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An Economic Impact Analysis of the U.S. Biobased Products Industry

2016

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- Tecnon OrbiChem
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- U.S. Forest Service
- Verdezyne, Inc.
- Walmart Stores, Inc.
- Yulex Corporation

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Dr. McConnell's research has focused on input-output modeling of the forest products industry, timber, and lumber price trends, and the typologies of production forestry clientele. His Extension program provides information to clientele and stakeholders regarding wood technology, wood products sustainability criteria, economic impacts, and industrial trends. Dr. McConnell's professional service includes contributing to the Forest Products Society, the Society of American Foresters, and the Society of Wood Science and Technology.

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Executive Summary

This report was prepared for the U. S. Department of Agriculture (USDA) BioPreferred® Program as a follow-up to the 2015 report to the Congress of the United States mandated in Section 9002 of the 2014 Farm Bill (the Agricultural Act of 2014; P.L. 113-79).[1] The conclusions and recommendations in this report are those of the authors, and have not been endorsed by USDA. The report seeks to provide information on the following contributions of the biobased products industry in the United States:

(i) Changes in value added and jobs between 2013 and 2014 for the national biobased products industry;
(ii) The value added and jobs contributed by the biobased products industry for all 50 states and the District of Columbia in 2013;
(iii) Changes and updates to the domestic biobased products industry, including case studies of advances and innovations;
(iv) The quantity of petroleum displaced by biobased products;
(v) Policy recommendations.

Established by the Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) and strengthened by the Food, Conservation, and Energy Act of 2008 (2008 Farm Bill) and the Agriculture Act of 2014 (H.R. 2642 2014 Farm Bill), the USDA BioPreferred Program is charged with transforming the marketplace for biobased products and creating jobs in rural America. The Program's mandatory federal purchasing initiative and voluntary labeling initiative have quickly made it one of the most respected and trusted drivers in today's biobased product marketplace. Private and government purchasers now look to the USDA BioPreferred Program to ensure that their purchases are biobased. Beginning in 2005 with its first designations of six product categories, the Program has now designated 97 product categories representing approximately 14,200 products on the market today. With the Federal Government spending about $450 billion annually on goods and services, there is an incredible opportunity to increase the sale and use of biobased products as required by federal law. Executive Order 13693, Planning for Federal Sustainability in the Next Decade, increases federal agency accountability for achieving biobased purchasing requirements.[2]

Although there have been several studies on the contributions of the biobased products industry to the European and global economies, this report is the first to examine and quantify the effects of the U.S. biobased products industry on each state and the District of Columbia. The report provides a snapshot of available information and a platform upon which to build future efforts as more structured reporting and tracking mechanisms are developed.

As detailed in this report and similar to the 2015 report, we undertook an updated approach to gathering information on the biobased products industry. A broad spectrum of government, industry, and trade association representatives involved in the biobased products industry were

[1] Golden, J.S., Handfield, R.B., Daystar, J., and McConnell, T.E, An Economic Impact Analysis of the U.S. Biobased Products Industry: A Report to the Congress of the United States of America, A Joint Publication of the Duke Center for Sustainability & Commerce and the Supply Chain Resource Cooperative at North Carolina State University, 2015.
[2] The President, "Executive Order 13693 – Planning for Federal Sustainability in the Next Decade", *Federal Register*, accessed April 2015, https://www.federalregister.gov/articles/2015/03/25/2015-07016/planning-for-federal-sustainability-in-the-next-decade.

interviewed in order to gain a better understanding of the challenges and the future growth potential for biobased products. Data were collected from government agencies and published literature on the biobased products industry. We also conducted extensive economic modeling using IMPLAN modeling software, which was initially developed by the U.S. Forest Service to analyze and trace spending through the U.S. economy and to measure the cumulative effects of that spending on the U.S. economy. The IMPLAN model tracks how dollars spent in one sector of the economy result in increased spending in other sectors of the economy because of those dollars, creating waves of economic activity (the "economic multiplier" effect). IMPLAN uses national industry data and county-level economic data to generate a series of multipliers, which, in turn, estimate the total implications of economic activity as direct, indirect, and induced effects. The spillover effect can be calculated from these results by adding the indirect and induced effects. A contribution analysis was conducted to assess the effects of specific biobased sectors of the U.S. economy.

The seven major sectors chosen here to represent the biobased products industry's contribution to the U.S. economy are:

- Agriculture and Forestry
- Biorefining
- Biobased Chemicals
- Enzymes
- Bioplastic Bottles and Packaging
- Forest Products
- Textiles

The USDA's definition of biobased products excludes the energy, livestock, food, feed, and pharmaceutical industries, so they have been excluded from this report as well.

Figure 1 shows that the total contribution of the biobased products industry to the U.S. economy in 2014 was $393 billion in value added and 4.223 million jobs. Every 1,000 jobs in the biobased industry supported 1,760 additional jobs in other parts of the economy. Figure 2 shows these numbers broken down into direct effects and spillover effects. The 1.528 million jobs directly supported by the biobased industry supported 2.695 million indirect and induced jobs. Similarly, the $127 billion in value added from sales by the biobased products industry generated another $266 billion in indirect and induced sales.

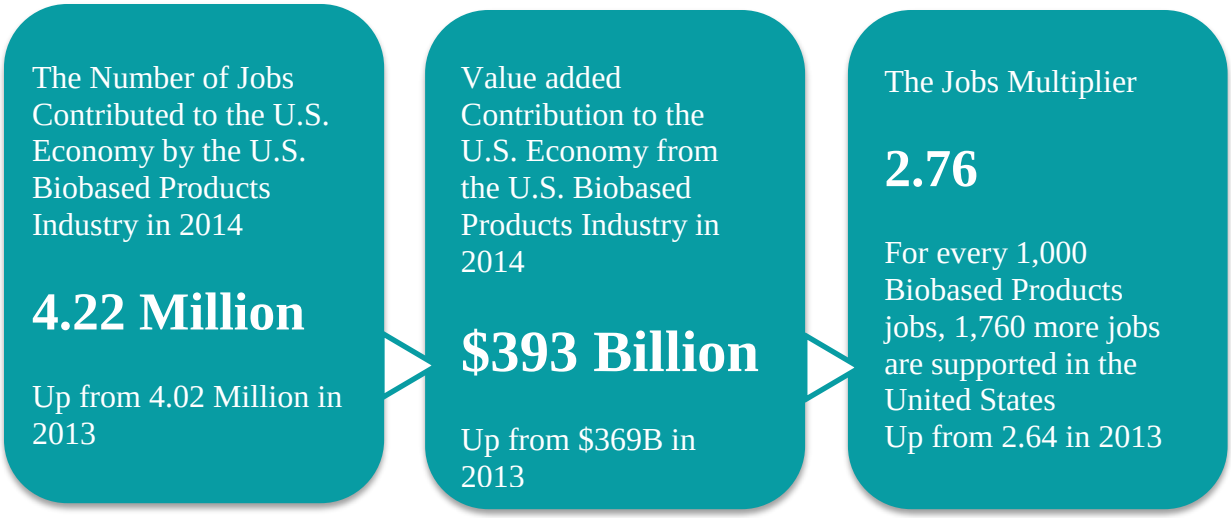


Figure 1: Key Findings of the U.S. Biobased Products Industry in 2014

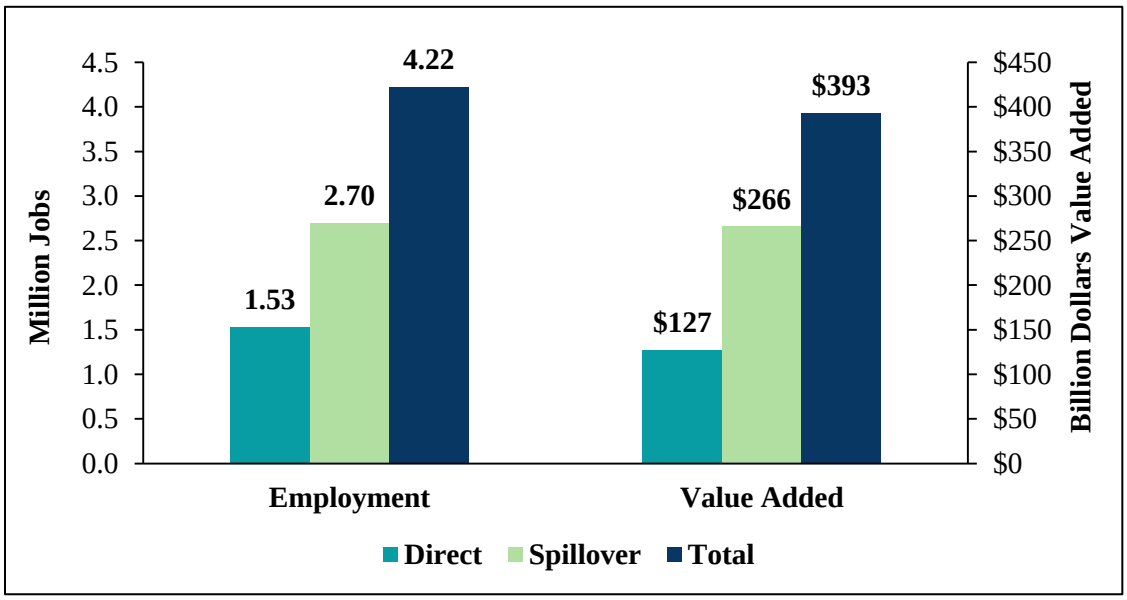


Figure 2: Total Employment and Value Added to the U.S. Economy from the Biobased Products Industry in 2014.

In the 2015 report, we highlighted states with particularly high concentrations of activity in the biobased products industry using location quotients (relative comparisons of direct jobs in each state to the national average for the biobased products industry). In this 2016 report, Section III provides fact sheets that detail jobs and value added contribution by the biobased products industry for all 50 states and the District of Columbia. Figure 3 shows the direct number of jobs supported by the biobased products industry for each state and the District of Columbia in 2013. The direct number of jobs by state is also listed in Appendix C. Table 1 lists the 10 states with the most direct jobs in the biobased products industry. Similarly, Figure 4 shows the direct value added by the biobased products industry in each state and the District of Columbia, while Table 2 lists the 10 states with the highest direct value added by the biobased products industry.

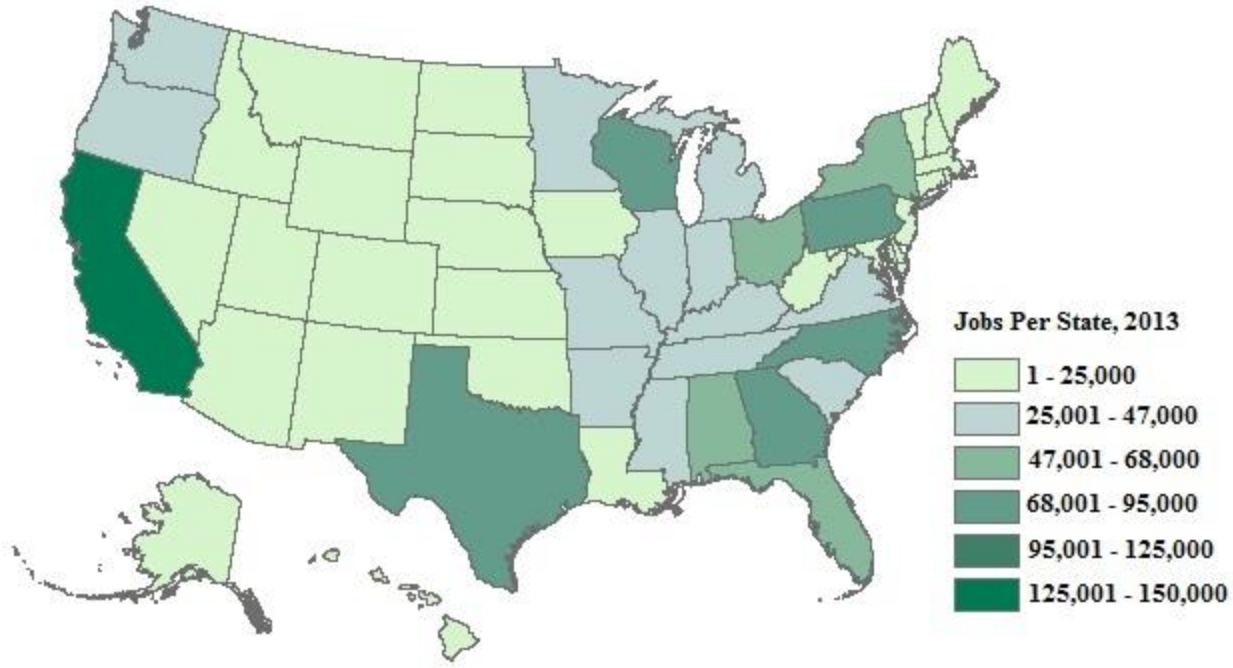


Figure 3: Direct Jobs Contributed by the Biobased Products Industry in Each State and the District of Columbia in 2013[3]

Table 1. Top 10 States for Direct Jobs in the Biobased Products Industry in 2013

Rank	State	Direct Jobs
1	California	145,080
2	North Carolina	90,040
3	Texas	88,680
4	Georgia	80,520
5	Pennsylvania	71,360
6	Wisconsin	68,250
7	Ohio	52,930
8	New York	52,300
9	Alabama	49,650
10	Florida	47,690

[3] Esri, TomTom, Department of Commerce, Census Bureau, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). "USA States" Basemap. *ArcGIS Online*, accessed 3/3/16, http://www.arcgis.com/home/item.html?id=1a6cae723af14f9cae228b133aebc620.

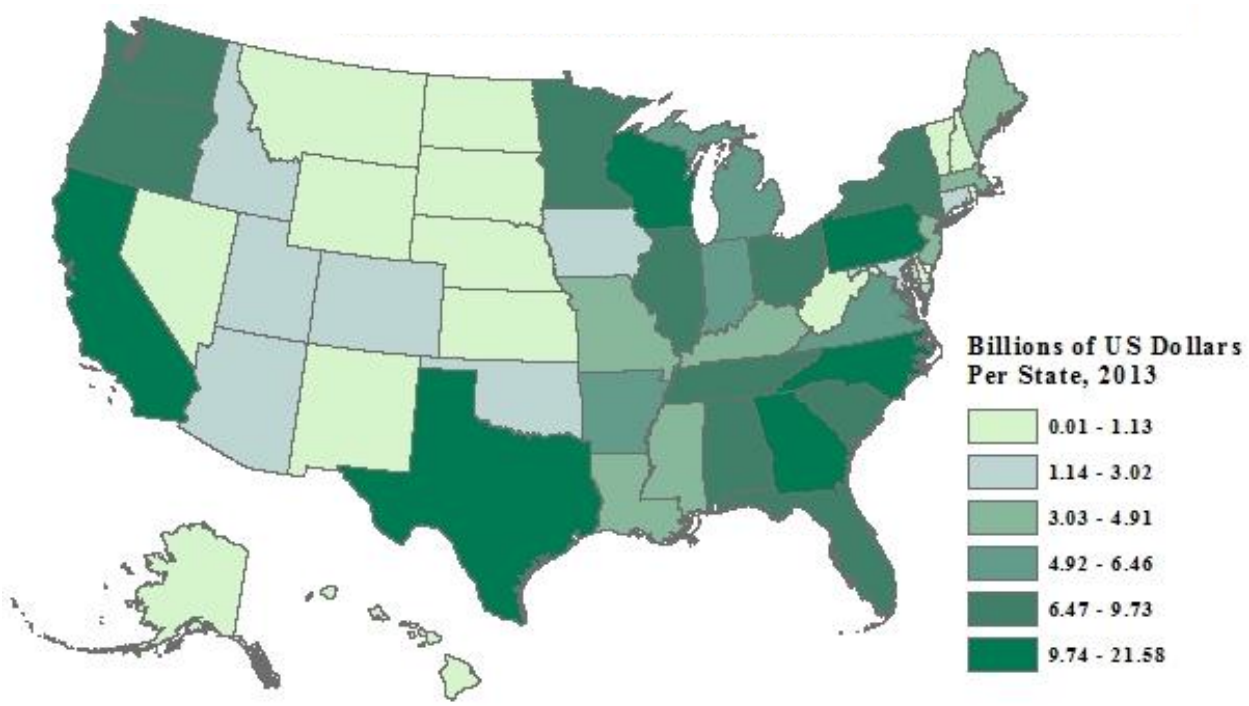


Figure 4: Direct Value Added Contribution in Each State by the Biobased Products Industry in 2013[4]

Table 2. Top 10 States for Direct Value Added to the Biobased Products Industry in 2013

Rank	State	Direct Value Added
1	California	$9,862,930,000
2	Georgia	$8,237,608,000
3	Texas	$6,828,425,000
4	Pennsylvania	$6,522,151,000
5	North Carolina	$6,437,140,000
6	Wisconsin	$6,252,403,000
7	Alabama	$4,977,941,000
8	Tennessee	$4,429,804,000
9	Ohio	$4,276,668,000
10	South Carolina	$4,227,162,000

[4] Esri, TomTom, Department of Commerce, Census Bureau, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). "USA States" Basemap. *ArcGIS Online*, accessed 3/3/16, http://www.arcgis.com/home/item.html?id=1a6cae723af14f9cae228b133aebc620.

The original report sought to answer six questions:

(i) The quantity of biobased products sold

While there is no database that tracks the quantity of biobased products sold, the USDA BioPreferred Program's database currently includes over 20,000 biobased products. This database contains a limited number of forest products or traditional textile fiber products, as these products were only included in the Program recently. Therefore, we estimate that the actual number of biobased products on the market is dramatically higher than the number in the BioPreferred Program's database. In terms of jobs and value added contributed, the forest products sector alone more than doubles the estimates for the remainder of the biobased products industry. Thus, 40,000 would be a conservative estimate of the total number of existing biobased products. The data required to estimate the total number of individual "units" of biobased products that have been sold are not available. However, the total value added from direct sales of biobased products in 2014 was estimated to be $127 billion (Figure 2).

(ii) The value of biobased products

The total value added contribution to the U.S. economy from biobased products was $393 billion in 2014, the most recent year for which data are available (Figure 2).

(iii) The quantity of jobs contributed

The biobased products industry directly supported 1.53 million jobs in 2014 and through spillover effects, supported 4.22 million total jobs throughout the economy in the United States (Figure 2).

(iv) The quantity of petroleum displaced

The use of biobased products reduces the consumption of petroleum equivalents by two primary mechanisms. First, chemical feedstocks from biorefineries have replaced a significant portion of the chemical feedstocks that traditionally originate from crude oil refineries. Biorefineries currently produce an estimated 150 million gallons of raw materials per year that are used to manufacture biobased products. Second, biobased materials are increasingly being used as substitutes for petroleum-based materials, which have been used extensively for many years. An example of this petroleum displacement by a biobased material is the use of natural fibers in packing and insulating materials as an alternative to synthetic foams, such as Styrofoam. In this report, the research team utilized newly available data and scientific literature which, when modeled, estimate petroleum displacement of up to 6.8 million barrels in 2014.

(v) Other environmental benefits

While only limited lifecycle analyses of the production of biobased products have been conducted, the key environmental benefits of manufacturing and using biobased products are 1) reducing the use of fossil fuels and 2) reducing the associated greenhouse gas (GHG) emissions. The previous paragraph presents an estimate of the petroleum displacement associated with the biobased products industry. We also estimated the GHG emission reductions associated with the

production of biobased products as alternatives to petroleum-based products. This number was not calculated for the 2015 report and is presented here for the first time. A literature review showed that there are a wide range of GHG reductions resulting from the use of biobased products as an alternative to petroleum-based products. Using the upper range of GHG emissions reductions potential, the analysis indicates that up to 10 million metric tons of CO_2 equivalents may have been reduced in 2014. Given the increasing interest in and use of biobased products, it is essential to conduct additional analyses of their potential impacts on water quality, water use, land use and other environmental impact categories.

(vi) Areas in which the use or manufacturing of biobased products could be more effectively used, including identifying any technical and economic obstacles and recommending how those obstacles can be overcome

A wide range of both near-term and long-term opportunities exists that the government and biobased products industry members can pursue to advance the biobased products industry. Congress should continue to advance the biobased products industry for National Security and Domestic Industrial Strength by enacting a short-term production tax credit, investment tax credits, and master limited partnerships for biobased product manufacturers to help level the playing field with petroleum-based products. Congress should also direct the U.S. Department of Commerce to work with USDA to develop NAICS codes that describe companies in the biobased products industry. Suggested avenues for promoting the biobased products industry also include funding the USDA BioPreferred Program at the levels similar to its counterparts to increase the visibility of the USDA Certified Biobased Product label, and expansion of other related USDA programs. Additionally, members of the biobased products industry should work together to solve the challenges facing their industry.

As noted above, in addition to collecting data from published sources and collecting government statistics, we interviewed organizations in the biobased products industry to understand the dynamics, drivers, and challenges that will affect the continued growth of the industry. We conducted the interviews with personnel in the following organizations, institutes, and companies:

- Agricultural Utilization Research Institute
- American Cleaning Institute
- American Chemical Society
- BASF Corporation
- Bayer AG
- BioAmber, Inc.
- BioFiber Solutions International
- Biotechnology Innovation Organization
- The Bureau of Labor Statistics of the U.S. Department of Labor
- The Coca-Cola Company
- ConVergInce Advisers
- Cotton Incorporated
- Deere & Company
- Dow Chemical Company
- DuPont
- Eastman Chemical Company
- Enviva
- Ford Motor Company
- Green Biologics Ltd.
- General Motors Company
- Johnson and Johnson
- Lanzatech
- Lenovo
- Lux Research, Inc.
- Michigan Biotechnology Institute
- Myriant Corporation
- NatureWorks LLC
- Nike

- North Carolina Biotechnology Center
- Novozymes
- Patagonia, Inc.
- Penford Products
- POET, LLC
- Procter & Gamble
- Seventh Generation, Inc.
- Society of the Plastics Industry
- Tecnon OrbiChem
- Tetsis
- Tyton BioEnergy Systems
- United Soybean Board
- U.S. Forest Service
- Verdezyne, Inc.
- Walmart Stores, Inc.
- Yulex Corporation

The report includes case studies of the development, manufacture, and use of biobased products by the following organizations:

- NatureWorks LLC
- BASF Corporation
- Eastman Chemical Company
- Michigan Biotechnology Institute
- DuPont
- The Coca-Cola Company
- POET LLC
- Verdezyne, Inc.
- Green Biologics Ltd.
- Agricultural Utilization Research Institute

Glossary of Terms

Biobased: Related to or based on natural, renewable, or living sources.

Biobased chemical: A chemical derived or synthesized in whole or in part from biological materials.

Biobased content: The amount of new or renewable organic carbon in a material or product as a percent of the material or product's total organic carbon. The standard method ASTM D6866 is used to determine this amount.

Biobased product: A product determined by USDA to be a commercial or industrial product (other than food, feed, or fuel) that is:

(1) Composed, in whole or in significant part, of biological products, including renewable domestic agricultural materials and forestry materials; or

(2) An intermediate ingredient or feedstock.

Biobased products industry: Any industry engaged in the processing and manufacturing goods from biological products, renewable resources, domestic or agricultural or forestry material. The USDA excludes food, feed, and fuel when referring to the biobased products industry.

Bioeconomy: The global industrial transition of sustainably utilizing renewable aquatic and terrestrial resources into energy, intermediates, and final products for economic, environmental, social, and national security benefits.

Biomass: Material derived from recently living organisms, which includes plants, animals, and their by-products. For example, manure, garden waste, and crop residues are all sources of biomass. It is a renewable energy source based on the carbon cycle, unlike other natural resources, such as petroleum, coal, and nuclear fuels.[5]

Biobased plastics: Plastics derived from renewable biomass sources, such as vegetable oil and cornstarch. In contrast to conventional plastics that utilize petroleum-based products as raw material, biobased plastics utilize biomass, which can be regenerated, as their raw material.

Biobased polymers: Polymers produced by living organisms that form long chains by the interlinking of repeating chemical blocks. Common biobased polymers in nature are cellulose in the cell walls of plants and polysaccharides such as starch and glycogen.

