FACTSHEET: BIOPRODUCTS

BIOMASS TO BIOPRODUCTS: ECONOMIC AND ENVIRONMENTAL VIABILITY

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Bioproducts are produced from renewable matter, usually found in the form of living plants. Commonly, biomass can be transformed into products, packaging, or alternative power, but must meet approval of the USDA.

Biomass-based chemicals: Fifty chemical molecules are gradually being changed to biomass-based molecules with projected or known uses. (energy.gov) The uses (not mutually exclusive as intermediates could also be building blocks, as could reagents or chemicals for fuel) for these chemicals include:

1. **Building blocks** are molecules that can be transformed into new, useful, and potentially valuable molecules which are then used to create biomass-based materials, like methanol
2. **Intermediates** are molecules resulting from a chemical reaction, involving building blocks and other chemicals, that may react further to become desired chemical products, as in butanol or acetone.
3. **Reagents** are chemicals used to create reactions with other chemicals such as building blocks and intermediates or fuel, to form bioproducts like oxalic acid.
4. **Fuels** are typically end products of chemical reactions and conversions, for example: ethanol.

Bioproducts in the Global Economy: As of 2012, global biomass-based chemical production was estimated to be 50 million tons[2] and there were $252 billion of biomass-based chemical sales at 9% of the global chemical sales market. The global market share of biomass-based chemicals is projected to increase from 2% in 2008 to 22% in 2025.[3] Projections indicate that by 2020, there would be $375 to $441 billion of biomass-based chemical sales in the global chemical sales market; this is approximately 11% of the global chemical market.[2]

WHAT ROLE DO BIOPRODUCTS PLAY?

The bio-economy uses renewable biological resources from land and sea to produce food, feed, materials, chemicals, fuels, and energy. It is not a new idea but an old idea that historically was employed in the production of bread, cheese, and wine through fermentation.

Although most of the 20th century was dominated by inorganic chemicals and the development of the petrochemical sector, recent advancements in the field of biology present the world with a more sustainable alternative; numerous biomass-based products are already commercialized or being brought to the market. Consumer demand for environmental-friendly products, and a finite supply of non-renewable resources provide bio-products with an opportunity for growth.[3]

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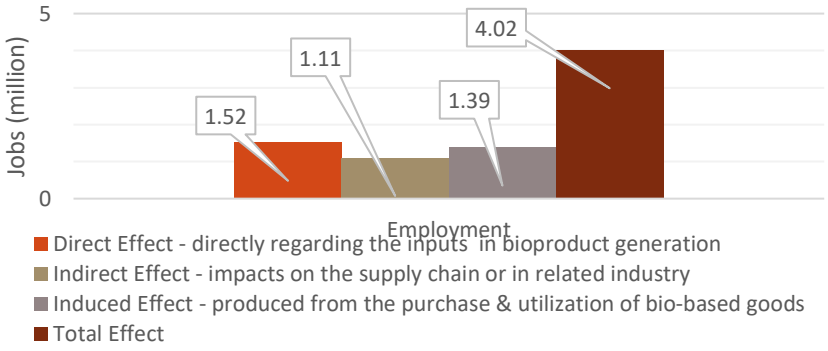
[2] Biddy, Mary J., Christopher Scarlata, and Christopher Kinchin. "Chemicals from Biomass: A Market Assessment of Bioproducts with Near-Term Potential." *National Renewable Energy Laboratory (NREL). DOI* 10 (2016). Print.

