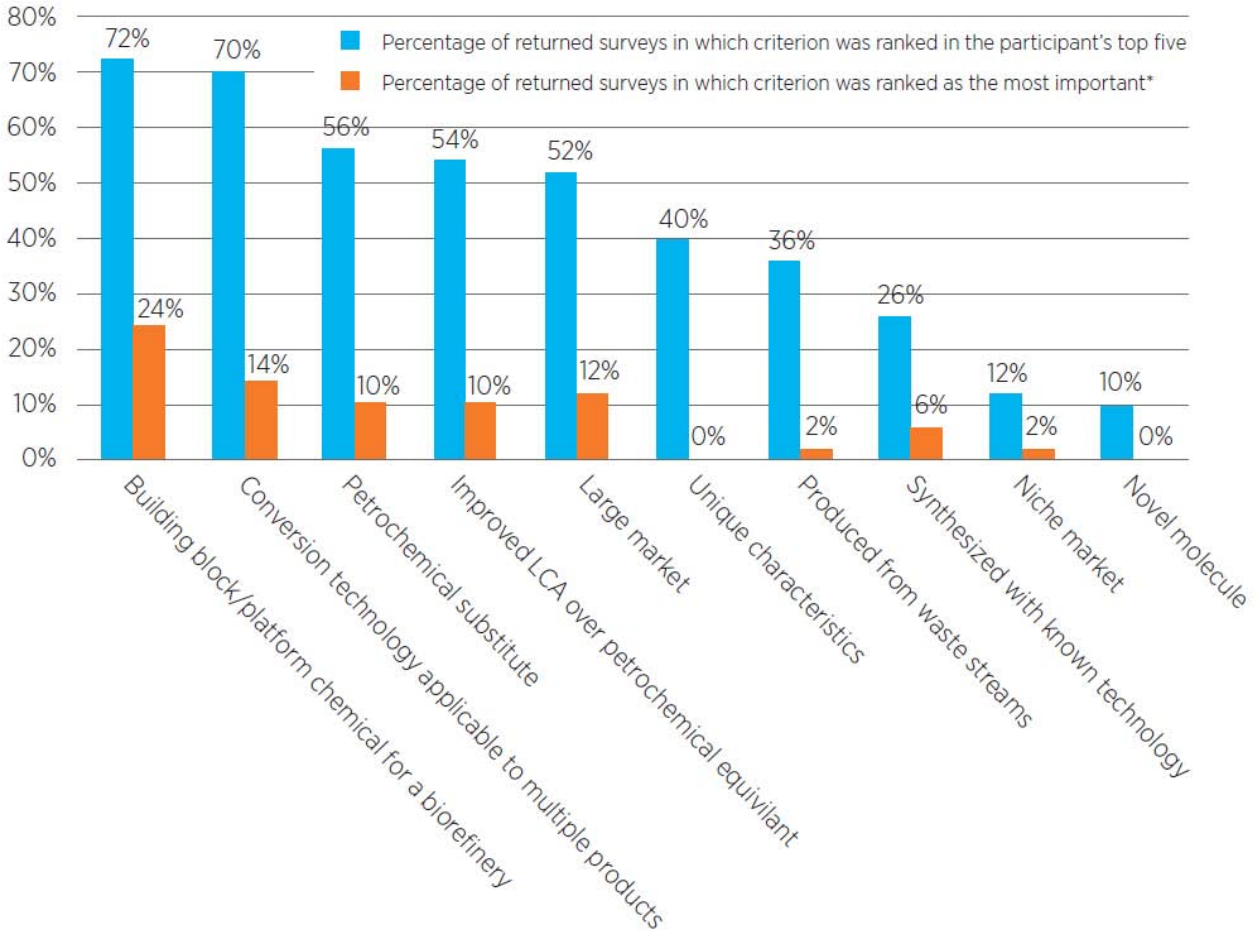
Cons

- May distract from research on biofuels
- Producers may choose to abandon biofuels entirely if the bioproduct is highly profitable
- Market saturation of key products

Most participants agreed products will be necessary to ensure the economic feasibility of advanced biofuels

Bioproducts to Enable Biofuels Workshop – July 2015

- Participants were asked to discuss **what would make a desirable target bioproduct** and how this could fit into BETO's current R&D portfolio



(Workshop report can be found on the BETO website under Information Resources -> Publications.)

Bioproducts to Enable Biofuels Workshop – July 2015

- **A desirable target bioproduct should**:
  - Be an environmentally favorable direct replacement for a petroleum product
  - Act as a building block for other products and fuels
  - Capitalize on the inherent structure of biomass

Desirable Platform Molecules	Corresponding Platform Technology
Mixtures of compounds that could be used as fuels or products (e.g., BTX)	Fast pyrolysis and related technologies
Molecules that mimic existing biomass structure (e.g., methoxyphenols from lignin)	Biological and chemical upgrading of sugars
Molecules with functionality amenable to chain extension to the diesel range (C_8–C_{21})	Syngas upgrading

(Workshop report can be found on the BETO website under Information Resources -> Publications.)

Bioproducts to Enable Biofuels Workshop – July 2015

- Participants were also asked identify **short and long term challenges** associated with bioproducts.

Short term (less than 5 years) challenges	Long term (greater than 5 years) challenges
Feedstocks cost, purity, variability	Using real feedstocks over model feedstocks
Catalyst lifespan and cost	Market variability
Issues with separations and purification	Technology transfer
Robust reactor design	Continuous processing
Risks associated with scale-up	Predicting the scalability of technologies
Funding	Decentralized processing

(Workshop report can be found on the BETO website under Information Resources -> Publications.)

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.
- Awards will be announced Fall 2016

Flexible production of fuels and products

Recent Funding Opportunities

Incubator II

- **$10 million** in funding for innovative technologies not currently represented in the BETO portfolio that will support BETO's work to develop renewable and cost-competitive biofuels from **non-food** biomass feedstocks and support the development of a more robust bioeconomy.
- Announced 5/16/2016 six projects:
  - **Arizona State University**, Tempe, Arizona: ethyl laurate
  - **Arizona State University**, Tempe, Arizona: mixotrophic algae
  - **Lygos Inc.**, Emeryville, California: aspartic acid
  - **LanzaTech Inc.**, Skokie, Illinois: acetone
  - **White Dog Labs**, New Castle, Delaware: acetone and others
  - **Duke University**, Durham, North Carolina: metabolic valves for products

"Open" FOA for off-roadmap technologies

Selection of Recent Activities Focused on Bioproducts

- $11M MEGA-BIO: Bioproducts to Enable Biofuels (awards anticipated Fall 2016)
- $10M Incubator 2: (awards May 2016)
- **Bioproducts to Enable Biofuels Worskshop (July 2015)**
- $18M Targeted Algal Biofuels and Bioproducts (awards July 2015)
- $11M Renewable Carbon Fiber (awards July 2014)

Bioenergy Technologies Office Website:
http://energy.gov/eere/bioenergy/bioenergy-technologies-office