Biorefining: Process of production of heat, electricity, fuel, or chemicals from biomass. For example, production of transportation fuel such as ethanol or diesel from natural sources, such as vegetable oil and sugarcane.

By-product: Substance, other than the principal product, generated because of creating a biofuel. For example, a by-product of biodiesel production is glycerin and a by-product of ethanol production is distiller's dried grains with solubles.

Cellulose: Fiber contained in the leaves, stems, and stalks of plants and trees. Cellulose is the most abundant organic compound on earth.[6]

Contribution analysis: The economic effect of an existing sector, or group of sectors, within an economy. The results define to what extent the economy is influenced by the sector(s) of interest.

Co-product: Product that is jointly produced with another product, which has a value or use by itself. For example, paraffin wax is a

[5] Khan, F.A., Biotechnology Fundamentals: Second Edition, (Boca Raton: CRC Press, 2015), 336.

[6] The Biofuels Handbook, ed. J. G. Speight (London: RSC Publishing, 2011), 524.

co-product during the refining of crude oil to derive petroleum products.

Direct effects: Effects generated by the industry of interest through employment, value-added, and industrial output to meet final demands.

EIO-LCA: Economic input-output life cycle assessments quantify the environmental impact of a sector of the economy.

Emissions: Gases and particles that are released into the air or emitted by various sources.[7]

Employment: Considered in this report as full and part-time jobs in a sector.

Enzyme: A protein that catalyzes or increases the rate at which chemical reactions occur in living organisms.[8]

Ethanol: Produced from fermenting any biomass that contains a high amount of carbohydrates. It is typically made from starches and sugars but advanced generation technologies allow it to be made from cellulose and hemicellulose.[9].

Forestry materials: Materials derived from the practice of forestry or the management of growing timber.[10]

Genetically Modified Organism (GMO): An organism (i.e., plants, animals, or microorganisms) whose genetic material (DNA) has been altered in a way that does not occur by mating or natural recombination.[11]

IMPLAN: Originally developed by the U.S. Forest Service and currently owned and operated by IMPLAN Group LLC (Huntersville, NC). The IMPLAN database and software system can be used to measure the economic effects of a given change or event in a region.

Indirect effects: The result of all sales by the industry of interest's supply chain.

Induced effects: The changes produced from the purchasing of goods and services by households because of changes in employment and/or production levels.

Intermediate ingredient or feedstock: A material or compound that has undergone processing (including thermal, chemical, biological, or a significant amount of mechanical processing), excluding harvesting operations. It is subsequently used to make a more complex compound or product.[10]

Location Quotient: The measure of the concentration of an industry in a state, relative to the national average concentration of that industry.

NAICS: Acronym for the North American Industry Classification System. A classification system for grouping businesses by similarity of production process.

Output: An industry's gross sales, which includes sales to other sectors (where the output is used by that sector as input) and those to final demand.

PET: Polyethylene terephthalate

PLA: Polylactic acid

Production Tax Credit (PTC): A tax credit that provides a company with financial support based on their production. PTCs can be offered by the Federal Government or a State Government, and can be refundable, partially refundable, or nonrefundable.

[7] U.S. Environmental Protection Agency (EPA), "Air Pollution Emissions Overview", *U.S. EPA*, accessed June 2016, https://www3.epa.gov/airquality/emissns.html.
[8] Alberts B, Johnson A, Lewis J, et al., Molecular Biology of the Cell (New York: Garland Science, 2002), http://www.ncbi.nlm.nih.gov/books/NBK26911/#A466.
[9] International Energy Agency (IEA), "Glossary", *IEA*, accessed May 2016, http://www.iea.org/aboutus/glossary/e/.
[10] U.S. Government Publishing Office (GPO) Electronic Code of Federal Regulations (e-CFR), Title 7 CFR part 3201.2, *e-CFR*, accessed June 2016, http://www.ecfr.gov/cgi-bin/text-idx?SID=c2eba5045067ce569f1d820d6d77b694&mc=true&node=se7.15.3201_12&rgn=div8.
[11] World Health Organization, "Food Safety", *World Health Organization*, accessed June 2016, http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/.

Qualified biobased product: A product that is eligible for the BioPreferred® Program's mandatory Federal purchasing initiative because it meets the definition and minimum biobased content criteria for one or more of the 97 product categories designated for this initiative.

Renewable chemical: A monomer, polymer, plastic, formulated product, or chemical substance produced from renewable biomass.

Sector: Unique field of firms that is a portion of the U.S. economy defined by NAICS.

Spillover: Used in the economic modeling in this report to define Employment and Value Added resulting collectively from indirect and induced activities.

Subsector: Field of firms that produce a specialized product.

Total effect: The sum of the effects of all sales generated by all sectors, supply chains, and influence of employees spending within the study region. The sum of the direct, indirect, and induced effects.

Type I multiplier: The sum of direct effect plus indirect effect divided by the direct effect.

Type Social Accounting Matrix (SAM) multiplier: The Type SAM multiplier considers portions of value added to be both endogenous and exogenous to a study region. It is the sum of the direct, indirect, and induced effects divided by the direct effect. Type SAM multipliers are generally the preferred multipliers used in input-output analysis.

USDA Certified Biobased Product: A biobased product that meets the BioPreferred® Program's criteria to display the USDA Certified Biobased Product certification mark.

Value Added: Composed of labor income, which includes employee compensation and sole proprietor (self-employed) income, other property type income (OPI), and taxes on production and imports, less subsidies (TOPI).

- OPI in IMPLAN includes corporate profits, capital consumption allowance, payments for rent, dividends, royalties, and interest income.
- TOPI primarily consist of sales and excise taxes paid by individuals to businesses through normal operations.
- A sector's value added is its contribution to the study area's Gross Regional Product.

I. INTRODUCTION

A. The USDA BioPreferred® Program

The USDA BioPreferred Program is charged with transforming the marketplace for biobased products and creating jobs in rural America. It was established by the Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) and strengthened by the Food, Conservation, and Energy Act of 2008 (2008 Farm Bill), and the Agriculture Act of 2014 (H.R. 2642 2014 Farm Bill). The Program's mandatory federal purchasing initiative and voluntary USDA Certified Biobased Product label have quickly made it one of the most respected and trusted drivers in today's biobased marketplace. Visit www.BioPreferred.gov for more information.

Strategic Goals

The mission of the BioPreferred Program is to facilitate the development and expansion of markets for biobased products. To accomplish this mission, the Program has two broad strategic goals: 1) to advance the markets for biobased products and 2) to increase the purchase of biobased products government-wide. As of June 2016, there were approximately 20,000 products in the BioPreferred Program's database.

Mandatory Federal Purchasing

Private and public purchasers now look to the USDA BioPreferred Program to ensure that their purchases are biobased. Beginning in 2005 with its first designations of six product categories, the Program has now designated 97 product categories that include approximately 14,200 products that are in the mandatory federal purchasing initiative. The Program offers purchasers of biobased products an independent assessment of the product's biobased content using a universal standard.[12] By providing a central product registry through its online catalog, accessible at www.BioPreferred.gov, the BioPreferred Program enables purchasers to find and compare products, such as cleaners, lubricants, and building materials, from all participating manufacturers. This encourages manufacturers to compete to provide products with higher biobased content.

Voluntary Consumer Label

In February 2011, USDA introduced the BioPreferred Program's voluntary label to the consumer market. To date, more than 2,700 products have been authorized to display the USDA Certified Biobased Product label, and the number of applications continues to increase. With a web-based application process, the BioPreferred Program makes it simple for manufacturers to apply for the label and track their applications. The Program's partnership with ASTM International ensures quality control and consistent results.

Executive Order 13693, Planning for Federal Sustainability in the Next Decade

With the Federal Government spending about $450 billion annually on goods and services,

[12] American Society for Testing and Materials (ASTM) International, "ASTM D6866-16. Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis," *ASTM International*, accessed April 2015, http://www.astm.org/Standards/D6866.htm,.

there is an extraordinary opportunity to increase the sale and use of biobased products as required by Federal law. Executive Order 13693, "Planning for Federal Sustainability in the Next Decade[13]" increases federal agencies' accountability for purchasing biobased products in each of the 97 designated product categories. Federal agencies are directed to establish annual targets for the number of contracts awarded that include biobased products in these categories. The dollar value of biobased products is required to be reported under those contracts. Federal agencies are also directed to ensure that contractors submit timely annual reports of their biobased purchases.

B. About this Report

To date, the availability of data quantifying the biobased products industry in the United States has been very limited. Consistent with the 2015 report, a three-pronged approach to gather information was taken for this report. A broad spectrum of representatives of government, industry, and trade associations involved in the biobased products industry were interviewed to understand the challenges and future growth potential for biobased products. Information was also collected from government agencies and published literature on biobased products. IMPLAN's economic databases were used to analyze and trace spending through the U.S. economy and measure the cumulative effects of that spending.[14]

IMPLAN is an economic impact modeling system that uses input-output analysis to quantify the economic activities of an industry in a given region. Impacts or contributions to the region are expressed in terms of dollars added to the economy and the number of jobs produced. IMPLAN models are ready-made using benchmark data from various government sources and non-survey techniques to create regional input-output tables. The time and money savings advantages provided by non-survey techniques must be balanced with the limitation of introducing potential error into local accounts. The inaccuracies of individual cells, though, do not necessarily compromise the overall holistic portrait a regional table can provide of an economy's interactions. Users do have the ability to override any presented data when locally collected information is deemed superior.

When examining the economic contributions of an industry, IMPLAN generates four types of indicators:

- Direct effects: effects of all sales (dollars or jobs) generated by a sector.
- Indirect effects: effects of all sales by the supply chain for the industry of interest.
- Induced effects: A change in dollars or jobs within the study region that represents the influence of the value chain employees' spending wages in other sectors to buy goods and services.
- Total effect: the sum of the direct plus spillover (indirect effect and induced effect).

A Type Social Accounting Matrix (SAM) multiplier was used in determining the overall monetary contribution or jobs supported by an industry sector. The Type SAM multiplier accounts for the direct, indirect, and induced effects on employment and value added. Appendix A describes the IMPLAN modeling framework in detail.

[13] The President, "Executive Order 13693 – Planning for Federal Sustainability in the Next Decade", *Federal Register* web site, accessed April 2015, https://www.federalregister.gov/articles/2015/03/25/2015-07016/planning-for-federal-sustainability-in-the-next-decade.

[14] IMPLAN, "IMPLAN" Computer Software, *IMPLAN Group LLC*, http://www.implan.com.

The greatest limitation of the findings in this report relates to the percentages of biobased sectors within the larger economic sectors, such as biobased chemicals within the chemical industry. To provide conservative estimates of the biobased products sectors, we consistently utilized percentages at the lower end of the ranges we modeled. As discussed in the recommendations section, the authors of this report strongly emphasize the need to develop specific industrial sector (North American Industry Classification System/NAICS) codes so that the biobased products industry's activities can be tracked more effectively and accurately.

This report is intended to serve as a platform for greater understanding and tracking of the progress of the bioeconomy in the United States.

Section II provides an updated overview of the industry based on a search of the literature and interviews of industrial members, governmental agency personnel, members of non-governmental organizations (NGOs), and academics during 2015 and 2016. Also in Section II, there are case studies of eight companies that are engaged in different parts of the biobased products industry.

Section III begins with an overview of the state initiatives and policies that support the development of the biobased products industry at the state level. The most substantial new element of our report is the inclusion of in-depth analyses and economic modeling of all 50 states and the District of Columbia regarding their activities related to the biobased products industry. Section III provides this state-by-state value added contributions and jobs associated with the biobased products industry. There are also two case studies of organizations active in the biobased products industry at the state level.

Environmental considerations related to the biobased products industry are discussed in Section IV, where an overview of the GHG reduction benefits derived from the utilization of biological feedstocks in lieu of non-renewable feedstocks is provided.

Section V of this report explores various recommendations put forward to expand the domestic biobased products industry.

Appendix A describes the economic modeling framework using IMPLAN. Appendix B lists the product categories used by the BioPreferred Program to classify biobased products as well as the number of products grouped in each category. Appendix C ranks states by the number of direct jobs contributed by the biobased products industry. Appendix D ranks states by the direct value added contribution from the biobased products industry. Appendix E contains an alphabetical listing of the states with their direct jobs, direct value added contribution, and number of companies participating in the BioPreferred Program.

II. INDUSTRY OVERVIEW

This section provides an overview of the biobased products industry from 2013 to 2014. There is first a focus on some of the key metrics used for measuring the biobased products industry – jobs and value added contribution. This is followed by a discussion of some of the biggest factors influencing the biobased products industry. The focus then shifts to the future with a forecast of where the biobased products industry is headed. This section closes with case studies of eight companies at the forefront of the biobased products industry.

A. Overview of the Changes from 2013 to 2014

Figure 5 shows the contributions of the biobased products industry to employment and GDP in the United States in 2014. When compared to the 2013 results (presented in the previous study[15]), the direct value added contribution of the biobased products industry grew by 0.2 percent. Year to year percent changes in direct value added were measured using Producer Price Index for all commodities to account for inflation. The direct jobs contribution to the U.S. economy from the biobased products industry grew 0.5 percent from 2013 to 2014. Figure 6 shows the growth in total jobs and total value added to the biobased products industry from 2013 to 2014.

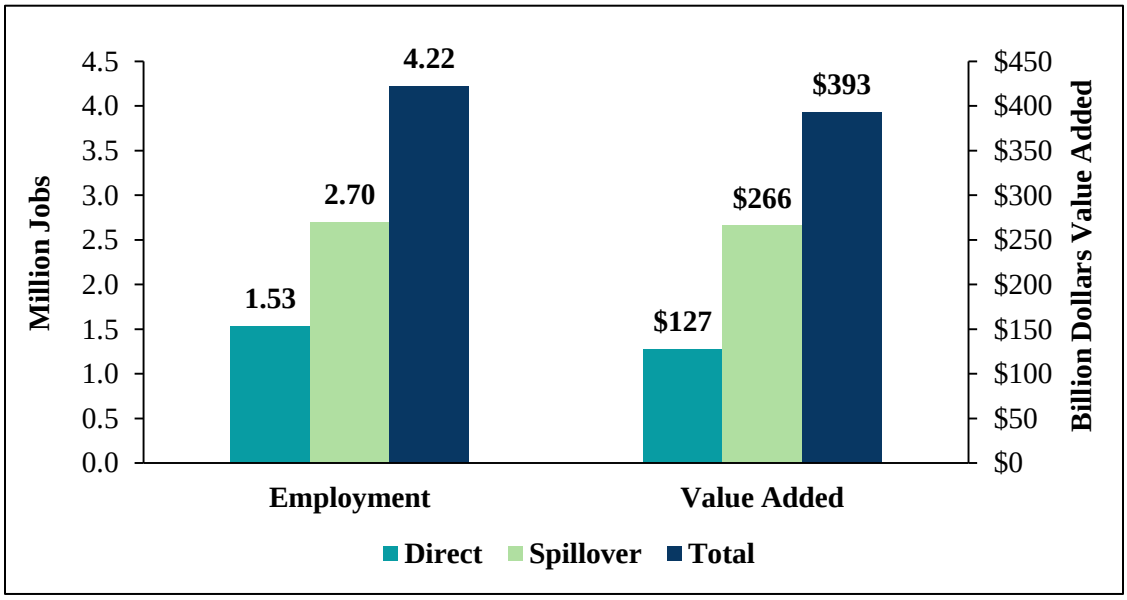


Figure 5: Total Employment and Value Added to the U.S. Economy by the Biobased Products Industry in 2014

[15] Golden, J.S., Handfield, R.B., Daystar, J., and McConnell, T.E, An Economic Impact Analysis of the U.S. Biobased Products Industry: A Report to the Congress of the United States of America, A Joint Publication of the Duke Center for Sustainability & Commerce and the Supply Chain Resource Cooperative at North Carolina State University, 2015.

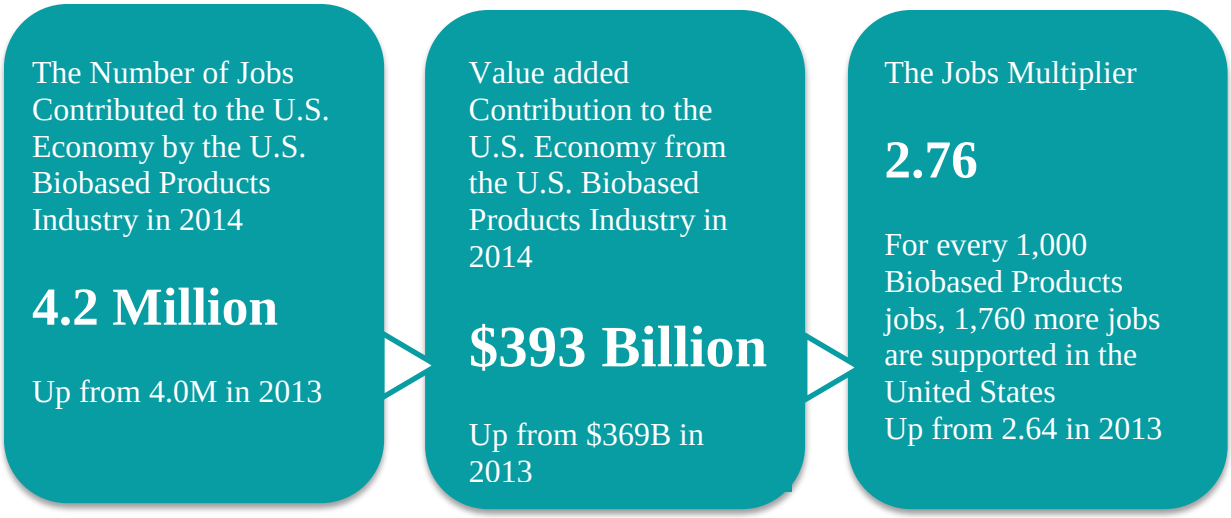


Figure 6: Key Findings of the U.S. Biobased Products Industry in 2014

The biobased products industry experienced steady growth from 2013 to 2014. The growth in the direct value added was smaller than the growth in the total value added. This contributions-based total value added growth is predicated on the strengthening of inter-industry linkages between the biobased products industry and other parts of the U.S. economy.

The steady growth of the biobased products industry is particularly impressive given that the price of oil dropped to roughly half its January 2014 price by December 2014. Many biobased products are in direct competition with petroleum-based products. One would expect that as the price of oil decreased and petroleum-based products became relatively cheaper, the biobased products industry would see a decrease in demand for the products that compete with petroleum-based products. The growth in the biobased products industry proves that the industry is robust and diverse enough to grow even in the face of a sharp decrease in oil prices. It is likely that the biobased products industry will experience even greater growth when the cycle of low oil prices turns around.

Interviews conducted for this report indicate that pricing pressure from petroleum-based products resulted in challenges to profitability, but, in spite of that, revenue and jobs increased and the biobased products industry expanded.

It is apparent that growth is occurring increasingly in specialty sectors (see the Eastman Chemical Company case study for an example). The methodology used to create this report involved scaling the outputs from IMPLAN using estimates of the biobased portion of each sector from the 2015 study. This limited the ability to measure the growth of specialty sectors. For example, the 2015 study estimated that 0.28 percent of all plastic bottles and packaging produced in the U.S. was made with biobased materials. The focus of this study was to provide a state-by-state analysis of the biobased products industry, so the authors kept the original 0.28 percent estimate for this report. It is very reasonable to assume however, that the biobased products share of the plastic bottles and packaging market increased from 2013 to 2014, so using the 0.28 percent estimate provides conservative growth estimates. It is inappropriate to draw conclusions from

the biobased products industry growth rate without recognizing that the market share of biobased products may be increasing, which is not reflected in the growth rate presented in the report. Including the change in the percentage of biobased products' market share would provide additional granularity that would enable a more meaningful analysis and understanding of the shifts in specific sectors of the biobased products industry.

B. Factors Shaping the Biobased Products Industry

The key factors that influence the biobased products industry are identified below. These factors reflect a challenging environment for the biobased products industry, but they also include several encouraging signs that suggest the industry is poised to grow in the next decade.

1. Oil Prices

Figure 7 shows the volatility in oil and natural gas prices over the past 16 years. When the price of oil is high, we expect the demand to increase for biobased chemicals that can be used as replacements for petroleum because they become relatively cheaper. The highly cyclical nature of oil prices suggests that prices have reached a low and are beginning to increase again The price was in the $40 to $50 per barrel range in the summer of 2016. As oil prices increase, the barriers to biobased ethanol producers using first-and second-generation feedstocks will decrease. Currently, producers are struggling to survive with the existing profit margins and they are receiving very low payments for their products, regardless of whether the products are used as additives or as fuels. This has made the business environment very challenging.

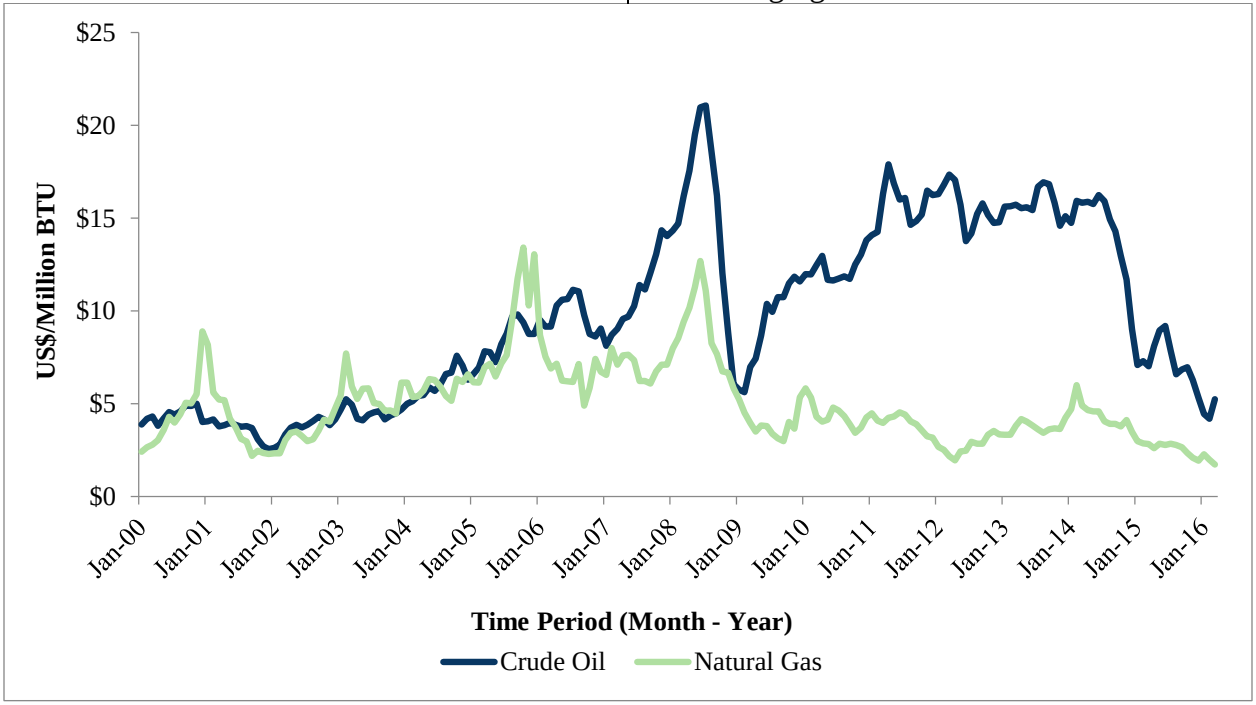


Figure 7: Crude Oil and Natural Gas Price Volatility

U.S. Energy Information Administration (EIA) a, "Natural Gas: Henry Hub Natural Gas Spot Price", *U.S. EIA*, accessed 6/6/16, https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm.

U.S. EIA b. "U.S. Crude Oil First Purchase Price", *U.S. EIA*, accessed 6/6/16, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=f000000__3&f=m.

Low margins tend to diminish investment in future business, so it is more important than ever to take a long-term view of this technology. Government incentives seeking to encourage investments in these technologies are critically important at this time because it is virtually certain that the outlook for these technologies will be more favorable from the long-term perspective.

