New Opportunities: Renewable Chemicals and Biobased Products

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Some Industrial and Environmental Section Members
Industrial Biotechnology

- The application of life sciences to conventional manufacturing and synthetic processes

- Industrial biotech uses genetically enhanced bacteria, yeasts, and other organisms.

- Biobased production processes result in:
  - lower production costs
  - reduction or prevention of pollution
  - enhanced resource conservation
Industrial Biotechnology and the Biobased Economy

- A biobased economy has the basic building blocks for industry and the raw materials for energy derived from plant/crop-based (i.e. renewable) sources and processed using industrial biotechnology

- Components include biofuels, bio-polymers and bioplastics, specialty chemicals, bioremediation, commodity chemicals, and marine biotechnology

- Biobased economy values at $1.25T nationally
Renewable Chemicals & Biobased Products

- Higher value products getting much more attention…

  - Bio-polyethylene
    - [Dow](https://www.dow.com)
    - [Braskem](https://www.braskem.com)

  - Bio-succinic acid
    - [Myriant Technologies](https://www.myrianttech.com)
    - [DSM](https://www.dsm.com)
    - [BioAmber](https://www.bioamber.com)

  - Bio-isoprene
    - [Genencor](https://www.genencor.com)
    - [Goodyear](https://www.goodyear.com)

  - Bio-acrylic acid
    - [OpX Biotechnologies](https://www.opxbiotech.com)
    - [Dow](https://www.dow.com)

  - Bio-butanediol
    - [Genomatica](https://www.genomatica.com)

  - Bio-isobutene
    - [Gevo](https://www.gevo.com)
    - [LANXESS](https://www.lanxess.com)
Bioproducts Success Factors

• The success of new biobased materials relies upon three factors

✓ Economics & performance are generally required
✓ Performance matches/exceeds petroleum counterpart
✓ Environmental aspects are typically valued as added benefit
Industrial Biotechnology
Fruits of Labor

Sales in Billions of Euros

Chemical products relying on either:
- Bio-based feedstock
- Fermentation
- Enzymatic conversion
Or a combination of the above

2000  2007  2012
~ 50   ~ 100  ~ 150

Logos of various companies: ABENGOA BIOENERGY, BASF, DSM, ADM, GEVO, TATE & LYLE, ExxonMobil, EVONIK INDUSTRIES, bp, GOODYEAR, MARATHON, Dow, ROQUETTE, Cargill, NESTE, Total, Dupont, Henkel, SOLVAY, P&G.
Sorona® Polymer in Carpet: Mohawk SmartStrand®

• For residential carpet applications, Sorona® delivers:
  • Softness and luxurious feel
  • Built-in permanent stain resistance
  • Exceptional durability and crush resistance

• Strong market penetration
Polylactic Acid (PLA)

- World's leading biopolymer player
- Proprietary PLA biopolymer marketed under the Ingeo trademark
- Competitive on a cost and performance basis with traditional plastics
- Superior environmental characteristics
- Significant manufacturing know-how and an extensive IP position
- Established global market channels
- Over 20 applications in more than 70,000 store shelves globally
- Over 100 million pounds in annual sales volume
- Customers include Wal-Mart, Frito-Lay, and Coca-Cola
Microalgae Converts Biomass to Bio-based Chemicals

- Indirect photosynthesis bio-production

- Process uses microalgae to convert biomass directly into bio-based chemicals and biofuels

- A process performed in standard commercial fermentation facilities cleanly, quickly, and at low cost and large scale

- Manufactured thousands of gallons of oil and hundreds of tons of bio-chemicals for replacing fossil petroleum and plant oils in a diverse range of products from oleo chemicals to cosmetics and food
A History of Breakthrough Innovation

Biochemicals Commercialized from DuPont
- Lysine, Threonine, Tryptophan, Indigo, Biotin, Ascorbic Acid

PDO polymer DuPont Tate & Lyle
- Sorona™ carpets, cosmetics, etc.
- 40% less energy, GHG reduced 20%

Bioisoprene™: strategic biobased alternative
- Major potential to reduce tire & rubber industry dependence on oil, natural rubber
- 2 B lbs/year isoprene used in tires and other products
- Broad applications in rubber, adhesives, fuel
- LCAs to ensure process will be sustainable

Concept Biolsoprene™ Tire for the UN Climate Summit, Dec 2009, CPH
Trends in Industrial Biotechnology

- **Renewable chemical platforms development** is surging as a result of:
  - More start-ups on horizon; Partnerships globally are forming and strengthening the value chain
    - Dow & OPX Biotechnologies; Dow & Solazyme; BASF & Ford
  - Biofuel companies are moving into high value add renewable chemicals – offers improved value proposition
  - Technologies are mature, and ready for scale-up

- **Innovative development of industrial enzyme technologies** continue in:
  - Food ingredients, Pharmaceutical intermediates for health care, Industrial catalysts
- **Biopolymers continue to penetrate new markets**
- **Algae technologies are maturing**
- **IPOs filed by startup companies in 2010 and 2011**, showing a positive financial signal: Codexis, Gevo, Amyris, Solazyme, Myriant, Genomatica, KiOr, Inc.
Future of Renewable Chemicals and Biobased Products

