Green Chemical Market

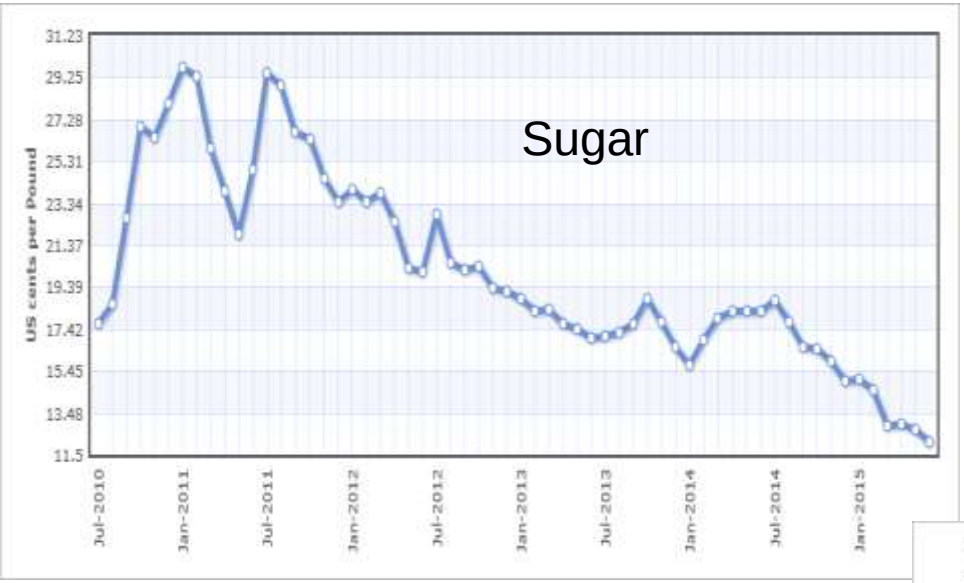
Rick Heggs Battelle

Traditional Chemical Feedstocks

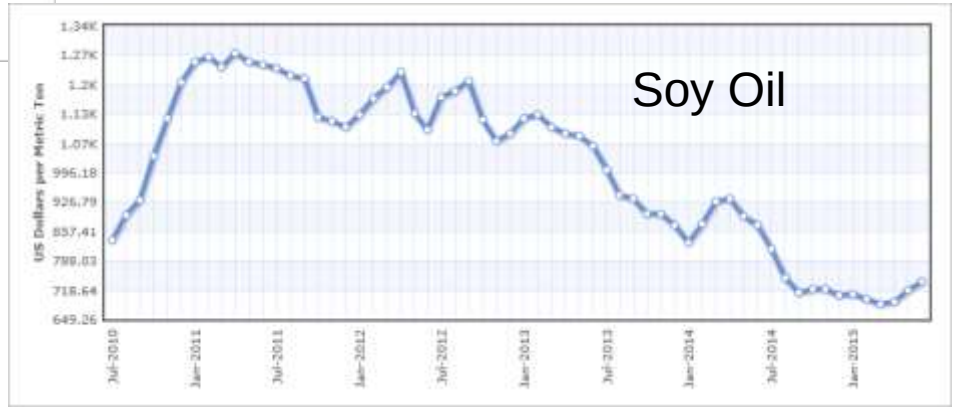
$2.75/MCF=0.08/lb C

$50/bbl = 0.11/lb C

Alternative Chemical Feedstocks



0.12/lb = 0.29/lb C



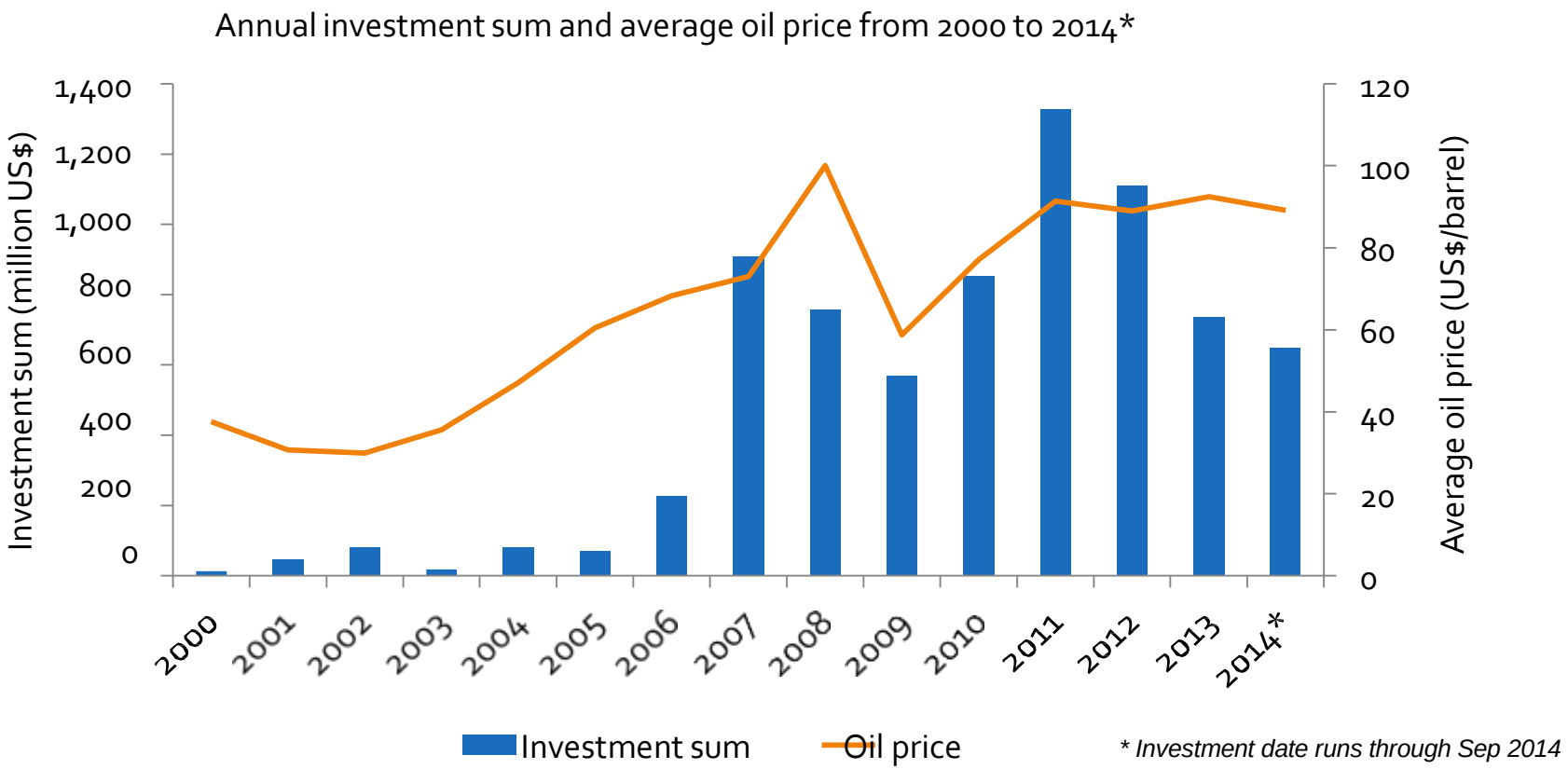
$700/Ton = 0.42/lb C

Chemical Feedstock Summary

Feedstock	Carbon Cost	Comments
Oil	11 cents/lb	Historical and predominant little oxygen content
Natural Gas (ethane)	8-9 cents/lb	Very attractive and switching is occurring no oxygen content
Sugar	29 cents/lb	Fermentation feedstock of choice high oxygen content complex chemical structure
Soy Oil	42 cents/lb	Suitable for many chemical transformations lower oxygen content less complex chemical structure

Difficult or impossible to compete on price for simple (C4 and lower) chemicals need to find specialty chemical targets with higher complexity and oxygen content