As oil prices increase, large companies are increasingly focused on making more investments in the biobased chemicals sector and enhancing their production capacity in this sector. This is evident in the on-going mergers of Dow Chemical and DuPont to produce a division focused on biobased technologies, as well as other investment strategies in the works at BASF, Bayer AG, Eastman Chemical Company, and other leaders in the chemical industry.

We project that oil prices will not remain low for an extended period. The expected increases in oil prices will have a positive impact on the biobased products industry because often, the overall investments made in petrochemical plants and in biobased product development come from the same companies and investors. Even though many view the two industries as competitors, there are strong ties between them.

Investors, as well as the public, sometimes think that biobased products cost more than their petroleum-based counterparts do. Several third-party studies have been conducted, and the results support the contention that biobased products sequester carbon and have more favorable LCAs than non-biobased products. In fact, a 2015 Argonne National Laboratory report indicated that all biobased products they research that have a fossil-based counterpart exhibited reduced cradle-to-grave GHG emissions reductions ranging from 27% to 86%.[16] Additionally, life cycle assessment models that incorporate biogenic carbon storage show even higher environmental performance.[17] Our interviews suggest that industry executives are beginning to understand how efficient the chemical transition from sugar to plastic is, and these processes should become cost competitive when they are scaled up. However, to achieve this, biobased product producers must collaborate with investors who have a long-term view and who will invest in efficient facilities and eventually find their functional fit in the marketplace.

2. Second-Generation Biobased Feedstocks

First-generation feedstocks are the easiest to utilize and the most common. They are derived from food components such as vegetable oil, sugars, grains, and animal fats. Second generation feedstocks are from non-food biomass: waste, woody or highly cellulosic sources, and agricultural by-products, which are referred to as lignocellulosic biomass.

One of the key insights gained from our interviews indicated that the level of investment for second-generation biofuels and feedstocks has diminished significantly. Many of the company representatives with whom we spoke have been working to reduce the cost of a commercially viable plant, but the slow start of the second-generation technologies has resulted in less capital available for investments in equipment.

[16] Dunn, J., Adom, F., Han, J., and Snyder, S. "A Life Cycle analysis of Bioproducts and Their Conventional Counterparts in GREET™", *Argonne National Laboratory*, last updated 9/30/15, https://greet.es.anl.gov/publication-bioproducts-lca.

[17] Pawelzik, P., Carus, M., Hotchkiss, J., Narayan, R., Selke, S., Wellisch, M., Weiss, M., and Patel, M.K. "Critical aspects in the life cycle assessment (LCA) of bio-based materials – Reviewing methodologies and deriving recommendations", *Resources, Conservation and Recycling* 73 (2013): 211-228.

A second reason for the slow start of production using second-generation feedstocks is the global uncertainty regarding the projected demand for second-generation fuels. Few of the industries that use these fuels expect demand to increase enough to influence the adoption of biobased products. There is a need to develop a better understanding of the potential and real impacts of government policies on the biobased industry, especially on biobased chemicals. As the numbers of collaborations and co-development activities continue to increase, it is apparent that the stimuli for these activities are investments and the perceived success of second-generation technologies that produce biofuels. However, rather than investing in a new facility, it may be more practical to use existing systems for the production and collection of feedstocks rather than developing new systems. After years of effort, there are also indications that other feedstocks, such as algae, are becoming more practical for higher value chemicals.[18]

Our discussions with the manufacturers of several major brands suggest that they prefer using first-generation feedstocks because there is no efficient pathway and supply chain for cellulosics. Taking the woody stems of plants and trying to convert them into carbon sugar costs a lot more and takes more effort than using first-generation feedstocks. Sugar is the most efficient feedstock in terms of the acreage required to grow product biobased feedstocks, and, until this changes, there is uncertain growth in second-generation feedstocks.

3. New Applications for Enzymes

Enzymes are used in detergents in the textile sector to break down proteins, starches, and fatty stains in the finishing of fabrics. Enzymes also are used in several other industrial sectors, such as pulp and paper. An innovation in the enzymes sector is the use of symbiotic microorganisms to improve the yields of agricultural products.

Generally, the enzymes sector is undergoing stable, moderate growth driven by various businesses, including manufacturers of household care products and laundry detergents. Enzyme companies traditionally acquired very large accounts in end-use packaged goods, which allowed them to make investments in innovations with a specific application in mind. However, now enzymes are being used to improve biobased products and companies are seeking to collaborate with smaller, more nimble companies to drive new product innovation.

One of the differentiators of the enzyme sector is that, even with low revenue growth, returns are improved by optimizing production based on biological efficiencies as well as capital investments, such as purchasing new fermenters. Enzyme companies can select organisms that have better biological efficiencies and can improve them over time through genetic engineering. The ability to improve without capital upgrades is an important characteristic of the enzyme sector, but may not provide advantages over chemical plant and petroleum refinery processes, which can also be improved with new catalysts or alterations to operational conditions, without major capital expenditures.

4. Federal Government Purchasing

One key to stimulating growth and participation in the biobased products

[18] Savage, S., "Replacing Petro-chemicals With Bio-Based Alternatives. Can We Do It?", *Forbes*, last modified 4/23/16, http://www.forbes.com/sites/stevensavage/2016/04/23/replacing-petro-chemicals-with-bio-based-alternatives-can-we-do-it/#6218f036378a.

industry is a reliable and robust purchasing commitment from the Federal Government. The USDA BioPreferred® Program, which includes procurement preferences within the Federal Government and voluntary labeling, provides a key way to inform the public. The Program has been remarkably successful, despite a funding setback when the 2008 Farm Bill expired. Interest in the Program from companies producing biobased products is growing and the number of products participating in the Program is increasing. The entire Federal Government should follow the example set by USDA and ensure that biobased products are given preference whenever possible in the procurement process.

There is a general lack of awareness from the public regarding biobased products, as is the case in some parts of the Federal Government outside USDA. Non-fuel biobased products are virtually unknown to the people along the supply chain, including wholesale and retail distributors, Federal Strategic Sourcing Initiative contract holders (sellers), Federal buyers, and most importantly, American consumers. Awareness in the private sector is of particular importance because purchasing biobased products is a matter of choice. If the Federal Government becomes a reliable customer, these products will be produced and distributed efficiently, demand will be met, and the industry will thrive. If manufacturers assume the risk of producing biobased products in response to the requirements of the Federal Government, the government, in turn, should support these products and help "jump start" this industry. One executive noted that the non-fuel biobased products industry is in the early stages of evolution, and as such, products in this industry are "custom made" for the federal government. That executive believes that, in light of this, these types of products should be supported by the government.

Our interviews also led us to believe that the Federal Government's ability to gain traction in the acquisition community relative to the purchase of biobased products and services is in a nascent stage. This is not due to any lack of effort on the part of the USDA; rather, it is due to a lack of widespread awareness within the General Services Administration and Federal agencies, including the Department of Defense (DoD) regarding the availability and use of biobased products.

One company executive remarked that, while the USDA Certified Biobased Product label is important, he/she believes it is not providing the level of market benefit and impact at the consumer level that it was believed would emerge. Furthermore, from this executive's perspective, the extent to which DoD mandated purchasing of biobased products is driving demand for these products within the traditional chemical industry is not clear.

Another executive emphasized that there is a lack of top-down federal policy on using biobased products, which makes it difficult for industry leaders to commit to long-term investment, given that there is no indication that investment will be supported. According to this executive, there is a lot of support for biofuels, but there has not been an equal level of support for biobased materials until recently. For example, legislation has been written around biofuels, creating investment tax credits for biofuels, but not for biobased products. Thus, without investment from a big firm, there is no assurance that biobased products will be supported. This executive believes that a solid value proposition is essential to access the capital needed in order for the biobased industry to grow.

5. Biobased Product Innovation and the Need to Consider Supply Chain Impacts

To innovate in the biobased products industry, companies must consider the factors that affect supply chain integration and consider incentives to build in the United States. Petrochemical supply chains are highly integrated and the pathways for plastics are already reasonably well established and understood. However, the biobased chemicals supply chain is a combination of the chemical and biotechnology fields. The creation of an efficient supply chain requires investment and education, both within the industry and the consumer base. Many of these supply chain challenges are related to reaching a revenue break-even point that will support investments in the infrastructure that must be built for this emerging industry.

Education within the industry is essential to help biotechnology scientists understand the dynamics of the chemical industry. The people who run some of the new start-up biobased companies have no experience in the traditional petrochemical industry. Many rely on consultants and market studies to make their decisions and they do so without understanding the nature of the overall chemical sector supply chain. Some individuals point to the fact that there is a huge end market but they neglect to emphasize that 70 percent of that market is already captive to downstream conversion processes. When chemical companies decide which chemical to produce, they already have downstream applications in mind, ensure that the products they produce are cost effective, and can beat out competitors.

However, when a new product is introduced into the biobased chemicals sector, there is sometimes less of a clear downstream application in mind and sustainable options are not always immediately accepted into the supply chain. The decision to introduce a biobased chemical product is often made without understanding the macro-level issues in the chemical market, such as understanding the end users' technical specifications, volume requirements, environmental and regulatory requirements, and controlled-substance issues. This lack of understanding can cause otherwise highly innovative companies to fail.

To prevent the recurrence of this situation, companies producing biobased chemicals should hire people from the both the chemical and biotechnology fields. Comprehensive knowledge and consideration of the factors involved in operating a business in the chemical sector helps insure profitability.

6. Emerging Education

Education is emerging to address food versus fuel and GMO misconceptions. Many of the organizations interviewed for this report noted that the food-versus-fuel debate remains an inhibitor to market growth, based on consumers' misperceptions concerning this issue. In addition, many consumers will not buy products that are derived from GMOs. Many biobased products fall into this category, as it is difficult to trace whether the feedstocks used to make the biobased products come from GMO or non-GMO sources, and even in cases where the feedstocks can be traced, the distribution and processing and of the feedstocks frequently mixes GMO and non-GMO feedstocks.

The origin of this debate goes back to the 1990s, when some NGOs were fighting against the push of companies selling genetically modified crops into European markets. Some NGOs campaigned against GMOs, and as a result, many consumers became sensitized to genetically modified

ingredients. Even when biobased companies purchase non-GMO corn to send to the mills that provide them with sugar, many of the mills are part of a larger biorefinery campus, which makes it impossible to segregate non-GMO feedstocks. Although many European brands accept the idea that offsets, such as wind power, used by these facilities are enough to cancel out the use of GMOs, many North American retailers and manufacturers do not feel that these offsets are enough to cancel-out the use of GMOs.

In fact, many large European brands point to the fact that sugar cane and corn are the most efficient plants to use for biobased products and second-generation feedstocks, such as wood stems, take a lot more effort and are much more costly to utilize. Second generation feedstocks have encountered limited growth in the market, but there are concerns that the release of GHGs globally may cancel the benefits of our domestic renewables policy. The link between the use of domestic crops for biobased products rather than as a food source has almost no correlation with the changes in the patterns of land use worldwide; nevertheless, it is a concern that some people express in the "food versus fuel" debate. In actuality, the United States is using fewer acres for corn than it did 10 years ago, but the public perception is that a higher percentage of corn being used to make ethanol means there is less land available for food production, which simply is not true.

7. Production credits and financing incentives

Investments by large chemical companies are focused on biobased chemicals facilities, but production credits and financing incentives are needed to create U.S.-based facilities. After a somewhat rocky start following the expiration of funding from the 2008 Farm Bill, the BioPreferred Program had a good level of support in the 2014 Farm Bill. The administrative regulatory rules are well developed, particularly for the Biorefinery Assistance Program. Previously, this rule was strictly for advanced biofuels, whereas the current iteration expanded the program to include biobased products and renewable chemicals. This has led to the development of a framework for assessing the biobased products economy. However, this framework also requires that the public and private sectors be made aware of the fact that biobased products are not in stand-alone facilities; rather, they are part of a large supply chain that begins with biorefineries. In the past, if a biorefinery produced anything other than biofuels, it did not qualify for Farm Bill benefits, but this has changed.

The Biomass Crop Assistance Program (BCAP) is an extremely important part of the Farm Bill. For members of the farming community to grow cellulosic, non-food crops, they need assurance that they can make money by doing so. Some biomass crops require a planting lead-time of one to five years, and this program now provides an assured market with mandatory funding.

Cellulosic ethanol was the initial focus of the BCAP, but the first wave of cellulosic technologies were disappointing. The second- generation cellulosic biofuels have a PTC that expires on December 31, 2016, but currently, they are receiving a tax credit. There is a possibility that a PTC linked to a flexible format based on the specific business plan would be very beneficial. This is currently in the works for the biofuels and renewable chemicals sectors. This tax credit is available to the oil and gas industry through Master Limited Partnerships (MLPs) and the credit is related to how business partners and business liabilities are defined.

MLPs may be made available to renewable energy companies.

The Environmental Protection Agency (EPA) is developing general frameworks for carbon accounting. Currently, carbon accounting with low carbon fuel standards does not treat biobased carbon feedstocks as neutral; however, many in the biobased industry believe they should be. This long-term iterative framework could take years to resolve. Those in the industry hope that the framework will incorporate a credit for biobased feedstocks that are converted into biobased chemicals.

Many of the investments in the biobased products industry are being made by large chemical companies, and these companies are going through many mergers and acquisitions. These companies include Bayer/Monsanto, National Chemicals (China)/Syngenta, and Dow/DuPont. These mega-mergers will result in companies that will have many more resources to invest in biobased products and that have a longer capitalization timeline.

However, there are major challenges for emerging companies that are often small start-ups without significant capital. Without a partner to provide the required financial resources, it may be difficult to interest investors in a five-year planning horizon. The length of time required to develop a product is a function of the available infrastructure and the fact that the biobased products industry and the biofuels industry are closely connected. Currently, there is a lack of infrastructure for the value chain that extends from biofuels to biobased products, and biobased products do not have a public policy driving the front end of the value chain. This is an enormous roadblock to growth in the biobased economy.

Another legislative challenge has to do with EPA's regulations that are in place to standardize fuel. The regulations were intended to assure people that their vehicles would run properly when they buy fuel. The central focus of EPA's regulations in this area has been to standardize fuels with the intent of reducing emissions. However, EPA's standardization effort is focused primarily on gas derived from petrochemical sources rather than renewable sources. The assumption is that any biobased fuels that are added to fossil fuels must comply with the standards for fossil fuels. This has created a challenge for biobased fuels, making it more difficult to use them in flex-fuel vehicles, which are designed to operate primarily with 15 percent ethanol in the fuel mixture, imposing a cap on the growth of the market. The current challenge is how to go about getting approval for a higher level of renewable fuels for all vehicles. Various companies, including POET, are working on these problems with the automotive industry. The next- generation fuel for vehicles must meet these regulatory constraints because, currently, they are impeding the growth of the renewables market.

The biopolymer sector has experienced tremendous technology development over the last decade, with the United States leading these advancements. However, for production capacity, the sector is still in its nascent stage. The opportunity and the danger for the United States is whether the construction of biopolymer plants over the next five to 10 years and the full range of their associated facilities and jobs will predominantly be located in the United States or elsewhere, where feedstocks and the cost of production can be cheaper. For example, companies identified as the "hot leaders" in the biobased products industry, such as Verdezyne, are building facilities in Malaysia, because of the vision and financial

support of the country's government. It is clear that certain governments and emerging economies are offering incentives to convince companies to invest there in an effort to ensure their country's long-term, sustainable growth. Southeast Asia, Europe, and Brazil are establishing regional hubs of industrial biobased products. Good examples of companies facing this issue are Verdezyne and Green Biologics, both of which have pursued a dual approach of sourcing outside and inside the United States based on local government support.

The businesses that will survive most easily in the biobased products industry are those that emerge from creatively designed collaborations. This means carefully selecting a pathway, carefully assessing and minimizing the risks associated with that pathway, and appointing leaders who are creative, smart, and spend money wisely, as they go forward. This is the basic path forward for this industry, all the way from feedstock suppliers and treatment technologies, to downstream building block technologies and sustainable materials that are converted into higher value chemicals. Partners along the end-to-end supply chain will need to work together to design these supply chains, with a given end product in mind, and the total end-to-end cost to serve the customer must be used to drive cost targets for those enterprises along the way. This may involve larger companies collaborating with smaller companies that have new and innovative ideas.

One example of successful use of PTCs is in Iowa. Iowa also has identified biobased products as a targeted growth industry for the state and has advocated for a biobased production credit to be established.[19]

Interviews suggest that a renewable chemical PTC would be fundamental to the ultimate location decision in or outside Iowa for new projects. Iowa has invested more in biobased manufacturing capital assets than any other state. The state invested $61 million in the ethanol industry. This money will be returned to the state though taxes and increased economic activity. The payback from income taxes alone would take just two years. The payback period is only one year if we assume that 8 percent of the economic activity is returned in taxes.[20]

The success of the biobased products industry depends on its ability to function at a large enough scale to be competitive with the petrochemical industry. Being competitive does not require that biobased products industry be the size of the petrochemical industry, but it cannot simply be a series of small plants scattered around a landscape. Moreover, many of the chemicals produced through fermentation that go into biobased products happen to be competing in commodity markets. Producers should think clearly about focusing on specialty markets, with products that have unique performance characteristics, based on conversion of biobased commodity chemicals into specialized chemicals through chemical synthesis. Specialty biobased chemicals can be produced in this manner at a total cost of production that is lower than the variable cost of production of petrochemically derived chemicals, which allows them to grow and compete.

An executive interviewed argued that producers of biobased products must adapt to the market they are in, and to do this, they must understand their product on every level. This executive continued, adding that it is

[19] Willett, B. and Hrdlicka, J., "The Case for a Renewable Biochemical Production Tax Credit", Iowa Biotechnology Association, 2016.

[20] Cultivation Corridor, "Biobased Chemicals: The Iowa Opportunity," *Cultivation Corridor*, last updated 1/14/16, http://www.cultivationcorridor.org/assets/pdf/Iowa-Biobased-Chemicals-Full-Report.pdf.

important to understand the performance of the molecules that make up a product and how they blend with other ingredients; it is important to be able to target the right applications through innovation and understand the commercial impacts of a product. According to this executive, having a deep understanding of their products allows biobased producers to be more adaptable than big commodity players.

Our interviews regarding PTCs also lead us to believe that short-term incentives are sorely needed. Several companies with U.S.-developed biobased technologies are looking for locations to build new facilities. Some countries provide incentives to build these types of facilities, but incentives for them are absent in the United States. Given the intense international competition at this historic point, the companies we interviewed are exploring all global options for expansion projects, which includes taking into account political leadership and market push and pull policies.

Investment in the biobased products industry remains strong. However, continued growth can be bolstered by the development of a strong end user market as well as growth in production credits to help launch the industry.

C. Biobased Products Industry Growth Forecast

A recent forecast stated the following: "One of the bright spots in American manufacturing is the petrochemical industry, which produces chemicals used to make everything from car tires to fertilizer to fabrics. According to the American Chemistry Council (ACC), chemical companies have committed $153 billion in new investment in production in the United States over the next decade."[21] Given the growth in the petrochemical investment sector as a whole, it is also likely that some growth will be seen in the biobased chemical sector investment as part of overall increased investment in the chemicals sector. Indeed, interviews we conducted with university centers that focus on piloting new biobased chemical technologies indicated that the university centers are seeing strong demand for their services, an indicator of the increasing number of emergent technologies, especially in the pilot stage. (See the MBI case study in section III.) The ACC estimates that growth in the chemicals sector will create more than 800,000 permanent jobs, paying an average salary of over $69,400 and generating more than $322 billion in annual economic output.

However, if the price of oil stays low for an extended period, projects may be delayed or cancelled, which would result in fewer manufacturing jobs being supported in the U.S. In addition, the number of gas field jobs would decrease, because less natural gas is needed for domestic manufacturing.

Despite the current low price of oil, we project that the biobased products industry in the United States will exhibit steady growth over the next five years. The rationale for this projection is the following trends evident in our interviews:

- The major focus of the leaders in the biobased products industry is on innovation and differentiation of products.
- Oil prices are increasing, which will make biobased products more competitive.

[21] Hoium, T., "4 Reasons Why Falling Oil Prices Are Worse Than You Think", *The Motley Fool*, last modified 12/5/15, http://www.fool.com/investing/general/2015/12/05/4-reasons-why-falling-oil-prices-are-worse-than-yo.aspx.

- There will continue to be growth in enzyme-related industries.
- Federal purchasing policies are becoming more focused on biobased products.
- A wave of emerging innovations is targeting the biobased products industry.
- Investments by large chemical companies are focused on biobased chemical facilities.

We also identified several steps that must be taken to overcome factors that challenge the growth of the biobased products industry:

- Production tax credits (PTCs) must be extended beyond biofuels to include biobased products.
- Further legislation is required to support the biobased products industry.
- Financial incentives are needed to promote the construction and operation of more U.S.-based facilities.
- States need to provide resources to support the growth of the biobased products industry, which is very important because currently there are insufficient pilot plants to foster innovation.
- Further efforts to integrate the biobased products industry's supply chain are needed.
- Increased education is needed to help address the "food versus fuel" myth and the "no-genetically modified organisms (GMOs)" faction, leading to increased understanding of and growth in the biobased products industry.

C1. Case Study: NatureWorks

NatureWorks began as a joint venture between Cargill (a large private agricultural products company) and Dow (a chemical, plastic, and agricultural products company). Cargill had done a lot of development work on high-end products using biological feedstocks and expressed interest in forming a company focused on creating a carbohydrate products economy. The Cargill-Dow joint venture included a 154,000-ton facility in Nebraska to transform carbon sugars (cornstarch) into lactic acid, which is a key building block for biobased products. The lactic acid produced on an industrial scale was used as a monomer to produce several different polymers, including 20 different grades of plastic.

One product, polylactide (Ingeo™), is used primarily by the packaging markets. The product has properties similar to PET and is a clear plastic that is used in drinking bottles, plates and cups, flexible film packaging, computer housings, baby wipes, apparel, covers for cellphones, and many other products. Ingeo produces 75 percent less GHGs and uses 50 percent less non-renewable energy than traditional plastics, such as PET and polystyrene (PS).

Identifying the right applications for Ingeo was a challenge. NatureWorks' Director of Public Affairs, Steve Davies, explained that NatureWorks understands that there is not a green premium for biobased products, so a product's performance must be superior to what is already on the market. Mr. Davies went on to say that after about ten years of studying the properties of Ingeo, NatureWorks now knows where the material works well and where it does not.

For example, NatureWorks determined not to use Ingeo to make plastic bottles because the material is technically "breathable", and the water it contains can evaporate. However, it is excellent for packaging leafy greens, as Ingeo allows a longer shelf life for the product.

Mr. Davies also emphasized that understanding the fundamentals and cost of what one is selling is important. There is a wide spectrum of biobased plastics, from hard (PET) to soft (polyethylene for trash bags), and everything in between. It is also important to look at the ratio of the pounds of sugar required to produce a pound of plastic. For PLA, 1.25 pounds of sugar produces one pound of plastic. Biobased PET requires a ratio of three pounds of sugar to one pound of plastic. Mr. Davies explained that there is constantly a need to make tradeoffs and consider the cost-effectiveness and characteristics of one plastic versus another, as PLA is better for some applications, while PET is better for others. Mr. Davies argued that materials must be cost-effective, and this point is often lost in discussion.

NatureWorks works with hundreds of partners that produce biobased products. They are also expanding, and a petrochemical company based in Thailand has invested as an equity partner, due to their large export of cane sugar. There are plans to build a new biorefining facility in Thailand near the source of feedstocks, as well as plans to expand the Nebraska facility due to the increasing demand.

There is significant interest in certain product sectors, including replacing PET clamshell packaging, using Ingeo for packaging yogurt at Danone, and in other food-packaging areas. Ingeo is cost neutral, but it performs better and has a smaller carbon footprint, and this has become a winning combination for many manufacturers.