**Challenges**
- Takes time to commercialize new technology (from feedstock to consumer) but may be faster than biofuels
- The limits of government policy are more apparent
- Fully integrated bio-refineries are in the nascent stage

**Opportunities**
- Cost effective solutions
  - Continued R&D investment
  - Establishment of supply chain
  - Compatibility with existing infrastructure / investment
- Renewable chemicals and bioproducts from bio-refineries are growing
  - Projected to gain about 15% of market by 2025 (C&NEWS Oct 12, 2009)
- Compliment petroleum refineries
## THE BIOBASED ECONOMY CURRENTLY

<table>
<thead>
<tr>
<th>Circa 2011</th>
<th>Market</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofuels</td>
<td>~ 10% of U.S. transport fuel market</td>
<td>~ 400,000 in U.S.</td>
</tr>
<tr>
<td>Renewable Chemicals / Biobased Products</td>
<td>~ 3 to 4% U.S. chemicals sales</td>
<td>~ 40,000 U.S. jobs</td>
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### THE BIOBASED ECONOMY FUTURE

<table>
<thead>
<tr>
<th>Circa 2025</th>
<th>Market</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofuels</td>
<td>~25% of U.S. transport fuel market under RFS</td>
<td>~800,000 additional jobs in U.S.</td>
</tr>
<tr>
<td>Renewable Chemicals / Biobased Products</td>
<td>&gt;20% U.S. chemicals sales (USDA)</td>
<td>237,000 additional direct jobs in U.S.</td>
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## Potential for Biobased Products: World Biobased Market Penetration 2010-2025

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<tr>
<th>CHEMICAL SECTOR</th>
<th>2010</th>
<th>2025</th>
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<tr>
<td>Commodity Chemicals</td>
<td>1-2 percent</td>
<td>6-10 percent</td>
</tr>
<tr>
<td>Specialty Chemicals</td>
<td>20-25 percent</td>
<td>45-50 percent</td>
</tr>
<tr>
<td>Fine Chemicals</td>
<td>20-25 percent</td>
<td>45-50 percent</td>
</tr>
<tr>
<td>Polymers</td>
<td>5-10 percent</td>
<td>10-20 percent</td>
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Source: USDA, U.S. Biobased Products Market Potential and Projections Through 2025
Local Growth and Job Creation Potential

- Industrial biotech can revitalize manufacturing infrastructure to help states become leaders in building the biobased economy.
- Industrial biotechnology is a key to creating good jobs in research and development, and manufacturing.
- Growth\(^1\) of biobased products has created 50,000 new jobs – doubling in just the past two years. It could create tens of thousands of additional jobs in coming years.

1. survey from Iowa State University released last year showed 50,000 U.S. jobs.
The Farm Security and Rural Investment Act (FSRIA) of 2002 included two programs that launched the BioPreferred™ program:

- A voluntary program for biobased intermediates and products having USDA labels

- Federal procurement of biobased intermediates and products by Federal agencies that are required by FSRIA to purchase biobased products and intermediates over their petroleum-based counterparts, as long as the biobased intermediates and products are:
  - Reasonably available
  - Reasonably priced
  - Comparable in performance
State Incentives are Driving Industrial Biotech Advancements

- “Grow it here, make it here” initiative by Senator Stabenow to advance emerging Michigan manufacturing industry
- Michigan-MI S 1764, bill to extend advanced energy project credit to renewable chemicals and biobased products. Gives 30% tax cut for new, expanded, or re-equipped bio-manufacturing projects
- Colorado-CO S 177 Promotes biomass energy development (property tax exemptions)
- Indiana-IN H 1261 Agricultural biomass infrastructure grants
- Missouri-S 420 Creates a state income tax credit for the purchase of processed biomass engineered fiber fuel
Federal Policy Priorities

- **Funding / Eligibility:**
  - Maintain funding for renewable biomass and biorefinery programs at USDA and DOE which increases investment in biorefinery projects and provides most promising opportunities for high quality domestic job creation
  - The next Farm Bill needs to ensure that programs support the full range of biorefinery products
    - USDA Loan Guarantee Program needs new legislative authority to include renewable chemicals and biobased products and not just focus on biofuels
    - USDA and DOE need to ramp up their investment in renewable chemicals

- **Tax Incentivize Innovation in Tax Code:**
  - Tax policy can effectively promote advanced biofuels commercialization by providing the long term opportunity similar to renewables such as wind and geothermal – producer credit or refundable tax credit
  - Tax code should incentivize commercialization of innovative renewable chemicals and biobased products – investment/production credits
Conclusions

- Industrial biotechnology can create thousands of new green jobs

- Supportive, consistent and enduring government policy is necessary to bring the vision of fully integrated biorefineries to reality

- Renewable chemical platforms and biobased products are surging and providing investors with new options and products with higher margins than biofuels (and this will help the development of multi-product biorefineries evolve)

- Climate change can be a driver for industrial biotechnology innovation

- There is more growth and success ahead for industrial biotechnology despite the economic challenges