VC Investment

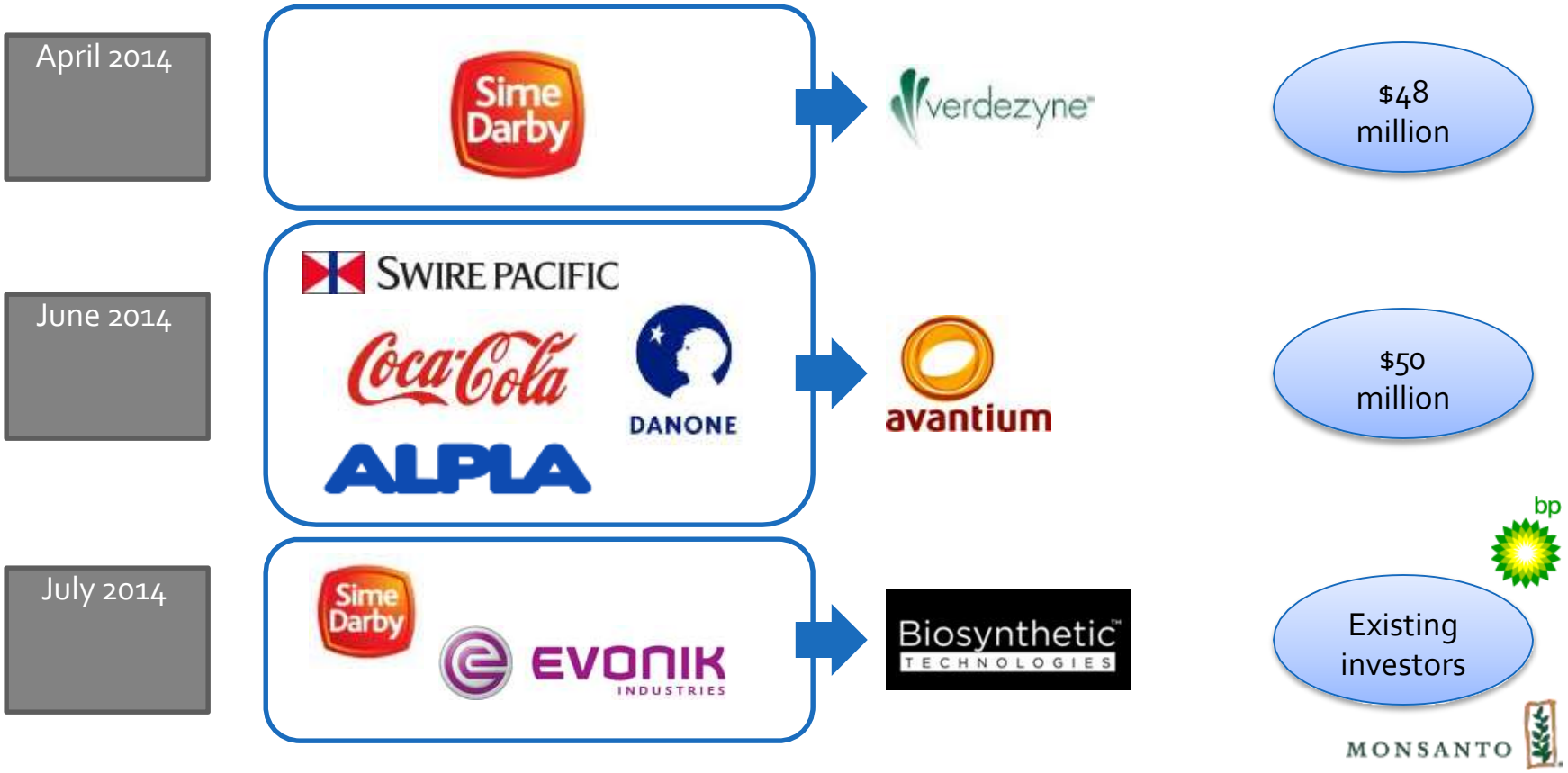


Data Courtesy of Lux Research

IPO Problems

- Solazyme's IPO had a valuation of $198 million, the largest of all the bio-based companies
- Falling stock prices of biobased product public companies underline their subpar performances and discouraged further investment through this route
- Gevo noted its communication problems with its investors over contamination troubles
- A class action lawsuit is being brought against Solazyme alleging false and misleading statements in 2014 related to its troubles in Moema Brazil