Another important element of food packaging is where the packaging ends up. Many people discard packaging and do not consider what happens to it after that. What if all of the food packaging could be composted? The "killer value proposition" is to render the entire value stream compostable by using PLA-based food packaging. Packaging for food products is one of the biggest opportunities on the horizon for NatureWorks, but there are enormous barriers. The conventional plastics industry may never be replaced, and other than milk jugs and water bottles, most plastics are not recycled.

Mr. Davies noted the importance of the Three Ps: **P**erforming the right function at the right **p**rice and meeting the customer's **p**reference, in that order. If a product is performing better than the alternative and it is priced competitively, then it follows that consumers will prefer it.

C2. Case Study: BASF

Biotechnology is a key component of the German chemical company BASF. It has the potential to manufacture products more efficiently than conventional chemical processes and it can produce new products inaccessible using conventional synthesis approaches. BASF uses biobased-based methods of fermentation and biocatalysis to manufacture various products, such as chiral compounds, enzymes, and specialty ingredients for the personal care industry.

In February 2012, BASF opened a new biotechnology and microbiology research center in Tarrytown, New York. In the new laboratory, scientists from a number of disciplines, including material scientists, biologists, polymer scientists, molecular biologists, and chemists, are working together to develop more efficient biotechnological production processes.

These researchers are also working to develop new antimicrobial products for medical technology, hygiene, and health care. The use of metabolic engineering, targeted metabolism modification, can enhance the efficiency of the microorganisms that are used in these production processes.

In 2013, BASF acquired Verenium, an enzyme company based in San Diego, CA. Using proprietary and patented genomic technologies, Verenium extracts microbial DNA directly from collected samples to avoid growing microbes in a laboratory. Then, Verenium mines its collection of microbial genes, which number in the billions, using high-throughput screening technologies designed to identify unique enzymes as candidate products. In making these investments, BASF demonstrated its

Source: BASF. Three BASF scientists in laboratory in Tarrytown, New York.

unmitigated belief in the strength of the biobased products industry. Now, BASF is working to integrate the Verenium technology into its business portfolio.

For example, BASF produces a biobased product known as polytetrahydrofuran 1000 (PolyTHF), which is used in outerwear, sportswear, and swimsuits. PolyTHF mainly is used as a chemical building block for thermoplastic polyurethane, which is used to make parts of ski boots and skates, shoe soles, and instrument panel 'skin' for automotive applications. It also is used to make hoses, films, and sheathing for cables and as a component of thermoplastic polyether esters and polyether amides. Other applications include cast elastomers, which are used, for example, in the production of wheels for skateboards and inline skates.

PolyTHF is derived from 1,4-butanediol (BDO), which BASF produces under license from Genomatica.[22] Although it is biobased, it is a bit more expensive than petroleum-based BDO. Cost of materials is a key issue that BASF always must consider. It is very important to evaluate customers' and brand owners' opinions of biobased products versus conventional products, particularly when the biobased products may be marginally less cost effective.

BASF is committed to biobased feedstocks, and to this end, in 2015, BASF expanded the scope of its license agreement with Genomatica. Using Genomatica's patented process, BASF produces BDO from renewable feedstocks in a large production facility. Under the expanded license agreement, BASF can produce up to 75,000 tons of renewable BDO per year, while Genomatica will continue to advance its patented process technology. Today, BASF produces more BDO than any other company, and it has the capability of producing this product in multiple locations. BDO is a versatile monomer, which can be used in the manufacture of many other chemicals. As such, BASF views BDO as an increasingly important product in its portfolio.[23]

BASF recognizes that a core unknown underlying the future of the biobased products industry is customers' perceptions. BASF's goal is to produce products to sell to customers in the most economical and sustainable way possible. The Company has invested in extended LCAs for many of its technologies, which involves exploring the various technological pathways to produce any given product. For some products, there are clearly huge advantages for chemical processes over fermentation. New chemical and fermentation processes are being developed, and these studies will continue. Markus Pompejus, Vice President of Research, noted that biotechnology is the only pathway for certain products, especially those that involve enzymes. BASF invests in research to examine internal pathways for the production of chemicals in integrated production facilities rather than in isolated facilities, which allows it to produce at a more efficient scale in its major production sites in Europe and China.

BASF does not let the low price of oil detract the company from its long-term view. Mr. Pompejus pointed out that technology in isolation is not a strategy. According to Mr. Pompejus, a strategy involves questions concerning the best ways to produce products, i.e., ways that are

[22] BASF, "BASF now offers bio-based PolyTHF", *BASF*, last updated 3/5/15, https://www.basf.com/en/company/news-and-media/news-releases/2015/03/p-15-163.html.

[23] BASF, "BASF and Genomatica expand license agreement for 1,4-butanediol (BDO) from renewable feedstock", *BASF*, last updated 9/24/15, https://www.basf.com/eg/en/company/news-and-media/news-releases/2015/09/p-15-347.html.

economically and environmentally optimal, and this involves evaluating barriers and tradeoffs. One of the most important issues in this industry is the lack of ability to predict the decisions that the government will make. Legislation that varies depending on who is in Congress can cause disruptions in long-term strategies. Predictability in legislation is a factor that supports the long-term approach to investments in biobased technology.

BASF is committed to collaborating with universities and small companies to conduct research. Mr. Pompejus emphasized that biobased is not about taking a wait-and-see attitude. He went on to explain that BASF has made a strong R&D commitment to industrial biotech with the full understanding that there is not a premium just because a product is sustainable and that these materials must be produced at the same cost level as non-biobased materials, or, alternatively, provide an extra form of value. Mr. Pompejus observed that there is no chemical that is a "pure" drop-in, as there are always performance differences. A monomer produced by fermentation is not a drop-in for a petroleum-derived material, as there always will be downstream processes that must adapt when the switch is made from a chemical raw material to a fermented chemical. The downstream impacts must always be considered. This is true even for a 99 percent pure chemical produced in two different ways. The minor side effects on the downstream process may cause it to perform in a somewhat different way.

Mr. Pompejus added that sometimes the process has to be changed, and familiarity with the whole supply chain allows BASF to do that internally.

C3. Case Study: Eastman Chemical Company

Using cellulose from wood pulp or cotton linters, Eastman Kodak developed cellulose nitrate, which was used in the film that launched the movie entertainment industry. An unfortunate property of cellulose nitrate film was that the heat from the projector's lamp often ignited it. This led to the development of cellulose acetate film, also known as "safety film", which became the industry standard by 1948. Because cellulose acetate film degraded over time, polyester film began to replace it in 1970. Polyesters, which are composed of mixed esters, also are used for filter media and coatings, with the latter producing a very clear, mirror-like image. The Eastman Kodak Company was the major producer of film for cameras prior to the digital camera era, when digital cameras virtually eliminated the Kodak film brand. The management of the Company understands how technology and the competitive ecosystem can change an entire industry in a very short period. In 1994, Eastman Chemical split off from the original Eastman Kodak Company.

Today, Eastman Chemical is one of the largest producers of cellulose acetate, which is used in a wide variety of applications, including pharmaceuticals, adhesives, automotive products, coatings, polishes, and food packaging.

Dr. Stewart Witzeman, an organic chemist who has been at Eastman for more than 30 years, noted that, to be successful, biotechnology requires a focus on techno-chemical analyses and on the ability to involve the multiple factors that impact innovation decisions. Eastman has made a specific strategic decision to focus on specialty materials rather than commodities. To support this decision, the Company established a group to develop innovation models that can balance the price of a barrel of oil versus corn and gas prices, capital costs, and feedstock prices. The models also consider the total lifecycle of feedstocks and products in relation to customers' needs.

Because Eastman is the only producer of mixed cellulose esters, the team focuses on how additional investments can drive the right market outcomes. For example, Eastman shut down its butanol facility when it became clear that the Company could not compete with the production of this chemical through petrochemical pathways. Strategically, it also was clear that adding butanol capacity was not consistent with the Company's direction in focusing on specialty materials.

The Company continues to drive innovation related to biobased products around a line of products focused on enzymatic analysis, some of which are biobased. For example, its GEM™ technology is focusing on the ingredients of sustainably manufactured cosmetic products. The Company's web site states "Sustainability… is embedded in everything we do. It's about balance."[24] Guided by the U.S. EPA's "Twelve Principles of Green Chemistry", GEM™ technology uses enzymes and closely

[24] Eastman, "Sustainability: Embedded in everything we do", *Eastman*, accessed May 2016, http://www.eastman.com/Company/About_Eastman/Our_Stories/Pages/Embedding_Sustainability.aspx.

controlled manufacturing conditions to eliminate high temperatures, strong acids, and unwanted by-products, while using less energy than conventional manufacturing processes.[25] Eastman's adhesives also include many natural products, such as its rosin resins, derived from the sap in tree stumps.

In all of these cases, biobased feedstocks contribute to the improved performance of these products. Dr. Witzeman emphasized that Eastman focuses on superior performance at a competitive price and pointed to chemicals, such as PLA, that have had some performance problems over the years. He noted that many start-ups are able to identify a biobased material, but struggle with articulating the market application. Dr. Witzeman went on to say that having an innovation without a clear value proposition from the outset is a recipe for failure.

To overcome this problem, Dr. Witzeman asserted that companies should not focus on innovations that are an adjacency or a minor adjustment to a current product or material. Rather, to be truly groundbreaking, companies must begin with market analysis at a macro level: understand the competition and the pain points that exist in the market. They can then begin to determine what is required to solve those pain points and explore that with customers. Based on customer feedback, companies can then decide if they have something that is worth pursuing.

[25] Eastman, "Eastman GEM™ technology", *Eastman*, accessed May 2016, http://www.eastman.com/Company/GreenProcess/Pages/Overview.aspx?utm_source=GEM%20Technology%20landing%20page&utm_medium=GEM%20Technology%20landing%20page&utm_campaign=GEM%20Technology%20landing%20page.

C4. Case Study: DuPont™

DuPont has a long history of research and innovation in the biobased products industry and is focusing on the innovative manufacturing of products made from biobased feedstocks. Its most successful product to date, Sorona®, was developed as a polymer and is currently used extensively in the carpet and apparel sectors. The Company also has invested in research on emerging technologies using plant-based feedstocks to produce new products.

A Global Marketing Manager of Biomaterials from DuPont commented on some of the leading challenges facing the biobased products industry: *From my perspective, one of the things that the commercial biobased industry as a whole is challenged with is the idea of getting consumers to recognize and pay for the value that sustainability offers them and society overall. The default for most consumers is to think short-term and buy the product that is the least expensive to do the job without regard to its longer-term impact on the environment. One of the ideas I believe we have to embrace is that sustainability and our need to make conscious consumer choices about living sustainably will become an increasingly bigger part of our daily lives. But to economically compete in a sustainable world, we need to have higher performing products, allowing companies to extract value for that differentiated performance while using renewably-sourced feedstocks to achieve these product attributes. We want to do the right thing, but a higher level of awareness and value recognition is needed in the consumer base.*

Another challenge to the biobased products industry concerns starch-based versus plant-based feedstocks. Plant-based feedstocks, such as agricultural waste or purposefully

grown crops, can be used for biobased products, but because the supply chain and technologies for these feedstocks are still not well developed, the costs are still excessive. Therefore, the industry must continue to build on the success of the grain-based and starch-based agricultural inputs that already provide significant advantages in terms of GHG reductions, economic benefits to rural economies, and reducing our reliance on fossil fuels.

DuPont aims to create sustainable solutions for the masses, not just for those who can afford to pay a green premium. They believe that biobased product technology should be designed to benefit the greatest number of people. DuPont has a strong research program that is focused on developing other value-added polymers based on biotechnology and renewable feedstocks. According to our interview, this means extending the amount of renewable feedstocks that can be produced sustainably by using biomass consisting of the residual, non-food parts of current food crops, as well as other non-food crops. These types of feedstocks also include industrial waste like woodchips and the skins and pulp from fruit

pressing.[26] This, in turn, will require greater collaboration between entities to co-develop new technologies that are the products of two different complementary capabilities.

A good example is the case of Sorona® (produced from Bio-PDO™ manufactured by DuPont Tate & Lyle). This product is sold primarily for fiber applications, including apparel, residential carpets and rugs, commercial carpets, and automotive carpets, mats, and interiors.[27] The research into Bio-PDO™ began with the realization by Tim Gierke, Research Manager at DuPont Central Research & Development, that 1,3-propanediol (PDO) has three carbons and that three-carbon and six-carbon forms are prolific in nature. A team of DuPont scientists and engineers collaborated with polymer experts to discuss the possibility of producing PDO using biological processes. This led to a research project that lasted over a decade and that eventually resulted in a biological process that could produce the quantities of PDO required for a commercially viable product.

Next, DuPont scientists partnered with scientists from Genencor, an industrial biotech company that later was acquired by DuPont, to develop an organism that could use the glucose from cornstarch to produce PDO. They also developed a proprietary fermentation process that included meticulous cleaning and distillation to produce a pure form of Bio-PDO™.

Then, a commercial scale, $100 million dollar Bio-PDO™ plant was built in Loudon, TN, as a joint venture between DuPont and Tate & Lyle. Today, railcars full of corn arrive at the Tate & Lyle wet mill where glucose is produced from cornstarch and pumped from the wet mill to the Bio-PDO™ production facility, where microorganisms are added to the glucose. Five nine-story-tall fermenters are filled with glucose that contains the organisms. The organisms excrete Bio-PDO™, forming a broth that is separated and distilled, producing 99.97 percent pure Bio-PDO™. The remaining 0.03 percent is primarily water. The Bio-PDO™ is loaded into rail cars and shipped to customers who use it to make a variety of products.

One of these products is Sorona®. Carpeting made with Sorona® offers durability that is equal to or better than nylon carpeting, and it provides crush resistance and resilience. In addition, carpeting made with Sorona® is naturally permanently stain-resistant: the resistance is built into the fibers and does not diminish with time or use as occurs with topical treatments. Apparel made with Sorona® has exceptional softness, strength, quick drying time, and stretch and recovery characteristics. As a result, the sales of this product have increased in the various markets every year since its introduction.

There are several important points that should be emphasized evident in this case study:

- The timeline for product development was about 10 years, which is longer than most. This is clearly indicative of the need for longer-term planning horizons, because biotechnology research often requires multiple iterations to produce compounds with the required characteristics, and then, the required process technology must be developed.
- DuPont found it important to envision and consider the end-to-end

[26] Inderwildi, O.R. and King, D.A, "Quo vadis biofuels?", *Energy & Environmental Science* 2, no. 4, (2009): 343-346, doi: 10.1039/B822951C.

[27] DuPont, "The Manufacturing Process of Bio-PDO™ and Bio-Based Fibers", *DuPont,* accessed 6/2/16, http://www.dupont.com/products-and-services/fabrics-fibers-nonwovens/fibers/brands/dupont-sorona/articles/how-dupont-sorona-is-made.html.

supply chain for a new product to be commercialized. Tate & Lyle had a technology that was suitable for the development of Bio-PDO™ that DuPont could use. If it had been necessary for DuPont to initiate the development of a new technology for this purpose, the project would have had a lower probability of success.

- From commercial and marketing perspectives, the performance characteristics of Sorona® carpet and apparel are unique, in that the product outperforms PET or nylon products based on several attributes in these categories. Sorona® continues to gain market share in competition with these products, and it has sustained its performance advantages over them.

These issues form an important set of "lessons learned" that researchers and manufacturers of biobased products should consider. Some of the key questions for executives to consider include the following:

1. From a market standpoint, does the technology serve a specific market need? What volume can be produced? Specialty products are certainly attractive since niche markets tend to have higher margins. However, companies should also consider the broader market and ask 1) whether their technology can address a larger, broader market and 2) what it will take that larger market to use their technology.
2. What complications will be involved in setting up the supply chain for the technology? What does the capital footprint look like for this technology? Is there a drop-in solution that exists within a current asset, and, if so, can a partnership or joint venture be established to utilize this capacity? This can make the difference between a $20 to $30 million capital investment to expand a facility and the $350 million typically required to build a new plant.
3. If the capital assets result in an acquisition, is the acquisition complementary to what the company already has in its portfolio. If so, would it help diversify the company and result in improving what the company already has?
4. Is the sustainable product using truly renewable materials? Often, this issue is overlooked, and it requires an understanding of many complicated issues. For instance, will it fall into the perceived "food versus fuel" issue, is the site itself sustainable, and how does it participate in the renewable materials cycle?

These issues require significant strategic insight and discussion during product development and scientific research targeting processes. A holistic approach is required, and all factors, such as markets, supply chains, and sustainability requirements, that come into play as the scenario for a new biomaterial evolve must be considered.

Recently, DuPont announced an intended merger with Dow with a subsequent plan to split into three separate companies. This activity will result in a large "specialty" company that has a significant interest in the biobased products industry. Future technology platforms include emerging biomaterials for various markets, such as paper and personal care, and fibers to replace existing products with biobased products.

C5. Case Study: The Coca-Cola Company

When Coca-Cola set out be more sustainable, it recognized from the outset that the entire end-to-end lifecycle of a beverage bottle had to be considered. Biobased feedstocks are used to make the PlantBottle™ packaging, and on the back end, when the consumer is through with it, the bottle can be recycled or repurposed. This can help keep the CO_2 the biobased feedstocks removed from the atmosphere sequestered inside these products, rather than released back into the atmosphere.

Coca-Cola's PlantBottle™ is made from 30 percent plant-based materials and 70 percent traditional, petroleum-based materials. Because the end product is still PET plastic, the PlantBottle™ package delivers the same performance as PET plastic bottles made from fossil fuels (e.g., shelf life, recyclability, weight, chemical composition, appearance), but it reduces potential CO_2 emissions. PET plastic is made up of two components: MEG (mono-ethylene glycol), which makes up 30 percent of the PET by weight and is made from plants, and PTA (purified terephthalic acid), which makes up the other 70 percent.

Coca-Cola is exploring the development of furanic building blocks from plant-based sugars, under the name YXY. These furanics building blocks are the basis of next-generation, plant-based plastics and chemicals. Avantium, the company producing these furanic compounds, is focusing its efforts on using the YXY technology as a catalytic process to convert sugars to 2,5-furandicarboxylic acid (FDCA), a biobased alternative to terephthalic acid (TA). FDCA can be used to produce the polyester polyethylene-furanoate (PEF), a 100 percent biobased material that could replace PET in large markets, such as bottles, fibers, and film. Coca-Cola is working with Avantium, Danone, Gevo, and Virent to support the scale-up of Avantium's plant-based PEF. Virent's chemical allows the remaining 70 percent of the bottle to be plant-based.

PlantBottle™ packaging is available to consumers in more than 40 countries and, to date, the Company has produced over 40 billion bottles. This is a large, critical mass of PET that is used in a number of leading brands, such as Simply Orange, Minute Maid, Gold Peak Tea, Dasani, and SmartWater. Biobased PET is predominantly used for the packaging of carbonated soft drinks, which accounted for more than 75 percent of the market in 2013. The increasing consumption of beverages in the emerging markets of Brazil, Russia, India, China, and South America are expected to drive the growth of the biobased PET market. Coca-Cola has committed to promoting the use of biobased

PET in packaging, which is expected to have a major impact on market growth in the near future.[28] The feedstock for PlantBottle™ packaging is sugar cane from Brazil, and it is moving toward cost parity with PET derived from crude oil. Coca-Cola sees a pathway for PlantBottle™ technology to emerge as the dominant PET option in the end, especially since oil prices are expected to increase. Coca-Cola's has an on-going effort to take the 70 percent non-renewably-sourced portion of the bottle, and move it towards a 100 percent biobased resin. The Company is slowly making headway towards this goal.

There are three driving forces behind Coca-Cola's decision to create and use the 100 percent PlantBottle™ package.

1. **Sustainability and carbon capture.** The response from consumers was overwhelmingly positive concerning PlantBottle™ packaging. The Company has also made significant strides in better communicating the technology used to create the PlantBottle™ to its consumers, distributors, and partners.
2. **Cost and line-of-sight around competitive elements.** This came about as the cane sugar feedstocks in Brazil proved to be cost- competitive. Coca-Cola also needed to prove that the sugar cane was being grown on arable land, was not competing for land or water with other crops, and that the by-products from sugar extraction were not being wasted.
3. **Top-line growth and brand differentiation.** PlantBottle™ packaging has become a core element differentiating Coca-Cola beverages, especially with consumers' growing focus on sustainability. Coca-Cola has collaborated with the World Wildlife Fund to form a consortium that includes brands, such as Nestle, Danone, Unilever, Ford, P&G, Nike, and others, to set guidelines and industry standards that prevent others from jumping in with green washing claims or creating confusion.

Michael Knutzen, Global Program Director for PlantBottle™, indicated that Coca-Cola is the largest biobased PET buyer. According to Mr. Knutzen, Coca-Cola views itself as a catalyst for the industry to increase use of renewable materials, and it is working with its partners to do so. Mr. Knutzen went on to say that Coca-Cola is sharing their technology with other companies so they can all benefit from the PET supply chain that Coca-Cola is creating.

Mr. Knutzen remarked that one of the benefits Coca-Cola would like to see is for the polymer sector to enjoy the same benefits that the Renewable Fuel Standard (RFS) provides to biofuels. It is easier to incorporate ethanol into biofuels than to make plastic out of ethanol. Furthermore, fuel companies tend to have limited partnerships that provide tax benefits, while buyers of renewable plastics are not eligible for the same benefits.

[28] Grand View Research, "Bio-Based Polyethylene Terephthalate (PET) Market By Application (Packaging (Bottles), Technical, Consumer Goods), And Segment Forecasts To 2020 Is Expected To Reach 5,800 kilo tons By 2020", last updated 12/1/14, https://globenewswire.com/news-release/2014/12/01/687467/10110349/en/Bio-Based-Polyethylene-Terephthalate-PET-Market-By-Application-Packaging-Bottles-Technical-Consumer-Goods-And-Segment-Forecasts-To-2020-Is-Expected-To-Reach-5-800-kilo-tons-By-2020.html

C6. Case Study: POET

POET stared when Jeff Broin and his family bought a foreclosed ethanol plant in Scotland, South Dakota. POET has since grown from a single, small refinery into one of the largest producers of ethanol and other biorefined products in the world. The success of the first enabled POET to operate more than 25 production plants and form a vertically integrated business system with several business entities. In addition to biofuels, POET produces a variety of products, including Dakota Gold distiller's grains, Voila™ corn oil, and INVIZ™ zein. The Company is also focusing on the development of natural, renewable food sources and alternatives to petrochemicals. The Company has "an integrated business model that combines technology development with expertise in construction, operations, risk management, and marketing".[29]

POET is also on the forefront of encouraging the switch to a bioeconomy. The RFS has largely pushed the United States toward blending renewable fuel with transportation fuel. To diversify, the Company has moved into animal feed, which is another emerging market due to the trend towards higher protein diets. POET is also working on developing cellulosic ethanol, with a ramp up of a 25 million gallon cellulosic plant. It is working to use corn to power its cellulosic operations, and feeding an adjacent corn ethanol plant with leftover raw materials.

POET has patented a unique technology using a raw starch hydrolysis process, called BPX, which converts starch to sugar with a proprietary blend of enzymes, whereas other ethanol producers use a jet cooker to break down starch with heat. BPX reduces the energy requirement in the plant by 8 to 15 percent and increases the yield by 0.10 to 0.15 gallon per bushel. After years of development, the process was ramped up to commercial-scale production in 2004, and it is currently used in all of POET's biorefineries. The EPA recognizes BPX as an advanced corn ethanol technology under the second RFS regulations.

POET is working on the branding of their products. The American Petroleum Institute's (API's) press releases beginning in the mid-2000s were initially supportive of the RFS and of biofuels in general. However, as the production of biofuels has increased and has become more of a competitive threat, the petroleum industry has become less supportive. To educate the public and change this perception, POET has focused on three key messages related to biofuels and biobased products: biofuels are clean burning, based on renewable materials, and emit fewer toxic compounds than gasoline. The Company also recognizes that additional work is required to support public views concerning GMOs and to counter false conjectures related to the food-versus-fuel debate. One Company executive noted that the biobased products and biofuels industries have the potential to replace the petroleum industry, and loosely supported conjectures could hamper this potential. Rigor and focus are needed on these issues and the academic

[29] POET, "Company At a Glance", *POET*, accessed August 2016, http://www.poet.com/at-a-glance.

community can play a big role in this regard. The POET executive believes that rigorous analytical study on this subject will show the actual environmental impacts of both sources of fuel. The API must face the facts that there will be more fuel-efficient vehicles on the roads and that there will be increased competition from renewable fuels. While the Corporate Average Fuel Economy (CAFE) standards cannot be changed, surpassing the competition is always an option. When this option is exercised, there should be strong efforts to ensure that the public receives the right message.