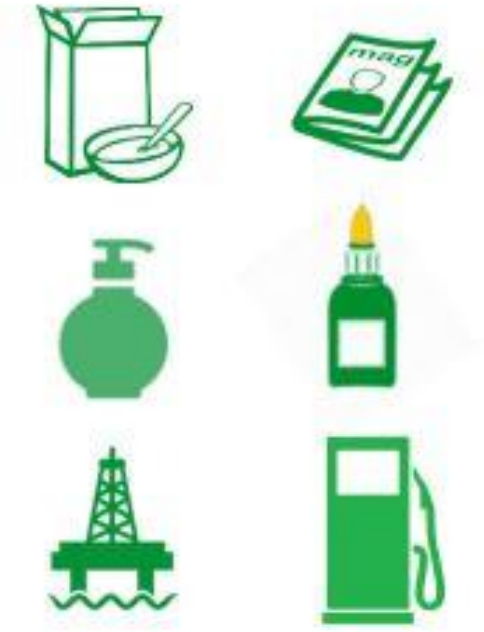
[3] de Jong, Ed, et al. "Bio-based chemicals value added products from biorefineries." *IEA Bioenergy, Task42 Biorefinery* (2012). Print

3 Cluster Industrielle Biotechnologie e.V. *The Bioeconomy Cluster: Creating Values through Bio-Based Innovation.* Düsseldorf: Cluster Industrielle Biotechnologie e.V., 2017. Print.

U.S. CONSUMPTION OF BIOPRODUCTS



In recent years, bio-products have been increasingly produced, sold, and used by industries. Within the United States, 4 million jobs and 2,500 USDA certified biomass-based products were



Advantages of Bioproducts: The up and coming bio-economy offers America solutions to energy, economic, and environmental crises; bioproducts present a national opportunity in renewable resources. Although differences exist in global approaches to further bio-based products, the U.S. has set its focus on developing feedstock and advancing research and development into synthesizing new biomass sources.

1. **Environment –** Bioproducts usually are improved versions of a conventional product, but utilize biomass sources to create the product. Due to this adaptation, products may be biodegradable, bio-compatible, and environmentally-friendly.[4] By embracing a sustainable and renewable biomass source, bioproducts lessen the amount of toxic emissions and waste. Reducing energy consumption in the supply chain enables the U.S. to shift from a limited source of fossil fuel and achieve more efficient generation of bio-based products.
2. **Energy –** With a sustainable feedstock source within the borders of the United States, there is less dependency on foreign fuel and fossil fuel markets. Fewer energy imports means higher energy security. The beginning of the supply chain will run on local biomass because of cultivation and retrieval, while the end of the supply chain will not heavily contaminate the air and water.
3. **Social** – The domestic production of bioproducts will support local production of biomass and assist the agriculture sector by creating jobs and improving pay. The U.S. will reap the aggregate benefits of American-driven bioproduct innovation.

How profitable is this? *Evonik Industries* is a German industrial corporation investigating biomass-based chemicals with $13 billion in sales in 2016.[5] In that same year, the company started a $600 million commercialization campaign of bio-surfactants; this is surface-active biomolecules produced from microorganisms with variety of applications. Europe's approach on bioproducts mainly centers on the

[4] S. Vijayakumar and V. Saravanan, 2015. Biosurfactants-Types, Sources and Applications. Research Journal of Microbiology, 10: 181-192. DOI: 10.3923/jm.2015.181.192
[5] Evonik Industries AG. *Annual Report 2016: Creating the Exceptional*, 2016. Print.
[8] United States Department of Agriculture: A Report to the Congress of the United States of America. *An Economic Impact Analysis of the U.S. Biobased Products Industry*. USDA, 2015, pp. 1–128, *An Economic Impact Analysis of the U.S. Biobased Products Industry*.

FAST FACTS

14%

Biomass makes up 14% of the world's energy supply

Bio-products should build on the idea that one's waste is another's input.

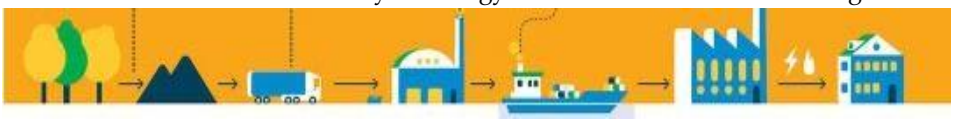
Advancements in the field of biology resulted in the economic viability of biomass in the production of bio-products.