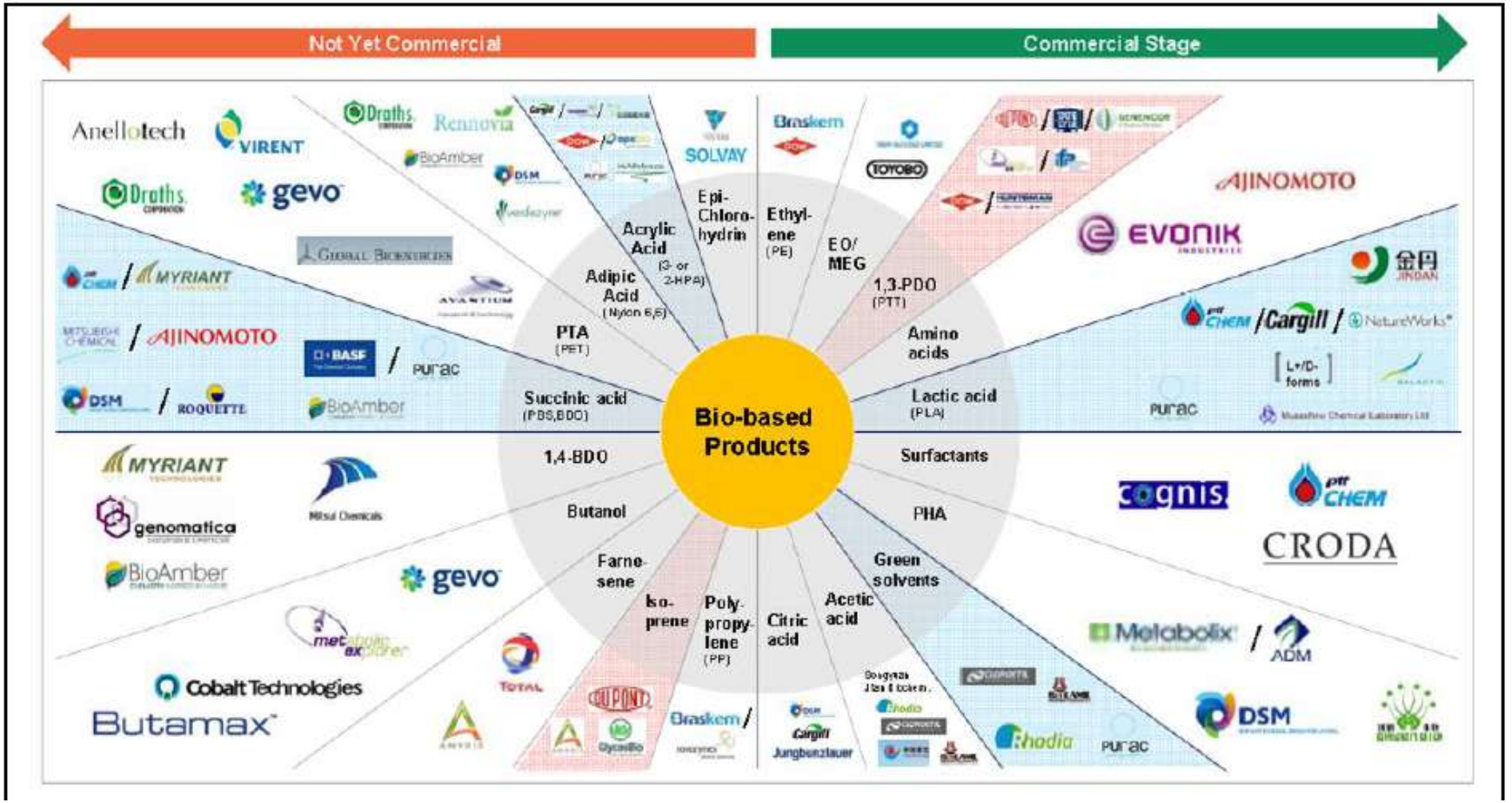
Partnerships Continuing



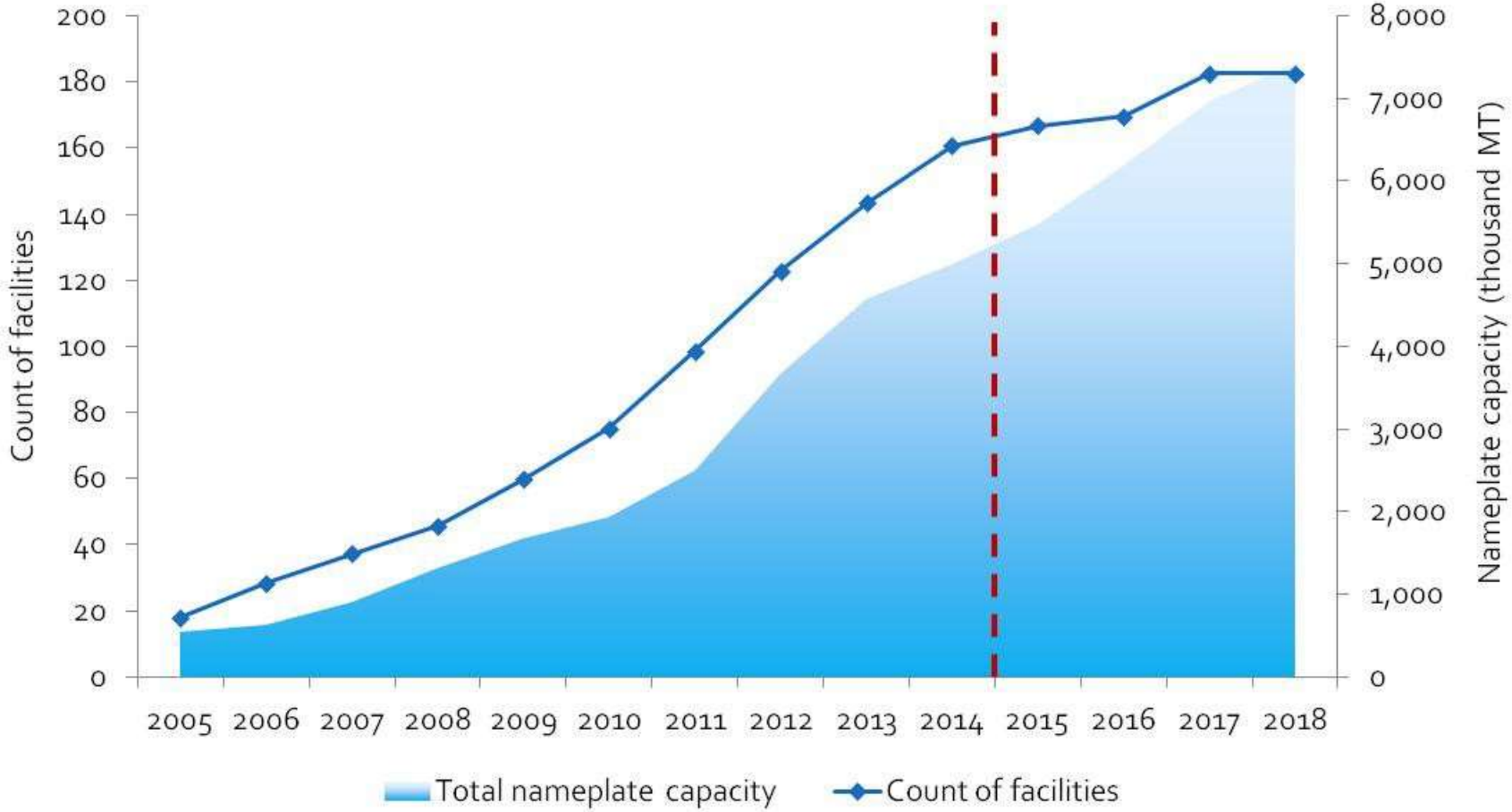
Green Chemical Market

- No green premium in the market
  - Must compete on price and performance
  - Strong headwinds from oil, shale gas and NGL
- VC funding has contracted since a peak in 2011
- IPOs have slowed or even stopped
- Parnerships and joint ventures are continuing where it benefits both parties

Lots of Progress



Industry Capacity Increasing



Data courtesy of Lux Research

Where is the industry going?

- Focus shifting from fuels to chemicals
- Start ups gaining traction with partnerships with other value chain members
- Increased emphasis on new materials rather than petrochemical drop-ins
  - Levulinic acid
  - Encapso from Solazyme
  - Long chain diacids
  - PEF
- New materials require increased focus on application development

Development Philosophies

Petrochemical Drop-In

- Break a biobased feedstock all the way down to a petro-derived molecule
- More chemical transformations needed
- No application development needed (ready market)
- No ability to use novel properties of biobased molecule

Novel Biobased Chemicals

Battelle's Focus

- Selectively functionalize or simplify a biobased feedstock to create a useful chemical
- Fewer chemical transformation needed
- More application development needed
- Many times unique products functions are discovered

Battelle Targeting Strategies

replacement of “chemicals of concern”	• Phthalates (plasticizer) • Formaldehyde (wood adhesive) • BPA • Brominated flame retardants • Alkylphenol ethoxylates (APEs) surfactants
applications that are “near the body” or in the home	• Hydrogels (diapers, tampons) • Creams lotions (C19 diacid ester, wax) • Candles (wax)
areas that can use undervalued co-products or processes for better economics	• Hulls or ARSOY (thermoplastic filler) • Glycerin (polyol, solvents, deicer) • Soy molasses (solvents, lactic acid) • Uses for mothballed hydrogenation units (wax, solvents)
opportunities that develop due to petrochemical industry changes	• Wax market

Battelle Lessons Learned

- Licensees who need to raise capital in the investment market will dramatically slow down commercial success
  - Focus on established companies
- Licensees who are not directly in the value chain currently will face many barriers
- Find applications with fewer value chain members
  - Closer to end user the better
- Engage industry experts ASAP in the application development phase

Closing Thoughts

- Industry is undergoing “growing pains”
- Projects are taking longer and costing more than first estimates
- Lots of activity in partnerships
- Both thermochemical routes and biological routes are being exploited
- Sustainability is growing in importance as a driver over “green” for end users