C7. Case Study: Verdezyne

Verdezyne is a global manufacturer of industrial chemicals that has developed technology for producing a range of chemical intermediates via fermentation of renewable feedstocks, primarily by-products of fatty acids. The Company has developed a proprietary platform for engineering yeast to metabolize multiple non-food-based renewable feedstocks and produce a number of widely used, high-value chemicals.

Verdezyne's first commercial plant in southern Malaysia is expected to produce its first commercial product, biobased dodecanedioic acid (DDDA), by the end of 2017. DDDA is a valuable intermediate used to produce high performance nylon 6,12; polyester resins; adhesives; and powder coatings. DDDA is used in many other applications as well, including, polyester polyols, adhesives, corrosion inhibitors, and coatings. Verdezyne uses a yeast platform to produce DDDA from low-cost, plant-oil feedstocks. DDDA is traditionally produced from butadiene using a multi-step petrochemical-based process.

Recently, Verdezyne was awarded the Bloomberg New Energy Pioneer Award as one of the 50 Hottest Companies in the Advanced Bioeconomy. The candidates were assessed using the following three criteria: potential scale, innovation, and momentum. Verdezyne also recently received the 2016 Small Business Award at the Presidential Green Chemistry Challenge Awards.

Jenna Ngian, who joined Verdezyne in January 2015 as Vice President of Global Sales and Supply Chain, has over 25 years of experience in sales, marketing, product management, supply chain management, operations, and business process reengineering for leading chemical companies, including DuPont and INVISTA. Prior to joining Verdezyne, she was leading product management at Genomatica, where she worked to create brand reputation and brought supply chain expertise to the commercialization of the Genomatica's products. Her experience working in the traditional chemical industry was important for moving into the field of biobased products.

Ms. Ngian's perspective is based on her work at both traditional chemical companies and biobased chemical companies. One very important key difference between the two is financing. According to Ms. Ngian, financing is more than just an important issue - it is the biggest issue. The financing options available to a company can differ depending on the company's size. Most large chemical companies self-fund their expansions and other needs from equity or debt since they have relatively good access to financial markets, but smaller biotech companies must depend on funds from their external partners. Because the technology development cycle usually takes a long time, venture capital or development partners often become impatient, and many companies deplete their available resources before they reach the proof of technology or commercialization

stages. Ms. Ngian believes that the government needs to play a bigger part in developing this industry, as do many other countries in the world except the United States. The implication is that the U.S. government should be more like the governments of other countries who have played bigger roles in developing this sector.

The field of biotechnology is rapidly changing due to many different factors. First, the productivity of sequencing and synthesis has increased at an exponential rate. The cost of genome sequencing in 2001 was $100 million per sequence. By 2007, it was $10 million and in 2016, it is $1,000, which is only 0.01 percent of what it was nine years ago. By 2020, it is expected to decrease to a penny. The cost of synthesis also has decreased to less than 0.6 percent of its base cost 15 years ago.[30] The biotechnology field is very different from other traditional members of the chemical sector, a fact that has made Verdezyne's strategy successful.

The second major change can be observed by studying the history of biotechnology. After the structure of DNA was discovered in 1953, the development of many other genome-related discoveries followed, such as gene expression, sequencing, and cloning. Decades later, these developments provided the basis for significant technologies the biobased industry now uses. Advancements in tools, methodologies, and digital technology have also aided in progressing this field. For example, at the onset of World War II, the United States and its allies lost access to the natural rubber supply from Southeast Asia. To prevent vulnerability due to the loss of this important material, the U.S. government provided support for multiple large rubber companies working together to find a solution. With the sponsorship of the U.S. government, the companies were able to pool their technologies, intelligence, and resources to produce general-purpose synthetic rubber at a commercial scale.[31] This situation shows how biobased technologies emerged from a direct shortage in the market. Today, we are faced with a similar need: support for biobased product manufacturing, which should receive greater investment support from the government; the need, in this case, is driven by climate change and the need for sustainable materials.

The third major change is the environmental movement, which began in the 1970s with the first Earth Day, the Clean Air Act, the Clean Water Act, and others. The movement was further spurred by social and environmental issues, including climate change, food security, and major pollution events. However, business-led sustainability platforms did not gain popularity until the mid-2000s. The launch of the Global Social Compliance Programme in 2006 emphasized that social and environmental sustainability must be a collaborative effort among companies to drive positive change and that business efficiency along the supply chain is essential. More recently, the concept of corporate responsibility is driving a much greater focus on reducing the carbon footprint, using renewable materials, and conducting product LCAs.

The rapid decreases in the cost of biotechnology; the speed of commercially available tools, processes, and technologies that are much more efficient than before; and the increasing awareness of social and environmental concerns indicate the speed at which the biotechnology world is changing. As a result, massive growth in this field is

[30] Timetoast, "History of Biotechnology", *Timetoast*, accessed 7/25/16, https://www.timetoast.com/timelines/history-of-biotechnology--3.

[31] American Chemical Society, "U.S. Synthetic Rubber Program", *American Chemical Society*, accessed 7/25/16, http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/syntheticrubber.html.

expected over the next 10 years. However, some short-term barriers are already apparent.

A barrier that stands in the way of progress is the lack of an established supply chain. The petrochemical supply chain is well established, with pipelines, storage facilities, and dedicated refining facilities that were created along with the supporting regulatory and legal infrastructure. Instead, the biobased chemicals sector must deal with the daunting challenge of combining two long-established, separate supply chains: the agriculture and chemical supply chains.

Verdezyne is an excellent example of how a chemical company executive can make a difference in a new biobased chemicals company by addressing the issues associated with the integration of supply chains. The Company targeted many different nylons, such as nylon 6,6 and nylon 6,10, and nylon 6,12, which impart high functionality, stability, and resistance. Premium nylons command a higher price, and are used in coatings, adhesives, and in automotive products, such as fuel hoses.

The decision to build the production facility in Malaysia was based partly on funding sources. In 2005, the Malaysian government established the National Biotechnology Policy (NBP) that sought to turn the biotechnology field into one of the key economic drivers in the nation with the goal of contributing 5 percent of the nation's GDP by 2020. The Malaysian Biotechnology Corporation (BiotechCorp) was given the responsibility for executing the objectives of the NBP. As such, it provided financial assistance and developmental services to facilitate and accelerate the growth of biobased companies. It also sought to create a conducive environment for promoting international investments in the biobased industry in Malaysia. These initiatives offered Verdezyne significant tax incentives, funding as much as the equivalent of $60 million U.S. dollars at favorable interest rates and access to plentiful sources of sugarcane feedstocks. Some individuals feel the U.S. government should provide similar incentives to drive a similar level of support for building the required infrastructure to support the domestic development and application of technology within U.S. borders.

Verdezyne's product is identical to DDDA derived from petrochemicals. It is a "drop in" like many others, but it has been recognized in the industry as having the highest quality and the lowest color, which may or may not generate a small premium in the market price. Ms. Ngian noted that while Verdezyne has identified a niche market where there are not many DDDA players, Verdezyne always strives to be competitive.

C8. Case Study: Green Biologics

Green Biologics grew out of two different companies that eventually came together to become what it is today. Edward Green, an ethanol fermentation expert, founded Green Biologics in England in 2003 to advance technologies for the production of renewable chemicals and biofuels, such as butanol. In an article for *Chemical & Engineering News*, Green Biologics' Chief Technology Officer, Tim Davies recalled that there was a lot of buzz around biofuels and funding for research at that time. Green Biologics thought higher alcohols might be useful, so they began applying methods of biology, metabolic engineering, biochemistry, fermentation, and process engineering to reinvent the acetone-butanol-ethanol (ABE) fermentation process. [32]

Green Biologics later began working with existing ABE plants in China, allowing the plants to use a strain of a butanol-producing microbe called *Clostridium* from its library of modified microbes to advance their existing processes. Mr. Joel Stone, who is the former president of Green Biologics' U.S. operations, remarked that Green Biologics was able to leverage the capability of the Chinese plants while using their own, more efficient organism. This, coupled with design capability for distillations systems designed in collaboration with the Chinese, resulted in a technology operating at commercial scale and generated sales for Green Biologics.

As Green Biologics grew its presence in Europe and Asia, an Ohio-based company called Butylfuel was formed by David E. Ramey and Thomas Grote. Like Green Biologics, Butylfuel's focus was on creating renewable chemicals and biofuels, and the company built a 40,000 L pilot fermentation plant to do so. In 2012, Green Biologics and Butylfuel merged, extending the company's operational presence to the United States. The newly merged Green Biologics shifted its emphasis to renewable chemicals, which, according to Mr. Stone, was because butanol as a chemical had a sizable market, and Green Biologics anticipated that there would be biobased demand. [33]

With the new company, the executives began efforts to de-risk their processes and eliminate duplication of effort across strain development, technology development, and other areas. As they continued to build the demonstration plant in the United States, it became clear that the economics of the ethanol market were not looking positive, and there were many distressed ethanol plants. This led to the idea that, after the demonstration plant was constructed, it would be best to avoid investing in a new plant, but to invest in and convert a distressed-asset plant instead.

[32] Bomgardner, M. M, "Green Biologics Pursues A Biobased Meeting Of The Minds", *Chemical & Engineering News*, last updated 6/25/15, http://cen.acs.org/articles/93/i26/Green-Biologics-Pursues-Biobased-Meeting.html?h=816950987.

[33] Bomgardner, M. M, "Green Biologics Pursues A Biobased Meeting Of The Minds", *Chemical & Engineering News*, last updated 6/25/15, http://cen.acs.org/articles/93/i26/Green-Biologics-Pursues-Biobased-Meeting.html?h=816950987.

Thus, Green Biologics found a smaller scale plant in Minnesota that would not work as an ethanol plant – because it did not have the scale of 100 million gallons a year, but it could produce 20 million gallons a year, which was ideally suited for what Green Biologics needed. The capital expense was reasonable, and, from an engineering standpoint, it was scalable to move from a demonstration plant to a commercial plant. A "creative deal" was negotiated, whereby Green Biologics entered into an agreement with a purchase option, using a monthly fee for up to one year, and an exercise option to close on the price of the facility in 12 months. This allowed the Company to "prove out" the technology moving from a demonstration plant. The deal was supported further by a grant from the State of Minnesota's Agricultural Department, which helped with the initial engineering work required for the plant. From a "de-risking" standpoint, this allowed the capital costs to be validated and effectively financed. Green Biologics exercised its option and took possession of the facility in December 2014. This led to additional engineering work, and, despite the incredibly difficult financial investment climate for biobased products in 2015, Green Biologics was able to raise over $76 million in funds in 2015. Squire Pacific was brought in as a new venture capital investor.

Several lessons from this experience are worth noting. Green Biologics started as a butyl fuel company, believing that it could successfully license the technology. It eventually moved to specialty line, butanol, which occurred through close collaboration, a frugal investment strategy, partnering between two companies with a similar set of leadership strategies, and a slow, but steady, scale-up from the bench, pilot, and demonstration phases to a full, commercial plan. This was achieved by spending a lot less than the hundreds of millions of dollars that other companies had spent.

III. STATE OVERVIEWS

A. State Incentives and Policies

In 2012, the Obama Administration announced The National Bioeconomy Blueprint, which outlined steps that agencies would undertake to drive the advancement of the bioeconomy.[34] The Federal Government sees enormous potential in the nation's abundant natural resources, capacity for emerging and advanced technologies, entrepreneurial spirit.[35] To realize both the immense potential of the bioeconomy and the important role that policy plays in championing the process, one can look to the emergent wood pellet subsector within the southeastern United States.

The success of the wood pellet subsector illustrates the importance of regulatory support. The Renewable Energy and Energy Efficiency Export initiative, supported by President Barack Obama, was created, in part, to improve U.S. export competitiveness in renewable energy. In 2010, the United States exported $128 million worth of wood pellets in response to the demand for a source of renewable energy.[36] In 2014, this figure grew to over $500 million, as growth was facilitated by the USDA Market Access Program's commitment to identifying and growing additional market opportunities for wood pellet exports in the European Union.[37] The same support for the broader biobased products industry must be demonstrated on a state level for the industry to maximize its potential.

A few states have specific policies in place to further the advancement of the bioeconomy and specifically the biobased products industry, as shown in Table 3. While this report does not include economic data on biofuels, we include biofuel incentives as examples of what could be done for biobased products, and to indicate movement by states towards increasing the utilization of biological feedstocks for industrial purposes in the United States.

Table 3. Overview of State Policies and Incentives for Biobased Products Development

	Tax Credit(s)	Tax Exemption	Loans	Production Payment	Grant(s)	Procurement Program
Iowa	X					
Massachusetts						X
Michigan			X			
Minnesota				X		
Oregon	X					
Virginia	X	X			X	
Washington	X					
Wisconsin	X					

[34] White House, "National Bioeconomy Blueprint", *White House*, last updated April 2012, https://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf.

[35] Biomass Research and Development Board, "Federal Activities Report On The Bioeconomy," *Biomass Research and Development Board*, last updated February 2016, http://biomassboard.gov/pdfs/farb_2_18_16.pdf.

[36] White House, "National Bioeconomy Blueprint", *White House*, last updated April 2012, https://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf.

[37] Lowenthal-Savy, D, "UK's renewable energy targets drive increases in U.S. wood pellet exports", *U.S. EIA*, last updated 4/22/15, http://www.eia.gov/todayinenergy/detail.cfm?id=20912.

Iowa

In April 2016, the Iowa legislature passed the Biorenewable Chemical Tax Credit Program, a revenue-neutral tax incentive and economic development package that allocates $100 million in tax credits over 10 years to be applied to the manufacturing of 40 key building block chemicals. For each pound of biobased chemicals produced in a given year, a company can receive a $0.05 tax credit. Financial incentives are annually capped at $500,000 for companies five years and older, and $1,000,000 for companies less than five years old. The program, which represents the strongest existing incentive package for the global biobased chemical industry, was designed and implemented to attract national biobased chemical companies and new businesses to the state.[38]

The production of higher-value basic chemical compounds, which can utilize the co-products of existing corn and soybean manufacturing facilities, is a fast growing segment of the biobased products industry, representing a significant change for Iowa to develop a cluster of biobased chemical companies.[39] The hope is that the Iowa Biorenewable Chemical Tax Credit Program will achieve the same success as the tax credits of the Iowa ethanol industry, which produces a quarter of the ethanol in the United States. An analysis of the Iowa ethanol industry indicated that 32 percent of the industry is located in Iowa because of the support given by the state. Furthermore, since 2006, tax credits in excess of $61 Million have been provided in support of the state's 38 ethanol plants. Total capital spending on these plants has been nearly $4.5 billion, meaning that tax support equaled just 1.3 percent of the total capital spending.[40]

Massachusetts

Massachusetts offers an Environmentally Preferable Products (EPP) Procurement Program, which aims to help the Commonwealth use its purchasing power to reduce both the environmental and public health impacts of state government, in addition to stimulating market demand for environmentally preferable products and services.[41] As part of the Procurement Program, the state provides an Environmentally Preferable Products and Services Guide that assists buyers in finding products, services, and vendors. Since its inception in 1995, the program has increased spending on EPPs from roughly $5 million to an estimated $400 million. Furthermore, Massachusetts works to identify locally sourced products that are grown, harvested, and processed within the state. Certified products are provided a "Commonwealth Quality" brand designation by the Massachusetts Department of Agricultural Resources, which works to provide a guarantee that such products are grown and harvested within the state, utilizing production practices that adhere to a set of criteria and environmental standards.[42]

[38] Cultivation Corridor, "Biorenewable Chemicals: The Iowa Advantage", *Cultivation Corridor*, accessed 6/1/16, http://www.cultivationcorridor.org/biochem/.

[39] Iowa Economic Development, "Renewable Chemical Production Tax Credit Program", *Iowa Economic Development*, accessed 6/1/16, http://www.iowaeconomicdevelopment.com/userdocs/documents/ieda/RenewChemTaxCredit_042016.pdf.

[40] Cultivation Corridor, "Biobased Chemicals: The Iowa Opportunity," *Cultivation Corridor*, last updated 1/14/16, http://www.cultivationcorridor.org/assets/pdf/Iowa-Biobased-Chemicals-Full-Report.pdf.

[41] E Commonwealth of Massachusetts Executive Office for Administration and Finance, "Environmentally Preferable Products (EPP) Procurement Program," *Mass.Gov*, accessed 6/14/16, http://www.mass.gov/anf/budget-taxes-and-procurement/procurement-info-and-res/procurement-prog-and-serv/epp-procurement-prog/.

[42] Massachusetts Department of Agricultural Resources (MDAR), Commonwealth Quality, *MDAR*, accessed 6/14/16, http://thecqp.com/index.html.

Michigan
In Michigan, the Department of Agriculture & Rural Development, in conjunction with the Michigan Economic Development Corporation, offers a variety of programs intended to help support the financing and growth of agricultural processing and support industries within the state.[43]

Minnesota
In 2015, the Minnesota legislature established the Bioincentive Program, which is intended to make Minnesota an excellent destination for commercial-scale advanced biofuel and biobased chemical plants. The program provides production payments to encourage commercial-scale production of advanced biofuels, biobased chemicals, and thermal energy production from agricultural, forestry, or solid waste sources.[44]

For companies to take advantage of the Renewable Chemical Production Incentive Program, chemicals must be at least 51 percent biobased. Manufacturing facilities must also (a) be located within Minnesota, (b) source 80 percent of their raw materials from Minnesota, and (c) produce a minimum of 750,000 pounds of chemicals per quarter to enter the program and for each quarter in which a reimbursement claim is made. Production payments range from $0.03 per pound of chemical produced from sugar, cellulosic sugar, or starch, to $0.06 per pound of chemical produced from cellulosic biomass.[45]

The producer payment incentive program, in addition to volumetric fuel blending requirements, was previously championed by Minnesota to build a strong first-generation ethanol industry.[46] Over the course of a decade, the State of Minnesota provided over $450 million dollars to help construct 21 corn ethanol plants within the state, which jointly contribute over $5 billion annually to the Minnesota economy.[47] As opposed to alternative financial programs, the inherent advantage of a producer payment program is that payments are only made for actual production of eligible products, thereby negating the risks inherent in grants or loans.

Oregon
Oregon provides tax credits for the production, collection, and transportation of biomass resources that are utilized for energy production.[48] To be eligible for the tax credits, the biomass material must be (a) sourced from within the state and (b) utilized as biofuel, or used in the production of biofuel in Oregon.

Virginia
Virginia offers incentives, such as tax incentives, grants, and investment programs, for emerging life science technologies and companies within the state.[49]

Washington
Washington has passed a House Bill that restored preferential timber industry

[43] Michigan Economic Development Corporation, "Agribusiness Financing Programs," *Michigan Economic Development Corporation*, accessed 6/1/16, http://www.michiganbusiness.org/cm/files/fact-sheets/agribusinessfinancingprograms.pdf?rnd=1464620718277.
[44] Minnesota Department of Agriculture, "Bioincentive Program", *Minnesota Department of Agriculture*, accessed 6/1/16, http://www.mda.state.mn.us/grants/agri/bioincentive.aspx.
[45] Minnesota Department of Agriculture, "Bioincentive Program", *Minnesota Department of Agriculture*, accessed 6/1/16, http://www.mda.state.mn.us/grants/agri/bioincentive.aspx.
[46] Bioeconomy Coalition of Minnesota, "Bioeconomy Production Incentive Program Created in Minnesota", *Bioeconomy Coalition of Minnesota*, accessed 6/1/16, http://mnbioeconomy.org.
[47] Bilek, A. and Jordan, B. "2015 Minnesota Legislative Session Recap: Bioeconomy Edition", *Great Plains Institute*, last updated 7/6/15, http://www.betterenergy.org/blog/2015-minnesota-legislative-session-recap-bioeconomy-edition.
[48] Business Oregon, "Renewable Energy", *Business Oregon*, accessed 6/1/16, http://www.oregon4biz.com/Oregon-Business/Tax-Incentives/Renewable-Energy.
[49] Virginia Biotechnology Association, "Incentives for Bioscience Research, Commercialization and Investment in the Commonwealth", *Virginia Biotechnology Association*, accessed 6/1/16, https://www.vabio.org/?page=incentives.

business and occupation tax rates for manufacturers of biocomposite surface products, in addition to existing incentives for timber harvesting and manufacturing/processing activities. Washington also offers a reduced tax rate for manufacturing wood biomass fuel.[50]

Wisconsin

Wisconsin creates a competitive advantage within its state by offering a "Manufacturing and Agriculture Credit", which serves to virtually eliminate the tax on income for both manufacturing and agricultural activities occurring within the state.[51]

B. State Statistics

Figure 8 shows the number of biobased products industry jobs per 1,000 people in each state in 2013. Table 4 shows the direct jobs contributed at the state level for the top 10 states. Similarly, Figure 9 shows the value added by the biobased products industry in each state, and Table 5 shows the top 10 states by value added contribution in the biobased products industry.

[50] Washington State Department of Revenue, "Incentive Programs: Deferrals, Exemptions, and Credits," *Washington State Department of Revenue*, accessed 6/1/16, http://dor.wa.gov/content/findtaxesandrates/taxincentives/incentiveprograms.aspx/.

[51] Wisconsin Department of Revenue, "Wisconsin Manufacturing and Agriculture Credit", *Wisconsin Department of Revenue Retrieved*, last updated 9/8/15, https://www.revenue.wi.gov/taxpro/fact/manufandagr.pdf.

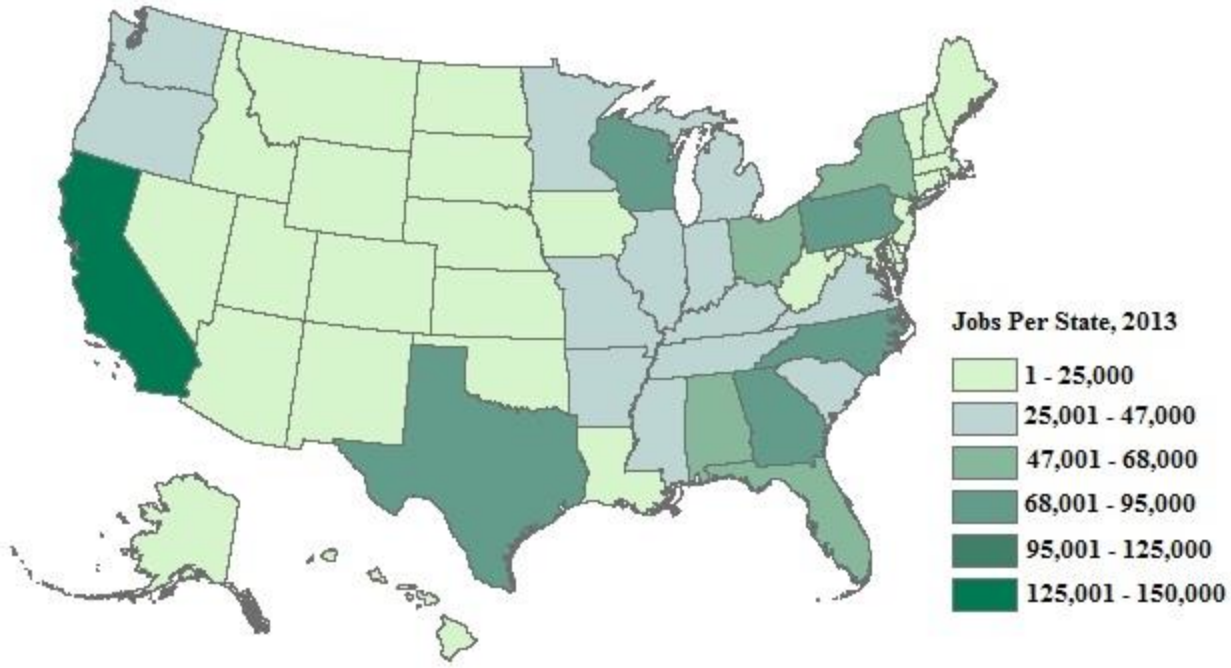


Figure 8: Direct Jobs Contributed by the Biobased Products Industry in Each State and the District of Columbia in 2013[52]

Table 4. Top 10 States for Direct Jobs in the Biobased Products Industry in 2013

Rank	State	Direct Jobs
1	California	145,080
2	North Carolina	90,040
3	Texas	88,680
4	Georgia	80,520
5	Pennsylvania	71,360
6	Wisconsin	68,250
7	Ohio	52,930
8	New York	52,300
9	Alabama	49,650
10	Florida	47,690

[52] Esri, TomTom, Department of Commerce, Census Bureau, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). "USA States" Basemap. *ArcGIS Online*, accessed 3/3/16, http://www.arcgis.com/home/item.html?id=1a6cae723af14f9cae228b133aebc620.