Europe is placing weight on the development of innovative processes that harnesses biomass and waste to produce bio-products.

The design of the supply chain of biomass-based chemicals industries is key to their development, since it affects the distribution of economic surpluses among the various stakeholders and thus its incentive to innovate.

Institutions matter and the development of the industrial-education complex that support R&D in these sectors will have significant effects on its development. Institutions that support these industries should be probed and better understood.

processing technology of bioproducts. The bio-economy is thriving now, but the future holds more in store. Many bioenergy firms are still in their R&D stages.

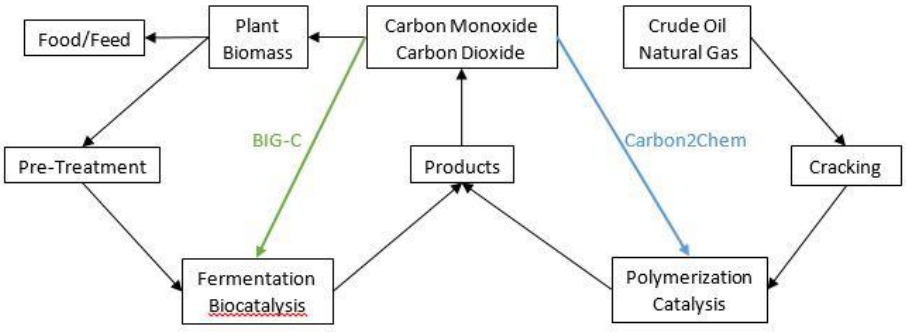


Utilization of CO_2 for Productive End Uses: Carbon dioxide gases are becoming a resource for the bio-economy in Germany and other parts of Europe. German conglomerate *ThyssenKrupp* and biotechnology R&D organization *Cluster Industrielle Biotechnologie* (CLIB) are developing their own processes to repurpose carbon, and other chemicals, generated from various production processes.

One's waste is another's input

- Simultaneously, is a growing focus on optimizing industrial processes to enable biomass-based products to be economically viable. [6]
- The Carbon2Chem project, by *ThyssenKrupp*, aims to recycle co2, carbon monoxide, and hydrogen emissions from steel production and turn them into raw materials or fuel.[7]
- BIG-C, or *Bio-Innovation Growth Mega-Cluster* by CLIB[8], aims to establish demonstration plants in Flanders, Belgium that produce chemicals and fuels using sustainable resources; by using biomass and gasses emitted from its production, CLIB hopes to make the region into a global leader in biomass-based innovation growth and expand the scope of biomass-based innovations and the bio-economy in Europe. The project focuses on three value chains that utilize carbon dioxide[6]:
    1. **Bio-aromatics** which aims to convert renewable biomass into aromatic platform molecules
    2. **C1 conversion** which seeks to harness CO2 and carbon monoxide as feedstocks for chemical building blocks using bioconversion
    3. **Aviation fuels**

The figure below depicts the circular value chains for both projects by ThyssenKrupp and CLIB[5,8]



[6] Cluster Industrielle Biotechnologie e.V. *The Bioeconomy Cluster: Creating Values through Bio-Based Innovation*. Düsseldorf: Cluster Industrielle Biotechnologie e.V., 2017. Print.
[7] "The Carbon2Chem® Project." *ThyssenKrupp*. ThyssenKrupp AG, n.d. Web. 22 Mar. 2017. <https://www.thyssenkrupp.com/en/carbon2chem/>.
[8] "BioInnovation Growth Mega-Cluster - BIG-C." *CLIB2021 - Cluster Industrielle Biotechnologie e.V.* Cluster Industrielle Biotechnologie e.V., n.d. Web. 22 Mar. 2017. <http://www.clib2021.de/en/clib2021/current-projects/big-c>.