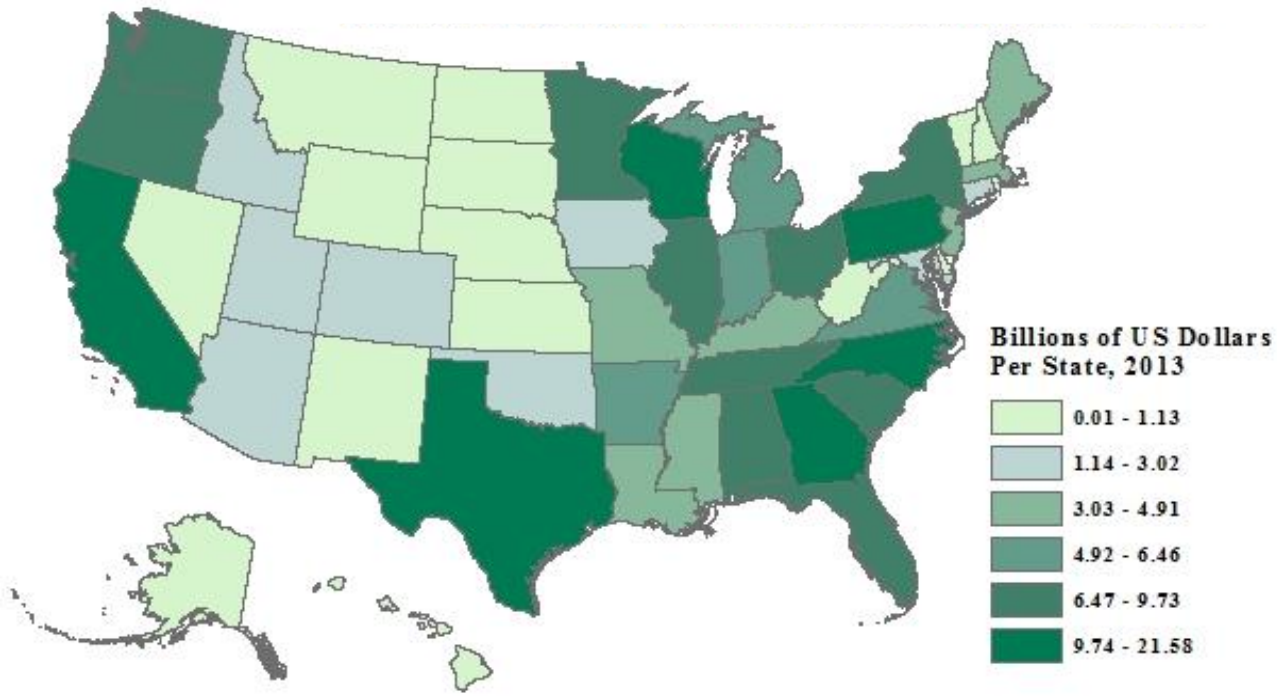


Figure 9: Direct Value Added Contribution in Each State by the Biobased Products Industry in 2013[53]

Table 5. Top 10 States for Direct Value Added to the Biobased Products Industry in 2013

Rank	State	Direct Value Added
1	California	$9,862,930,000
2	Georgia	$8,237,608,000
3	Texas	$6,828,425,000
4	Pennsylvania	$6,522,151,000
5	North Carolina	$6,437,140,000
6	Wisconsin	$6,252,403,000
7	Alabama	$4,977,941,000
8	Tennessee	$4,429,804,000
9	Ohio	$4,276,668,000
10	South Carolina	$4,227,162,000

[53] Esri, TomTom, Department of Commerce, Census Bureau, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). "USA States" Basemap. *ArcGIS Online*, accessed 3/3/16, http://www.arcgis.com/home/item.html?id=1a6cae723af14f9cae228b133aebc620.

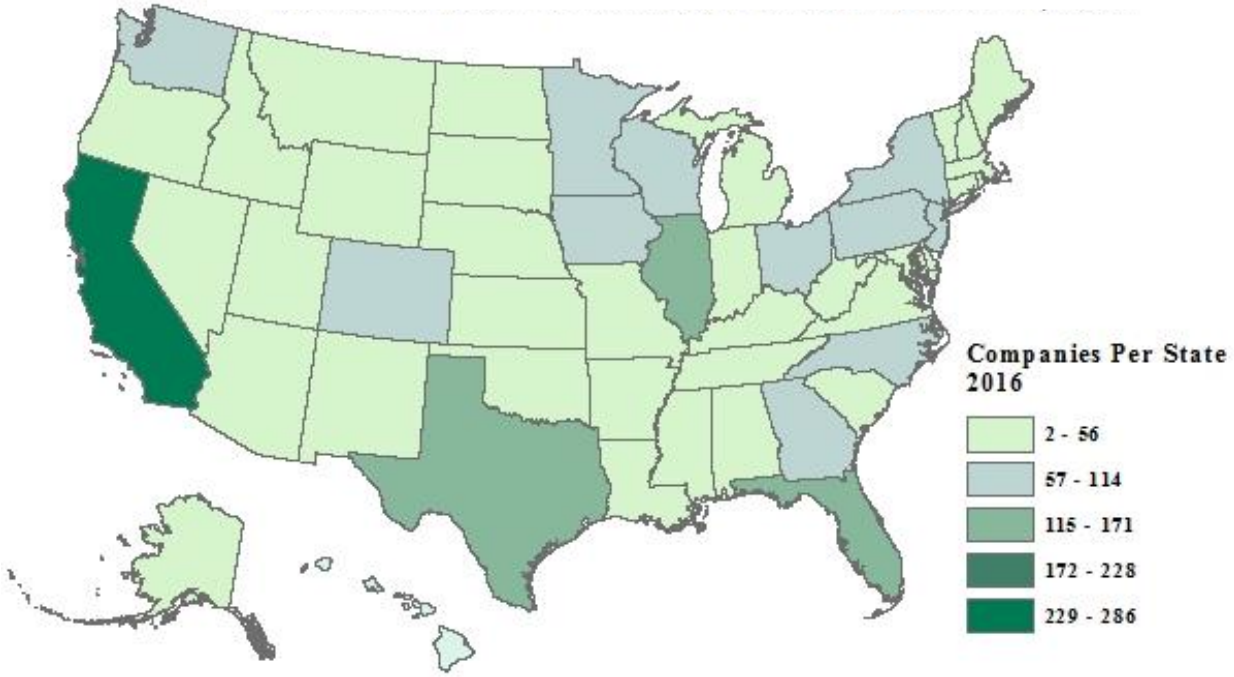
C. National and State Facts Sheets

A major addition in this report from the 2015 report is a detailed analysis of all 50 states and the District of Columbia. This report contains a single page for each state. Each fact sheet offers a snapshot of companies and associations that are active in the biobased products industry overall within the state, and information about the USDA's Rural Development office in that state. They also include the direct and total economic contributions of the biobased products industry in terms of value added contribution and jobs supported. Each of the biobased products industry's seven major sectors' direct jobs and value added are also provided. The numbers presented for each sector are limited to direct jobs for comparison of the biobased products industry size between states.

The national ranking by direct jobs and direct value added for each state are also provided in Appendix C (direct jobs) and Appendix D (direct value added). An alphabetical listing of the states with the number of direct jobs and value added are in Appendix E.

This section closes with two case studies of organizations supporting the growth of the biobased products industry at the state level and beyond.

United States



Number of Companies participating in the BioPreferred Program (June 2016).[54]

The Number of Jobs Contributed to the U.S. Economy by the U.S. Biobased Products Industry in 2014
4.2 Million

Value added Contribution to the U.S. Economy from the U.S. Biobased Products Industry in 2014
$393 Billion

The Jobs Multiplier
2.76
For every 1,000 Biobased Products jobs, 1,760 more jobs are supported in the United States

Agriculture and Forestry
Direct Jobs: 263,500
Direct Value Added: $15.8 B

Biobased Chemicals
Direct Jobs: 17,690
Direct Value Added: $5.0 B

Biorefining
Direct Jobs: 570
Direct Value Added: $155.0 M

Enzymes
Direct Jobs: 3,000
Direct Value Added: $873.8 M

Forest Products
Direct Jobs: 1,059,660
Direct Value Added: $93.3 B

Textiles
Direct Jobs: 164,370
Direct Value Added: $9.6 B

Packaging
Direct Jobs: 1,200
Direct Value Added: $11.4 M Direct Value Added: $11.4 M

[54] Esri, TomTom, Department of Commerce, Census Bureau, U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). "USA States" Basemap. *ArcGIS Online*, accessed 3/3/16, http://www.arcgis.com/home/item.html?id=1a6cae723af14f9cae228b133aebc620.

Alabama

Total Jobs: 102,850
Direct Jobs: 49,650

Total Value Added: $9.010 Billion
Direct Value Added: $4.978 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	10,740	$776.5M
Biobased Chemicals	260	$82.6M
Biorefining	< 50	< $5M
Enzymes	50	$14.2M
Forest Products	33,420	$3.9B
Textiles	5,840	$266.0M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

14 Alabama companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry

Jasper Lumber Company (Jasper, AL; jasperlumber.com): Jasper Lumber Company has manufactured quality southern pine lumber for more than 25 years, offering a wide range of wood products. The company is the only lumber manufacturer in the southeast U.S. to hold certifications from both the Forest Stewardship Council and the Sustainable Forestry Initiative.

Biobased Chemicals

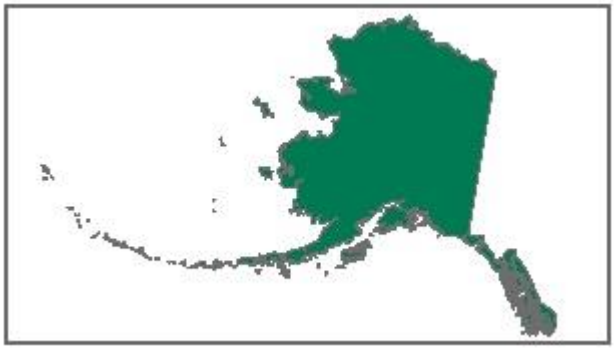
Alpha CLP (Winfield, AL; alphaclp.com): Alpha CLP manufactures a biobased, non-gumming firearm cleaner, lubricant, and protectant. The finished product is 99 percent biobased, utilizing vegetable oils during the production process.

Renewable Oil International, LLC (Florence, AL; renewableoil.com): Renewable Oil International is dedicated to developing and commercializing an advanced biomass distillation process based on fast pyrolysis technology. The objective is to cost effectively fractionate wood and other types of biomass into high-value products.

USDA Rural Development Alabama Office

Ronald Davis, State Director (www.rd.usda.gov/al)
4121 Carmichael Road, Suite 601, Montgomery, AL 36106-3683
Phone: (334) 279-3402

Alaska



Total Jobs: 1,980
Direct Jobs: 1,420

Total Value Added: $120 Million
Direct Value Added: $67 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	640	$46.8M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	670	$17.8M
Textiles	110	< $5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

5 Alaska companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Denali Organics, LLC (Chugiak, AK; denaliorganics.com): Denali Organics provides organic liquid fertilizer products, made with catfish by-products and proprietary digestive enzymes. These fertilizers can be blended to meet a customer's specific requirements.

Biobased Chemicals
Polyseal Insulation (Palmer, AK; polysealinsulation.com): Polyseal Insulation offers a range of services including insulation, spray foam, roofing foam, and advanced coatings. Their Green Cellulose Insulation product is non-toxic and manufactured from at least 80 percent recovered, post-consumer paper fiber.

Forest Products
Tongass Forest Enterprises (Ketchikan, AK; akforestenterprises.com): Tongass Forest Enterprises specializes in producing custom wood building products. The company uses the by-product from these products to produce wood pellets, as well.

USDA Rural Development Alaska Office

Jim Nordlund, State Director (www.rd.usda.gov/ak)
800 West Evergreen, Suite 201, Palmer, AK 99645-6539
Phone: (907) 761-7705

Arizona

Total Jobs: 27,730
Direct Jobs: 14,790

Total Value Added: $1.968 Billion
Direct Value Added: $912 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	3,510	$268.6M
Biobased Chemicals	120	$33.2M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	10,360	$582.8M
Textiles	830	$29.5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

30 Arizona companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Yulex (Phoenix, Arizona; yulex.com): Yulex manufactures 100 percent plant-based rubber. As the first commercial enterprise to produce biobased natural rubber latex in North America, Yulex, now collaborates with consumer, industrial, and medical market leaders to co-develop a variety of products.

Biobased Chemicals
GEMTEK (Phoenix, AZ; gemtek.com/): GEMTEK is dedicated to providing high performance cleaners, lubricants, solvents, and specialty chemicals derived from renewable plant-based resources.

Eco Safety Products, LLC (Phoenix, AZ; ecosafetyproducts.com): Eco Safety Products manufactures high-performance paints, stains, finishes, and chemicals that utilize sustainable biobased technology.

USDA Rural Development Arizona Office

Ernie Wetherbee, Acting State Director (www.rd.usda.gov/az)
230 North First Avenue, Suite 206, Phoenix, AZ 85003-1706
Phone: (602) 280-8701

Arkansas

Total Jobs: 64,590
Direct Jobs: 31,400

Total Value Added: $5.903 Billion
Direct Value Added: $3.165 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	7,330	$512.9M
Biobased Chemicals	190	$58.0M
Biorefining	< 50	< $5M
Enzymes	50	$8.2M
Forest Products	23,330	$2.6B
Textiles	860	$40.6M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

12 Arkansas companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Anthony Forest Products Company (El Dorado, AR; Urbana AR; anthonyforest.com): Anthony Forest Products operates a southern pine lumber producing mill in Urbana, and an engineered wood laminating plant in El Dorado. Some of the company's fastest growth has been in the engineered wood products sector.

Biobased Chemicals
AgSeal LLC (Harrison, AR; agseal.com): AgSeal services the growing needs of poultry and agriculture markets for energy saving retrofitting of facilities and structures. The company's foam sealants and insulation are biobased and made especially for poultry and agricultural applications.

Biobased Technologies (Springdale, AR; biobased.net): Biobased Technologies manufactures a high bio-carbon soy polyol, Agrol, which can replace some petroleum polyols. Agrol is used in a variety of products, including lubricants, furniture, adhesives, inks, and agricultural products.

USDA Rural Development Arkansas Office

Lawrence McCullough, State Director (www.rd.usda.gov/ar)
700 West Capitol Avenue, Room 3416, Little Rock, AR 72201-3225
Phone: (501) 301-3200

California

Total Jobs: 265,530
Direct Jobs: 145,080

Total Value Added: $21.577 Billion
Direct Value Added: $9.863 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	42,310	$2.4B
Biobased Chemicals	1,250	$324.4M
Biorefining	<50	$7.3M
Enzymes	170	$42.9M
Forest Products	71,340	$5.7B
Textiles	31,090	$1.5B
Bioplastic Bottles & Packaging	90	$7.5M

BioPreferred®

262 California companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals

TerraVia (San Francisco, CA; solazyme.com): TerraVia, formerly Solazyme, has refined its efforts to focus on manufacturing algae oil for the food and personal care industries for use in products that include cooking oils, protein powders, and face lotions.

Verdezyne (Carlsbad, CA; verdezyne.com): Verdezyne leverages the power of biology to produce chemicals from renewable, non-food sources. Verdezyne's feedstocks are derived from the by-products of vegetable oil production.

Bioplastic Bottles & Packaging

BeGreen Packaging LLC (Santa Barbara, CA; begreenpackaging.com): Be Green Packaging designs, manufactures, and distributes the only non-GMO Product Verified, tree-free, and compostable packaging for the food and consumer packaging industries. Renewable plant fibers are utilized to produce both consumer and food packaging products.

USDA Rural Development California Office

Janice Waddell, State Director (www.rd.usda.gov/ca)
430 G Street, #4169, Davis, CA 95616-4169
Phone: (530) 792-5800

Colorado

Total Jobs: 21,840
Direct Jobs: 11,500

Total Value Added: $1.526 Billion
Direct Value Added: $635 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,710	$54.9M
Biobased Chemicals	110	$31.9M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	8,510	$476.6M
Textiles	1,200	$72.4M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

60 Colorado companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Natracare LLC (Greeley, CO; natracare.com): Natracare LLC manufactures feminine hygiene products using responsibly sourced, biobased materials. Natracare's products are compostable and made to limit the user's exposure to chemicals such as chlorine, plastic, pesticides, and petroleum derivatives.

Forest Products
Sustainable Flooring (Boulder, CO; sustainableflooring.com): Sustainable Flooring offers various flooring and walls products, designed for both residential and commercial applications. In addition to wood, the company utilizes bamboo and cork in the manufacturing process.

Bioplastic Bottles & Packaging
Eco-Products (Boulder, CO; ecoproducts.com): Eco-Products offers a full selection of disposable products, including plates, cups, containers, and silverware. All products are produced from recycled content or renewable resources (e.g. corn, sugarcane, plant starch).

USDA Rural Development Colorado Office

Trudy Kareus, State Director (www.rd.usda.gov/co)
Denver Federal Center, Building 56, Room 2300, PO Box 25426, Denver, CO 80225-0426
Phone: (720) 544-2904

Connecticut

Total Jobs: 18,750
Direct Jobs: 8,970

Total Value Added: $1.905 Billion
Direct Value Added: $846 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	680	$19.2M
Biobased Chemicals	190	$47.0M
Biorefining	< 50	< $5M
Enzymes	< 50	$5.4M
Forest Products	7,200	$670.0M
Textiles	910	$109.5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

24 Connecticut companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Citrasolv (Ridgefield, CT; citrasolv.com): Citrasolv produces a line of earth-and-people-friendly cleaning supplies that are derived from renewable resources. Citra Solv Concentrate, a multipurpose cleaning product, is 95 percent biobased.

New Polymer Systems INC (New Canaan, CT; newpolymersystems.com): New Polymer Systems has patents pending on processes that yield lightweight, hydrophobic lignocellulosic fillers, the core component of their NeroPlast branded products. NeroPlast can be utilized in a host of applications, including car parts, decking, pallets, and roofing and is a USDA Certified Biobased Product with 100 percent biobased content.

Bioplastic Bottles & Packaging
Green Valley Packaging (Danielson, CT; vegware.us): Green Valley Packaging is a key distributor of the Vegware brand of eco-packaging products in the food service sector. Feedstock inputs include sugarcane bagasse and corn starch.

USDA Rural Development Connecticut Office

Scott Soares, State Director (www.rd.usda.gov/ct)
451 West Street, Amherst, MA 01002-2999
Phone: (413) 253-4300

Delaware

Total Jobs: 4,170
Direct Jobs: 2,140

Total Value Added: $5501 Million
Direct Value Added: $347 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	160	< $5M
Biobased Chemicals	60	$32.1M
Biorefining	< 50	< $5M
Enzymes	< 50	$8.9M
Forest Products	1,580	$290.7M
Textiles	330	$17.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

5 Delaware companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
DuPont Industrial Biosciences (Wilmington, DE; dupont.com): DuPont is a global leader in the development of renewably sourced biobased materials. By utilizing glucose as the basis for Bio-PDO, a biobased monomer, DuPont created an ingredient a biobased fiber, Sorona, which is used in a variety of everyday products.

Ensyn Corporation (Wilmington, DE; ensyn.com): Ensyn is a producer of advanced, drop-in cellulosic biofuel, produced from wood biomass and agricultural residues. Much of their biofuel production has been dedicated to the production of renewable chemicals and heating fuels for the specialty chemicals industry.

The Chemours Company (Wilmington, DE; chemours.com): Teflon, a brand of The Chemours Company, manufactures EcoElite, the first renewably sourced, non-fluorinated fabric treatment designed for durable water repellency. The product contains 60 percent renewable content.

USDA Rural Development Delaware Office

Bill McGowan, State Director (www.rd.usda.gov/de)
1221 College Park Drive, Suite 200, Dover, DE 19904
Phone: (302) 857-3580

Washington, D.C.

Total Jobs: 280
Direct Jobs: 220

Total Value Added: $26 Million
Direct Value Added: $18 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	< 50	< $5M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	180	$16.7M
Textiles	< 50	< $5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

3 Washington, DC companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Forest Products
Kwai (Washington, DC; kwaihome.com): Kwai produces handcrafted materials utilizing fronds from areca palm trees. Finished materials are 100 percent biobased, and fully biodegradable.

Bioplastic Bottles & Packaging
TemperPack Technologies (Washington, DC; temperpack.com): TemperPack seeks to replace petrochemical-based packaging with more sustainable forms of packaging, utilizing renewable jute fiber as a feedstock. Additional feedstocks include post-consumer recycled plastic and paper.

USDA Rural Development Washington, DC Office

U.S. Department of Agriculture (usda.gov/)
1400 Independence Ave., S.W.
Washington, DC 20250
Information Hotline: (202) 720-2791

Florida

Total Jobs: 98,460
Direct Jobs: 47,690

Total Value Added: $7.805 Billion
Direct Value Added: $3.738 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	14,800	$721.0M
Biobased Chemicals	410	$79.2M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	28,850	$2.8B
Textiles	3,950	$170.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

118 Florida companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Arizona Chemical (Panama City, FL; Pensacola, FL; arizonachemical.com): Arizona Chemical is the world's leading producer and biorefiner of pine chemicals. The company provides innovative, biobased chemical solutions to multiple industry sectors, including adhesives, roads and construction, tires, and coatings. Approximately 85 percent of the company's raw materials are made from renewable sources.

BioBag Americas, Inc. (Palm Harbor, FL; biobagusa.com): BioBag produces bags and plastic films derived from renewable agriculture feedstocks, including cornstarch and vegetable oils. Compostable products span both retail and commercial applications.

Naturally Green Products LLC (Seminole, FL; naturally-greenproducts.com): Naturally Green offers the most comprehensive line of USDA BioPreferred cleaning and floor care products. Product offerings include bathroom cleaners, dishwashing products, disinfectants, floor and carpet clearness, laundry products, and hand soaps and sanitizers.

USDA Rural Development Florida Office

Richard Machek, State Director (www.rd.usda.gov/fl)
Post Office Box 147010, 4440 NW 25th Place, Gainesville, FL 32614-7010
Phone: (352) 338-3402

Georgia

Total Jobs: 178,110
Direct Jobs: 80,520

Total Value Added: $16.365 Billion
Direct Value Added: $8.238 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	17,940	$1.5B
Biobased Chemicals	620	$168.9M
Biorefining	< 50	< $5M
Enzymes	70	$14.9M
Forest Products	41,970	$5.1B
Textiles	21,020	$1.6B
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

71 Georgia companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Arizona Chemical (Savannah, GA; arizonachemical.com): Arizona Chemical is the world's leading producer and biorefiner of pine chemicals. The company provides innovative, biobased chemical solutions to multiple industry sectors, including adhesives, roads and construction, tires, and coatings.

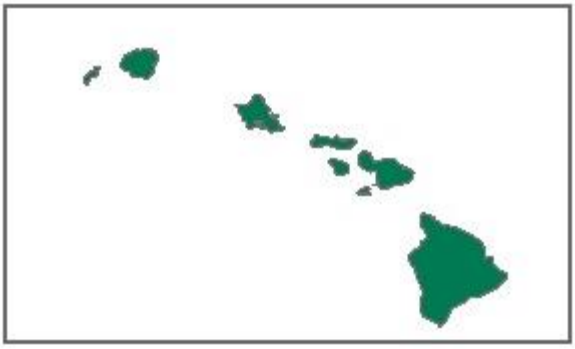
Forest Products
US Floors (Dalton, GA; usfloorsllc.com): US Floors is the leading producer of sustainable, biobased flooring, produced from cork, bamboo, and FSC Certified hardwood. US Floors is currently the only producer of cork and bamboo flooring with manufacturing facilities in the US.

Bioplastic Bottles & Packaging
The Coca-Cola Company (Atlanta, GA; coca-colacompany.com): In 2009, the Coca-Cola Company unveiled the first-ever fully recyclable PET plastic beverage bottle made from plants. In 2012, the Company announced the formation of the Plant PET Technology Collaborative, a strategic initiative aimed at developing 100 percent biobased PET.

USDA Rural Development Georgia Office

Jill Stuckey, State Director (www.rd.usda.gov/ga)
Stephens Federal Building, 355 E. Hancock Avenue, Stop 300, Athens, GA 30601-2768
Phone: (706) 546-2162

Hawaii



Total Jobs: 2,840
Direct Jobs: 1,930

Total Value Added: $138 Million
Direct Value Added: $66 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	420	$9.4M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	1,040	$40.1M
Textiles	460	$15.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

8 Hawaii companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Hawaiian Earth Products, Ltd. (Kapolei, HI; menehunemagichawaii.com): Hawaiian Earth Products makes products that use waste from yard trimmings, such as compost and potting mix. After being collected as waste from several cities in Hawaii, these trimmings are converted into useful products, rather than being sent to a landfill.

Biobased Chemicals
Malie Organics (Kalaheo, HI; malie.com): Malie offers a range of personal care and beauty products, all produced from natural and organic feedstocks. Product ingredients are all sustainably grown and harvested.

Forest Products
Honsador Lumber LLC (Kapolei, HI; honsador.com): Honsador is Hawaii's largest lumber supplier. In addition to lumber and plywood, the company offers an array of finished products, including cabinetry, doors, and windows.

USDA Rural Development Hawaii Office

Chris Kanazawa, State Director (www.rd.usda.gov/hi)
Federal Building, Room 311, 154 Waianuenue Avenue, Hilo, HI 96720
Phone: (808) 933-8380

Idaho

Total Jobs: 25,660
Direct Jobs: 12,250

Total Value Added: $1.724 Billion
Direct Value Added: $886 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	3,350	$213.3
Biobased Chemicals	60	$9.1M
Biorefining	< 50	$5.7M
Enzymes	< 50	< $5M
Forest Products	9,440	$647.8M
Textiles	390	$11.3M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

13 Idaho companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Eagle Forest Products (Eagle, ID; eaglefp.net): Eagle Forest Products offers a wide variety of lumber and wood products. The company provides lumber to a number of industries, including flooring, construction, music, and landscaping.

Idaho Forest Group, LLC (Coeur d'Alene, ID; idahoforestgroup.com): The Idaho Forest Group, one of America's largest lumber producers, grows, harvests, manufactures, and distributes sustainable wood. In addition to lumber, available products include oriented strand board, paper and packaging materials, wood pellets, wood chips, and bark for power production.

Biobased Chemicals
Pro-Tek Chemicals (Glenns Ferry, ID; protekchemical.com): Pro-Tek manufactures more than 10 biobased cleaning products that are readily biodegradable. Product offerings include cleaners, scrubs, polishes, and enzymes.

USDA Rural Development Idaho Office

Wallace Hedrick, State Director (www.rd.usda.gov/id)
9713 West Barnes Drive, Suite A1, Boise, ID 83709
Phone: (208) 378-5600

Illinois

Total Jobs: 90,930
Direct Jobs: 39,940

Total Value Added: $8.385 Billion
Direct Value Added: $3.543 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,950	$63.0M
Biobased Chemicals	1,000	$235.0M
Biorefining	130	$48.2M
Enzymes	130	$222.2M
Forest Products	34,380	$3.1B
Textiles	3,100	$157.6M
Bioplastic Bottles & Packaging	80	$9.2M

BioPreferred®

123 Illinois companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
ADM (Chicago, IL; adm.com): ADM is one of the world's largest agricultural processors, manufacturing a variety of food, animal feed, energy, and industrial products, which include those for construction, packaging, personal care, pulp and paper, and plastic. Oilseeds and corn are the company's primary feedstocks.

Elevance Renewable Sciences, Inc. (Woodridge, IL; elevance.com): Elevance Renewable Sciences is a specialty chemical company that creates chemicals from renewable feedstocks. Market uses include personal care products, detergents and cleaners, engineered polymers, lubricants, and other specialty chemical markets.

LanzaTech (Skokie, IL; lanzatech.com): LanzaTech's bioprocessing platform provides an economically robust route to carbon capture and re-use. The company's novel gas-to-liquid technology is the only process that converts waste gases (carbon monoxide and carbon dioxide) to fuels and chemicals.

USDA Rural Development Illinois Office

Colleen Callahan, State Director (www.rd.usda.gov/il)
2118 West Park Court, Suite A, Champaign, IL 61821
Phone: 217-403-6200

Indiana

Total Jobs: 85,530
Direct Jobs: 46,050

Total Value Added: $5.820 Billion
Direct Value Added: $2.843 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,850	$63.9M
Biobased Chemicals	490	$157.5M
Biorefining	< 50	$11.4M
Enzymes	60	$12.8M
Forest Products	41,740	$2.5B
Textiles	1,980	$95.2M
Bioplastic Bottles & Packaging	70	$5.4M

BioPreferred®

28 Indiana companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Toni Natural Products Co. LLC (Sunman, IN; toninatural.com): Toni Natural offers an assortment of products that contain 100 percent natural plant- and mineral-based compounds. These products include cleaning products, laundry detergents, fabric softeners, dishwashing liquid, soaps, shampoos, and lotions.

Trellis Bioplastics (Seymour, IN; trellisbioplastic.com): Trellis Bioplastics creates a wide range of bioplastic resins and consumer products, replacing upwards of 95 percent of the petroleum content used in traditional plastics. Starch-based feedstocks are currently used in manufacturing processes, with plans to expand feedstock use to include algae, distillery by-products, wheat chaff, and rice hulls.

Enzymes
Enzyme Solutions Inc. (Garrett, IN; enzymesolutions.com): Enzyme Solutions is a leader in "green" cleaning technology, manufacturing both enzymes and enzyme products. Manufacturing, testing, formulation, and bottling are all conducted in Indiana.

USDA Rural Development Indiana Office

Philip Lehmkuhler, State Director (www.rd.usda.gov/in)
5975 Lakeside Boulevard, Indianapolis, IN 46278
Phone: (317) 290-3100 ext.4

Iowa

Total Jobs: 37,430
Direct Jobs: 20,110

Total Value Added: $3.022 Billion
Direct Value Added: $1.735 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,400	$51.7M
Biobased Chemicals	230	$123.1M
Biorefining	80	$22.3M
Enzymes	140	$65.3M
Forest Products	17,620	$1.5B
Textiles	750	$45.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

79 Iowa companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Avello Bioenergy (Ames, IA; avellobioenergy.com): In collaborating with Iowa State University, Avello is commercializing proprietary technology that provides quality, low-cost, profitable feedstocks for producing bulk chemicals, specialty chemicals, lignin based chemicals, adhesives, and flavors and fragrances.

Corn Oil ONE (Pleasant Hill, IA; cornoilone.com): Corn Oil ONE refines crude corn oil, thereby eliminating free fatty acids, moisture, and waxes. The refined corn oil product delivers the same advantages as soybean oil, making it available as an alternative feedstock for oleochemical and biobased industries.

Renewable Energy Group, Inc. (Ames, IA; regfuel.com): Renewable Energy Group is a leading North American advanced biofuels producer and developer of renewable chemicals. The company's growing industrial biotechnology business manufactures sustainable chemical products using renewable feedstocks such as corn, sugarcane, and cellulosic sugars.

USDA Rural Development Iowa Office

William Joseph Menner, State Director (www.rd.usda.gov/ia)
Federal Building, Room 873, 210 Walnut Street, Des Moines, IA 50309
Phone: (515) 284-4663

Kansas

Total Jobs: 17,070
Direct Jobs: 9,080

Total Value Added: $1.129 Billion
Direct Value Added: $504 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	910	$44.2M
Biobased Chemicals	140	$56.5M
Biorefining	< 50	< $5M
Enzymes	60	$13.4M
Forest Products	6,890	$367.3M
Textiles	1,070	$35.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

27 Kansas companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Corbion (Lenexa, KS; corbion.com): Corbion is the global market leader in lactic acid, lactic acid derivatives, and lactides. Product offerings include bioplastics, biochemical, and biomedical products.

Nowa Technology, Inc. (Prairie Village, KS; nowatechnology.com): Nowa Technology, Inc. uses solids extracted from wastewater treatment sludge to create useful products, including fertilizer. The Nowa Technology process efficiently creates useful products from a source that would otherwise be undesirable waste.

LC Bioplastics (Wichita, KS; lcbioplastics.com): LC Bioplastics manufactures a range of bioplastic resins and additives, including a line of ready-to-use finished goods such as custom film and bag products. Biohybrid resins, which are a blend of renewable thermoplastic materials and traditional polyolefins, increase the renewable content of a product by up to 50 percent in comparison to traditional packaging.

USDA Rural Development Kansas Office

Patricia Clark, State Director (www.rd.usda.gov/ks)
1303 SW First American Place, Suite 100, Topeka, KS 66604-4040
Phone: (785) 271-2700

Kentucky

Total Jobs: 53,190
Direct Jobs: 27,290

Total Value Added: $4.037 Billion
Direct Value Added: $2.128 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	3,110	$98.3M
Biobased Chemicals	450	$11.9M
Biorefining	< 50	< $5M
Enzymes	50	$11.3M
Forest Products	21,960	$1.8B
Textiles	1,780	$76.5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

12 Kentucky companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Owensboro Grain Company (Owensboro, KY; owensborograin.com): Owensboro Grain Company manufacturers an array of products from soybeans, including protein meal and hull pellets for animal feeds, crude and degummed oil, lecithin, and various blends of refined vegetable oils for human consumption, biodiesel, and glycerin.

RyDol Lubricants (Shelbyville, KY; rydol.com): RyDol manufactures and distributes specialty high-performance, biodegradable lubricants, solvents, and degreasers. Products contain soybean oil, grease, and methyl esters as base fluids.

Soy Technologies, LLC (Nicholasville, KY; soytek.com): Soy Technologies is a specialty chemical manufacturer that develops renewable, biobased chemicals. Available products include biobased solvents and emulsions, personal care products, paint thinners, and additional specialty products.

USDA Rural Development Kentucky Office

Thomas G. Fern, State Director (www.rd.usda.gov/ky)
771 Corporate Drive, Suite 200, Lexington, KY 40503
Phone: (859) 224-7300

Louisiana

Total Jobs: 49,070
Direct Jobs: 22,440

Total Value Added: $4.906 Billion
Direct Value Added: $2.649 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	6,670	$451.0M
Biobased Chemicals	330	$151.8M
Biorefining	< 50	$8.1M
Enzymes	70	$27.9M
Forest Products	14,810	$2.0B
Textiles	780	$26.7M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

7 Louisiana companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Biosynthetic Technologies (Baton Rouge, LA; biosynthetic.com): Biosynthetic Technologies manufactures biobased synthetic molecules produced from organic fatty acids found in plant oils. Biosynthetic oils have numerous applications in the lubricant, chemical, and cosmetics industries. In conjunction with Albemarle, a specialty chemical company, the company operates a demonstration plant in Louisiana.

Myriant (Lake Providence, LA; myriant.com): Myriant developed a proprietary platform for the production of biobased chemical intermediates, which can be seamlessly integrated into existing chemical production processes in order to provide a wide range of consumer applications. A variety of feedstocks is utilized in the production process.

Giant Cleaning Systems, Inc. (Duson, LA; giantcleaningproducts.com): Giant Cleaning Systems manufactures a variety of industrial cleaners, including drill rigs, printing industry, and aircraft cleaners. Many of these products contain biobased materials.

USDA Rural Development Louisiana Office

Clarence Hawkins, State Director (www.rd.usda.gov/la)
3727 Government Street, Alexandria, LA 71302
Phone: (318) 473-7920

Maine

Total Jobs: 46,950
Direct Jobs: 20,500

Total Value Added: $3.574 Billion
Direct Value Added: $1.600 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	6,020	$268.7M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	13,390	$1.3B
Textiles	1,040	$47.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

14 Maine companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Genesan LLC (Gorham, ME; cleaneasier.com): Genesan is a leading source of high-performance, ecological, and biotechnological cleaning products in the US. Collaborating with Pollet, a world leader in developing and manufacturing biobased cleaning solutions, over 54 percent of Genesan SKUs are classified as biobased and derived from natural sources.

Textiles
Biovation II, LLC (Boothbay, ME; biovation.com): Biovation manufactures non-woven material consisting of natural, or naturally derived, fibers. The material is manufactured using a sustainable biopolymer, polylactic acid.

Grow-Tech, LLC (South Portland, ME; grow-tech.com): Grow-Tech manufactures BioStrate, a biobased non-woven textile used by aquaponics and hydroponics farms to grow lettuce, microgreens, and tomatoes.

USDA Rural Development Maine Office

Virginia Manuel, State Director (www.rd.usda.gov/me)
967 Illinois Avenue Suite 4, Bangor, ME 04401-2767
Phone: (207) 990-9160

Maryland

Total Jobs: 18,150
Direct Jobs: 9,570

Total Value Added: $1.613 Billion
Direct Value Added: $801 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,050	$40.7M
Biobased Chemicals	170	$73.0M
Biorefining	< 50	< $5M
Enzymes	60	$52.8
Forest Products	7,030	$546.8M
Textiles	1,310	$85.7
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

24 Maryland companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Forest Products
American Wood Fibers (Columbia, MD; awf.com): American Wood Fibers is a leader in the field of specialty forestry products. The company offers an array of products for people, pets, and livestock, all produced from wood shavings and wood flour. Industrial fiber applications include adhesives, absorbents, papers, and plastics.

Enviva Partners, LP (Bethesda, MD; envivabiomass.com): Enviva is the world's largest producer of wood pellets, owning and operating six plants within the southeastern US. Pellets are produced using sustainable practices that protect Southern forests.

Wicanders (Hanover, MD; wicanders.com/us): Wicanders developed Corktech, a technology that provides exclusive properties for floors and wall coverings made from cork.

USDA Rural Development Maryland Office

Bill McGowan, State Director (www.rd.usda.gov/md)
1221 College Park Drive, Suite 200, Dover, DE 19904
Phone: (302) 857-3580

Massachusetts

Total Jobs: 40,350
Direct Jobs: 19,140

Total Value Added: $3.613 Billion
Direct Value Added: $1.417 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,460	$43.7M
Biobased Chemicals	340	$79.8M
Biorefining	< 50	< $5M
Enzymes	< 50	$14.7M
Forest Products	14,160	$1.1B
Textiles	3,280	$184.3M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

49 Massachusetts companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Bum Boosa Bamboo Products (Mashpee, MA; bumboosa.com): Bum Boosa produces biodegradable, eco-friendly bamboo products, which can be adopted as an alternative to products produced from tree-pulp and many types of plastic used in fiber production.

Biobased Chemicals
Metabolix, Inc. (Cambridge, MA; metabolix.com): Metabolix is an advanced biomaterials company, focused on delivering sustainable solutions to the plastics industry. Metabolix produces biobased polymers utilizing renewable carbon-based feedstock.

Myriant (Quincy, MA; myriant.com): Myriant manufactures a broad pipeline of biobased chemicals, including bio-succinic acid and its derivatives, in addition to other biobased chemical intermediates that perform equal to, or better than, petroleum-based chemicals. Grain sorghum and other cellulosic feedstocks are used in the production processes.

USDA Rural Development Massachusetts Office

Scott Soares, State Director (www.rd.usda.gov/ma)
451 West Street, Amherst, MA 01002-2999
Phone: (413) 253-4300

Michigan

Total Jobs: 81,820
Direct Jobs: 37,790

Total Value Added: $6.426 Billion
Direct Value Added: $2.882 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	5,210	$243.2M
Biobased Chemicals	950	$169.8M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	30,090	$2.4B
Textiles	1,880	$117.1M
Bioplastic Bottles & Packaging	70	$5.5M

BioPreferred®

52 Michigan companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Lear Corporation (Southfield, MI; lear.com): Lear Corporation produces SoyFoam, derived from soybean oil, for automotive interior applications on North American Ford and other customer vehicles.

KTM Industries, Inc. (Lansing, MI; ktmindustries.com/products.html): KTM Industries develops, manufactures, and markets new technologies that incorporate bioplastics. One of the company's products is Green Cell, a starch-based biodegradable foam.

Biorefining
Hydro Safe, Inc. (Dewitt, MI; hydrosafe.com): Hydro Safe products use vegetable-based oils as base fluids for a number of market products, including hydraulic oils, cleaners, and lubricants.

Bioplastic Bottles & Packaging
Green Cell Foam (Lansing, MI; greencellfoam.com): Green Cell Foam produces a unique natural packaging material, produced from high-grade, non-GMO cornstarch.

USDA Rural Development Michigan Office

James Turner, State Director (www.rd.usda.gov/mi)
3001 Coolidge Road, Suite 200, East Lansing, MI 48823
Phone: (517) 324-5190

Minnesota

Total Jobs: 81,670
Direct Jobs: 35,850

Total Value Added: $7.371 Billion
Direct Value Added: $3.392 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	3,280	$146.9M
Biobased Chemicals	270	$74.1M
Biorefining	< 50	$6.3M
Enzymes	50	$10.5M
Forest Products	28,880	$3.1B
Textiles	1,730	$81.6M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

92 Minnesota companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
BioAmber (Plymouth, MN; bio-amber.com): BioAmber manufactures succinic acid, which can be used to create of a number of consumer products, including polyurethanes, artificial leathers, cosmetics and personal care products, plastics, and dyes and pigments.

Cargill (Minneapolis, MN; cargill.com): Cargill offers a variety of biobased products, suitable for a number of industrial applications and markets.

NatureWorks, LLC (Minnetonka, MN; natureworksllc.com): NatureWorks is dedicated to driving environmental progress through developing the global market for biobased plastics and fibers. Industry partnerships include service ware, home textiles, food packaging, and apparel.

StarchTech, Inc. (Minneapolis, MN; starchtech.com): StarchTech is a global manufacturer of cornstarch-based loose fill packaging material produced from ReNew Resin.

USDA Rural Development Minnesota Office

Mary Colleen Landkamer, State Director (www.rd.usda.gov/mn)
375 Jackson Street, Suite 410, St. Paul, MN 55101-1853
Phone: (651) 602-7800

Mississippi

Total Jobs: 68,760
Direct Jobs: 40,350

Total Value Added: $4.730 Billion
Direct Value Added: $2.692 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	9,330	$610.9M
Biobased Chemicals	170	$44.9M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	29,400	$1.9B
Textiles	1,470	$84.0M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

16 Mississippi companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
SpillEater (Flora, MS; spilleater.com): SpillEater manufactures natural, biobased spill absorbents, produced from cotton plants. Absorbents are available for a number of classifications, including all-purpose, oil, acid, and bodily fluid. Market segments include retail, transportation, manufacturing, and government.

Biobased Chemicals
ALGIX (Meridian, MS; algix.com): A subsidiary of ALGIX, Solaplast harnesses the potential of algae to produce biobased plastics for the replacement of traditional, petroleum-based plastics. Algae is sourced from areas that have historically had algae problems, enhancing the waterway.

Forest Products
Magnolia Forest Products, Inc. (Terry, MS; magnoliaforest.com): Founded in 1976, Magnolia Forest Products is a national supplier of quality, low-cost wood products, including wooden pallet parts, plywood, particleboard, oriented strand board, and furniture parts.

USDA Rural Development Mississippi Office

Trina George, State Director (www.rd.usda.gov/ms)
Federal Building, Suite 831, 100 West Capitol Street, Jackson, MS 39269
Phone: (601) 965-4316

Missouri

Total Jobs: 54,760
Direct Jobs: 27,290

Total Value Added: $4.693 Billion
Direct Value Added: $2.506 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	4,460	$266.5M
Biobased Chemicals	450	$127.7M
Biorefining	< 50	< $5M
Enzymes	130	$28.6M
Forest Products	20,850	$2.1B
Textiles	1,780	$75.3M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

50 Missouri companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Gateway Foam Insulators (Warrenton, MO; gatewayfoam.com): Gateway Foam Insulators produces a soy-based spray foam insulation, BioBased 501, which exhibits the same air sealing capabilities as low-density polyurethanes, and is produced using soybean oil.

Soya Systems (Saint Louis, MO; soya.com): Soya Systems Products are the first shampoos and conditions in the world to contain hydrolyzed soya protein.

Bioplastic Bottles & Packaging
Biodegradable Food Service LLC (Richland, MO; earth-to-go.com): Biodegradable Food Service produces over 82 biobased, single-use food service products, in addition to eco-friendly lid options. Feedstock inputs include bamboo fibers, cornstarch, potato starch, as well as additional vegetable starches.

USDA Rural Development Missouri Office

Anita "Janie" Dunning, State Director (www.rd.usda.gov/mo)
601 Business Loop 70 West, Parkade Center, Suite 235, Columbia, MO 65203
Phone: (573) 876-0976

Montana

Total Jobs: 11,350
Direct Jobs: 6,340

Total Value Added: $674 Million
Direct Value Added: $3334 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,860	$75.0M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	4,280	$250.8M
Textiles	190	$5.6M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

10 Montana companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Blue Marble Biomaterials (Missoula, MT; bluemarblebio.com): Blue Marble Biomaterials manufactures complex chemical compounds using refined green chemistry processes. Organic biomass material, including food co-products, spent brewery grain, and wood chips, is utilized in the production of chemical products.

Botanie Soap Inc. (Missoula, MT; botaniesoap.com): Botanie Soap manufactures all-natural soap, utilizing basic organic ingredients. The company's base oil blend includes combinations of certified organic coconut, palm fruit, sunflower, and safflower oils.

Forest Products
Bitteroot Valley Forest Products (Missoula, MT; bvfpmontana.com): Bitteroot Valley Forest Products provides a large range of specialty wood products, including logs, timber, siding, and wood shavings. The company works to incorporate beetle-kill and standing dead wood in some of their product lines.

USDA Rural Development Montana Office

John Walsh, State Director (www.rd.usda.gov/mt)
2229 Boot Hill Court, Bozeman, MT 59715
Phone: (406) 585-2580

Nebraska

Total Jobs: 11,890
Direct Jobs: 6,020

Total Value Added: $895 Million
Direct Value Added: $426 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	830	$30.5M
Biobased Chemicals	130	$56.8
Biorefining	< 50	< $5M
Enzymes	120	$46.3M
Forest Products	4,650	$307.8M
Textiles	< 50	< $5M
Bioplastic Bottles & Packaging	360	$18.8M

BioPreferred®

23 Nebraska companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
The Clean Environment Company (Laurel, NE; cleanenvironmentco.com): The Clean Environment Company manufactures a variety of cleaning products produced from naturally derived, renewable ingredients. Product offerings include cleaners, solvents, and detergents.

Laurel BioComposite, LLC (Laurel, NE; laurelbiocomposite.com): Laurel BioComposite manufactures Bio-Res powder and pellets using distiller's grain. The powder and pellets can be blended with thermoplastics and thermosets in a variety of manufacturing applications, replacing petroleum-based resins at inclusion rates up to 40 percent in final products.

NatureWorks, LLC (Blair, NE; natureworksllc.com): NatureWorks is dedicated to driving environmental progress through developing the global market for biobased plastics and fibers. NatureWorks's manufacturing facility is located in Blair, Nebraska.

USDA Rural Development Nebraska Office

Maxine B. Moul, State Director (www.rd.usda.gov/ne)
Federal Building, Suite 308, 100 Centennial Mall North, Lincoln, NE 68508-3859
Phone: (402) 437-5551

Nevada

Total Jobs: 7,130
Direct Jobs: 3,840

Total Value Added: $515 Million
Direct Value Added: $229 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	300	$6.3M
Biobased Chemicals	< 50	$5.5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	3,110	$193.9M
Textiles	390	$22.4M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

14 Nevada companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Aervoe Industries Inc. (Gardnerville, NV; aervoe.com): Aervoe Industries manufactures paints, cleaners, lubricants, and other industrial products and aims to meet strict environmental requirements and specifications. Several products made by Aervoe Industries contain biobased materials.

Bio Pac Inc. (Incline Village, NV; bio-pac.com): Bio Pac produces an assortment of biodegradable cleaning products. Available offerings include dishwashing products, laundry products, household cleaning supplies, and hand and body wash. All products are void of petroleum distillates, dyes, perfumes, and chlorine.

Enzymes
Bio-Pure Products Inc. (Minden, NV; biopureproducts.com): Bio-Pure Products provides microbiology-based on-site organic waste management solutions for many industries. All products intend to replace dangerous chemicals with a unique combination of living microbes and enzymes, which together act to break down and digest organic waste.

USDA Rural Development Nevada Office

Sarah Jose Mersereau-Adler, State Director (www.rd.usda.gov/nv)
1390 South Curry Street, Carson City, NV 89703-9910
Phone: (775) 887-1222

New Hampshire

Total Jobs: 13,480
Direct Jobs: 7,090

Total Value Added: $939 Million
Direct Value Added: $404 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,840	$81.4M
Biobased Chemicals	< 50	$7.6M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	4,110	$240.3M
Textiles	1,080	$71.7M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

18 New Hampshire companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Ink Mill (Sanbornton, NH; inkmillcorp.com): Ink Mill manufactures premium quality digital inks, including a line of inks produced with natural materials called, BTW BioSolvent Ink.

Forest Products
WE Cork, Inc. (Exeter, NH; wecork.com): For more than 100 years, WE Cork has offered an array of all-natural products derived from the bark of cork trees. Product offerings include flooring, expansion joints, insulation corkboard, and composition cork.

Bioplastic Bottles & Packaging
Stonyfield Farms, Inc. (Londonderry, NH; stonyfield.com): Stonyfield Farms, the world's largest organic yogurt producer, uses biobased plastic for its multipack yogurt cups. As a result, the company lowered its carbon emissions from packaging by 48 percent.

USDA Rural Development New Hampshire Office

Ted Brady, State Director (www.rd.usda.gov/nh)
87 State Street Suite 324, P.O. Box 249, Montpelier, VT 05601
Phone: (802) 828-6000

New Jersey

Total Jobs: 47,390
Direct Jobs: 21,950

Total Value Added: $4.541 Billion
Direct Value Added: $1.878 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,280	$38.8M
Biobased Chemicals	770	$215.1M
Biorefining	< 50	< $5M
Enzymes	150	$35.3M
Forest Products	16,660	$1.4B
Textiles	3,560	$205.7M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

60 New Jersey companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
AVEENO Active Naturals (Skillman, NJ; aveeno.com): Aveeno's Active Naturals brand uses a number of renewable, natural ingredients, including oat, soy, blackberry, and wheat. The company offers several skin, beauty, and hair care products.

Ingredion Incorporated (Bridgewater, NJ; ingredion.com): Ingredion has been a recognized leader in biomaterial innovation and application development since 1895. Biobased ingredients derived from feedstocks such as corn, tapioca, and potatoes, are used in a number of industry sectors, including personal care, household and fabric care, and biobased plastics.

National Bio+GreenSciences (Branchburg, NJ; biogreencrystals.com): National Bio+GreenSciences offers the world's first nutraceutical grade, zero waste, earth friendly product line of cleaning supplies, formulated with plant- and mineral-based ingredients.

USDA Rural Development New Jersey Office

Howard Henderson, State Director (www.rd.usda.gov/nj)
5th Floor North, Suite 500, 8000 Midlantic Drive, Mt. Laurel, NJ 08054
Phone: (856) 787-7700

New Mexico

Total Jobs: 6,630
Direct Jobs: 4,210

Total Value Added: $389 Million
Direct Value Added: $208 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,120	$53.1M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	2,740	$140.5M
Textiles	310	$12.0M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

8 New Mexico companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
BioShield Paint Company (Santa Fe, NM; bioshieldpaint.com): BioShield Paint Company manufactures a variety of paints, stains, thinners, and waxes, all of which are primarily produced from naturally derived raw materials such as citrus peel extracts, essential oils, seed oils, tree resins, and natural pigments.

Private Label Select (Ranchos de Taos, NM; privatelabelselect.com): Private Label Select manufactures lip balms, lip tints, glosses, and other high-quality personal care and cosmetics products. A pioneer in the natural and organic cosmetics industry, its manufacturing facilities were some of the first USDA certified organic.

Forest Products
Albuquerque Hardwood Lumber Company (Albuquerque, NM; abqhardwoods.com): Albuquerque Hardwood Lumber Company is the premier supplier of quality hardwood products in the southwestern US. In addition to lumber options, the company also offers wood panel products.

USDA Rural Development New Jersey Office

Terrence Brunner, State Director (www.rd.usda.gov/nm)
6200 Jefferson Street, Room 255, Albuquerque, NM 87109
Phone: (505) 761-4950

New York

Total Jobs: 100,630
Direct Jobs: 52,300

Total Value Added: $9.236 Billion
Direct Value Added: $3.848 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	4,450	$170.0M
Biobased Chemicals	720	$237.7M
Biorefining	< 50	< $5M
Enzymes	120	$33.6M
Forest Products	36,130	$2.6B
Textiles	11,260	$828.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

83 New York companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
AnelloTech (Pearl River, NY; anellotech.com): AnelloTech produces cost-competitive renewable chemicals form non-food biomass feedstocks. These chemicals can be used in a number of consumer goods, including beverage bottles, automotive and electronic components, clothing, footwear, and carpeting.

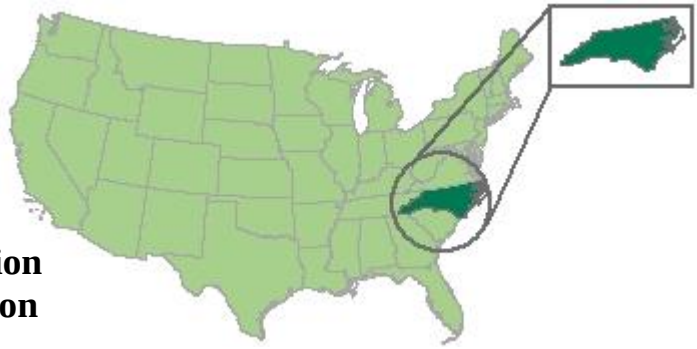
Forest Products
Ecovative (Green Island, NY; ecovativedesign.com): Ecovative is a leading biobased materials company, with products that span a range of applications, from furniture to packaging and insulation. Myco Board, one product offering, is a certified sustainable, engineered wood, which can be molded into desired shapes and designs.

Textiles
Carnegie Fabrics (Rockville, NY; carnegiefabrics.com): In 2013, Carnegie Fabrics introduced Xorel, the world's first and only biobased high performance interior textile. This line of fabrics is sourced from sugarcane plants and has a biobased content range from 60 to 85 percent.

USDA Rural Development New York Office

Scott Collins, Acting State Director (www.rd.usda.gov/ny)
The Galleries of Syracuse, 441 South Salina Street, Suite 357, Syracuse, NY 13202-2541
Phone: (315) 477-6400

North Carolina



Total Jobs: 179,380
Direct Jobs: 90,040

Total Value Added: $13.631 Billion
Direct Value Added: $6.437 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	9,410	$625.9M
Biobased Chemicals	860	$349.8M
Biorefining	< 50	< $5M
Enzymes	210	$103.6M
Forest Products	61,930	$4.3B
Textiles	17,870	$1.1B
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

61 North Carolina companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Enzymes
Novozymes North America (Franklinton, NC; novozymes.com): Novozymes is the world leader in biobased innovation, advancing both the biofuel and renewable chemical industries. Manufactured products include industrial enzymes, microorganisms, and biopharmaceutical ingredients.

Textiles
Cotton Incorporated (Cary, NC; cottoninc.com): Cotton Incorporated is the research and marketing company representing upland cotton. The company focuses its efforts in three key areas: fiber processing, product development and trend analysis, and dyeing and finishing.

Bioplastic Bottles & Packaging
Earth Renewable Technologies, Inc. (Brevard, NC; earthrenewable.com): Earth Renewable Technologies uses various plant-based resins, in conjunction with their patent pending, biobased microfiber-additive packaging, to produce superior plant-based alternatives to traditional plastic packaging. Feedstock sources include sugarcane and sugar beets.

USDA Rural Development North Carolina Office

Randall A. Gore, State Director (www.rd.usda.gov/nc)
4405 Bland Road, Suite 260, Raleigh, NC 27609
Phone: (919) 873-2000

North Dakota

Total Jobs: 5,600
Direct Jobs: 3,360

Total Value Added: $429 Million
Direct Value Added: $238 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	470	$21.1M
Biobased Chemicals	< 50	$5.1M
Biorefining	< 50	$5.8M
Enzymes	< 50	< $5M
Forest Products	2,740	$200.8M
Textiles	120	$6.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

5 North Dakota companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Bison Forest Products LLC (Fargo, ND; bisonforestproducts.com): Bison Forest Products is a wholesale lumber supplier. In addition to its lumber offerings, the company provides quality wheat and barley straw.

Forest Products
Weekes Forest Products, Inc. (Fargo, ND; weekesforest.com): Weekes is the leading distributor of specialty building materials, commodity lumber, engineered wood components, and industrial materials. Among its specialty product offerings, Eco-Side is a 100 percent recycled, ecologically friendly siding option.

USDA Rural Development North Dakota Office

Ryan Taylor, State Director (www.rd.usda.gov/nd)
Federal Building, Room 208, P.O. Box 1737, 220 East Rosser, Bismarck, ND 58502-1737
Phone: (701) 530-2037

Ohio

Total Jobs: 117,370
Direct Jobs: 52,930

Total Value Added: $9.730 Billion
Direct Value Added: $4.277 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	3,500	$165.5M
Biobased Chemicals	1,310	$443.6M
Biorefining	< 50	< $5M
Enzymes	180	$4.4M
Forest Products	45,260	$3.5B
Textiles	3,070	$192.0M
Bioplastic Bottles & Packaging	100	$8.5M

BioPreferred®

92 Ohio companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Arizona Chemical (Dover, OH; arizonachemical.com): Arizona Chemical is the world's leading producer and biorefiner of pine chemicals. The company provides innovative, biobased chemical solutions to multiple industry sectors, including adhesives, roads and construction, tires, and coatings. Approximately 85 percent of the company's raw materials are from renewable sources.

Procter & Gamble (Cincinnati, OH; us.pg.com): Tide, a Procter & Gamble brand, recently launched the first biobased detergent, Tide purclean. The detergent is comprised of 65 percent biobased ingredients and aims to set the performance standard for natural detergents.

Renewable Lubricants (Hartville, OH; renewablelube.com): Renewable Lubricants is the world's leading developer and manufacturer of high-performance, biobased lubricants, producing utilizing soy, corn, canola, sunflower, and other biomaterials. The company offers more than 250 biobased and biodegradable products.

USDA Rural Development Ohio Office

Tony Logan, State Director (www.rd.usda.gov/oh)
Federal Building, Room 507, 200 North High Street, Columbus, OH 43215-2418
Phone: (614) 255-2400

Oklahoma

Total Jobs: 21,550
Direct Jobs: 10,320

Total Value Added: $1.960 Billion
Direct Value Added: $995 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	2,790	$138.1M
Biobased Chemicals	100	$40.5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	7,000	$773.2M
Textiles	730	$63.6M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

8 Oklahoma companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Envia Energy (Oklahoma City, OK; enviaenergy.com): Envia Energy uses the latest developments in gas processing and Fischer-Tropsch technology to create high purity synthetic fuels and chemicals. Methane captured from landfills is used as a feedstock.

Forest Products
Forest Products Supply Co. (Oklahoma City, OK; fp-supply.com): Forest Products Supply is a leading wholesale distributor of lumber and building materials in the Midwest. Product offerings consist of over 2,500 products, ranging from general commodities to specialty products.

TO MARKET (Oklahoma City, OK; tomkt.com): TO MARKET prides itself on bringing alternative materials for interior paces to the commercial marketplace, designing and selling commercial flooring. Flooring products are manufactured utilizing recycled and sustainable content, including rubber and cork.

USDA Rural Development Oklahoma Office

David Ryan McMullen, State Director (www.rd.usda.gov/ok)
100 USDA, Suite 108, Stillwater, OK 74074-2654
Phone: (405) 742-1000

Oregon

Total Jobs: 92,520
Direct Jobs: 46,480

Total Value Added: $7.798 Billion
Direct Value Added: $4.159 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	13,460	$1.1B
Biobased Chemicals	90	$17.5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	31,700	$3.0B
Textiles	1,230	$50.8M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

49 Oregon companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Trellis Earth Products (Wilsonville, OR; trellisbioplastic.com): Trellis Bioplastics creates a range of biobased plastic resins and consumer products in efforts to replace traditional plastics. Trellis Earth branded food service disposables are currently the leading industry solution for "greening" the take-out food service sector.

Forest Products
DR Johnson Lumber (Riddle, OR; drjlumber.com): DR Johnson is the first APA/ANSI certified manufacturer for cross-laminated timber (CLT) in the U.S.

SierraPine (Medford, OR; sierrapine.com): SierraPine is North America's leading manufacturer of medium density fiberboard (MDF) and particleboard, which are used in a variety of applications including furniture, cabinetry, wall panels, shelving, and doors. SierraPine produces MDF and particleboard from recycled or recovered wood fiber and adhesives.

USDA Rural Development Oregon Office

Vicki L. Walker, State Director (www.rd.usda.gov/or)
1220 SW 3rd Avenue, Suite 1801, Portland, OR 97204
Phone: (503) 414-3300

Pennsylvania

Total Jobs: 151,090
Direct Jobs: 71,360

Total Value Added: $13.667 Billion
Direct Value Added: $6.522 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	6,860	$309.2M
Biobased Chemicals	820	$170.5M
Biorefining	< 50	< $5M
Enzymes	170	$52.7M
Forest Products	58,790	$5.8B
Textiles	5,370	$267.3M
Bioplastic Bottles & Packaging	70	$6.6M

BioPreferred®

79 Pennsylvania companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Armstrong World Industries (Lancaster, PA; armstrong.com): In response to increased market demand for non-PVC flooring products, Armstrong Flooring created a bio-flooring line that is made with 85 percent limestone and BioStride, a patented biobased polyester binder that is partly comprised of domestically produced corn.

Houghton International, Inc. (Norristown, PA; houghtonintl.com): Houghton International produces a variety of specialty chemicals, oils, and lubricants. The company has two hydraulic fluids that are USDA Certified Biobased Products and are derived from vegetable oil-based feedstocks.

Sun and Earth, Inc. (King of Prussia, PA; sunandearth.com): Sun and Earth has been producing non-toxic, all-natural cleaning supplies since 1988. In lieu of petroleum-based materials, the company produces products via plant-based, naturally derived ingredients.

USDA Rural Development Pennsylvania Office

Thomas P. Williams, State Director (www.rd.usda.gov/pa)
359 East Park Drive, Suite 4, Harrisburg, PA 17111-2747
Phone: (717) 237-2299

Rhode Island

Total Jobs: 6,670
Direct Jobs: 3,500

Total Value Added: $522 Million
Direct Value Added: $228 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	150	< $5M
Biobased Chemicals	70	$9.6M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	2,190	$158.5M
Textiles	1,100	$56.0M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

5 Rhode Island companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Spectral Chemical Co., Inc. (Warwick, RI; spectralchemical.com): Spectral Chemical Company offers a range of chemical and cleaning products, some of which are biobased products produced from soy-based feedstocks.

Toray Plastics, Inc. (North Kingston, RI; toraytpa.com): Toray Plastics is the only U.S. manufacturer of polypropylene, polyester, metallized, and biobased films. The company developed a biobased bio-axially oriented polyester film that is utilized in the manufacturing process of solar control window films for commercial and residential applications.

USDA Rural Development Rhode Island Office

Scott Soares, State Director (www.rd.usda.gov/ct)
451 West Street, Amherst, MA 01002-2999
Phone: (413) 253-4300

South Carolina

Total Jobs: 82,670
Direct Jobs: 38,430

Total Value Added: $7.448 Billion
Direct Value Added: $4.227 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	6,870	$449.0M
Biobased Chemicals	560	$152.1M
Biorefining	< 50	< $5M
Enzymes	< 50	$5.1M
Forest Products	22,930	$3.0B
Textiles	8,370	$640.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

15 South Carolina companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Ingevity (North Charleston, SC; ingevity.com): Ingevity manufactures specialty chemicals and high-performance carbon materials. Ingevity's biobased product offerings create value for many industries, including wood coatings, plastic stabilizers, mining, and specialty additives.

Sorbent Green LLC (Aiken, SC; greensorb.com): Sorbent Green develops, manufactures, and distributes biobased products for industrial and commercial applications. The biobased solvents offered are readily biodegradable, with zero volatile organic compounds.

Forest Products
Domtar (Fort Mill, SC; domtar.com): In addition to being a global leader in pulp production, Domtar is also North America's largest producer of uncoated freesheet paper. Domtar is committed to using fiber from responsibly managed sources, and was an early supporter of the Forest Stewardship Council.

USDA Rural Development South Carolina Office

Michele Cardwell, State Director (www.rd.usda.gov/sc)
Strom Thurmond Federal Building, 1835 Assembly Street, Room 1007, Columbia, SC 29201
Phone: (803) 765-5163

South Dakota

Total Jobs: 10,790
Direct Jobs: 6,160

Total Value Added: $677 Million
Direct Value Added: $332 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	670	$35.2M
Biobased Chemicals	< 50	$13.3M
Biorefining	< 50	< $5M
Enzymes	< 50	$9.7M
Forest Products	5,230	$274.7M
Textiles	240	$11.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

11 South Dakota companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Ultra Green Floor Sweep (Platte, SD; ultragreenfloorsweep.com): Ultra Green Floor Sweep produces an all-natural sweeping compound, which can be used to shine floors without the need for any water.

Biorefining
POET Biorefining (Chancellor, SD; poet.com): The POET Biorefining facility in Chancellor, the largest of the POET plants, processes 110 million gallons of ethanol each year. POET INVIZ zein, a natural, non-toxic edible protein product is extracted from the ethanol fermentation process and used as a biobased alternative for a number of industrial applications.

Forest Products
Pure Pulp Products (Plankinton, SD; purepulpproducts.com): Pure Pulp Products utilizes biomass waste as a sustainable substrate for packaging. Post-industrial waste from corrugated box manufacturing is re-purposed to create fiber that can be turned into an array of products, including food service plates and bowls, trays, and clamshells.

USDA Rural Development South Dakota Office

Bruce Jones, Acting State Director (www.rd.usda.gov/sd)
Federal Building, Room 210, 200 Fourth Street, SW, Huron, SD 57350
Phone: (605) 352-1100

Tennessee

Total Jobs: 100,980
Direct Jobs: 44,850

Total Value Added: $8.981 Billion
Direct Value Added: $4.430 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	5,890	$322.2M
Biobased Chemicals	720	$174.9M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	33,990	$3.7B
Textiles	4,320	$223.1M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

27 Tennessee companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Colonial Chemical (Pittsburg, TN; colonialchem.com): Colonial Chemical is an industry forerunner in the development and manufacture of products that are derived from renewable ingredients. Products include cosmetic and industrial surfactants, performance additives, and key building-block ingredients for use in personal care, household, industrial, lubrication, and oilfield applications.

DuPont Tate & Lyle (Loudon, TN; tateandlyle.com): DuPont's facility in Loudon was the first to produce commercial shipments of Bio-PDO, thereby creating a renewably sourced ingredient for biobased fibers. Bio-PDO can be used in cosmetics, apparel, and industrial applications.

Forest Products
International Paper (Memphis, TN; internationalpaper.com): International Paper is a global leader in packaging and paper. Ecotainer packaging is a compostable solution for single-use packaging that is produced entirely from renewable resources.

USDA Rural Development Tennessee Office

Bobby Mack Goode, State Director (www.rd.usda.gov/tn)
3322 West End Avenue, Suite 300, Nashville, TN 37203-1071
Phone: (615) 783-1300

Texas

Total Jobs: 178,480
Direct Jobs: 88,680

Total Value Added: $15.228 Billion
Direct Value Added: $6.828 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	24,440	$1.7B
Biobased Chemicals	1,680	$471.3M
Biorefining	< 50	$5.4M
Enzymes	350	$101.2M
Forest Products	57,020	$4.4B
Textiles	6,750	$253.1M
Bioplastic Bottles & Packaging	60	$5.6M

BioPreferred®

136 Texas companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
DSI Ventures, Inc. (Tyler, TX; dsiventures.com): DSI offers a comprehensive line of eco-friendly, biodegradable lubricant solutions. Feedstocks for the biobased lubricants include vegetable and citrus oils.

Samsill Corporation (Fort Worth, TX; samsill.com): Samsill Corporation manufactures business accessories and office supplies. The company's Earth's Choice™ Biobased binders are made using a biobased intermediate, and the binders are USDA Certified Biobased Products.

Bioplastic Bottles & Packaging
Accredo Packaging, Inc. (Sugar Land, TX; accredopackaging.com): Using renewably sourced resin from sugarcane feedstock, Accredo successfully pioneered sustainably produced packaging with a renewable content. The renewable packaging is predominantly used for the pre-packaged foods and consumer products markets.

USDA Rural Development Texas Office

Paco Valentin, State Director (www.rd.usda.gov/tx)
Federal Building, Suite 102, 101 South Main Street, Temple, TX 76501
Phone: (254) 742-9700

Utah

Total Jobs: 21,980
Direct Jobs: 10,770

Total Value Added: $1.825 Billion
Direct Value Added: $963 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	610	$12.9M
Biobased Chemicals	90	$32.4M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	9,140	$896.6M
Textiles	980	$28.7M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

11 Utah companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Prolix (West Jordan, UT; prolixlubricant.com): Prolix offers a biodegradable, non-petroleum based solvent/lubricant for firearms. The product can also be used to clean clocks, bike chain, knives, vehicle locks, lawn and garden equipment, and musical instruments.

Forest Products
Intermountain Wood Products (St. George, UT; Salt Lake City, UT; intermountainwood.com): Intermountain Wood Products offers a complete selection of wood products, including cabinet, casework, millwork, and flooring. In addition to using reclaimed wood, the company is also certified by the Forest Stewardship Council.

National Wood Products, Inc. (Salt Lake City, UT; nationalwood.com): National Wood Products is a multi-product, multi-location building products distributor. The company offers a range of lumber, plywood, and flooring products.

USDA Rural Development Utah Office

Wilson "David" Conine, State Director (www.rd.usda.gov/ut)
Wallace F. Bennett Federal Building, 125 South State Street, Room 4311, Salt Lake City, UT 84138
Phone: (801) 524-4321

Vermont

Total Jobs: 11,420
Direct Jobs: 6,500

Total Value Added: $630 Million
Direct Value Added: $278 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,820	$53.9M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	4,390	$213.9M
Textiles	280	$7.6M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

9 Vermont companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Currier Forest Products (Danville, VT; currierforestproducts.com): Currier Forest Products is a Forest Stewardship Council certified Chain of Custody supplier of custom sawn forest products, including an array of flooring, timber, and lumber products.

The A. Johnson Co. (Bristol, VT; vermontlumber.com): The A. Johnson Co. produces an array of flooring, paneling, and lumber products. Timber is harvested in accordance with the guidelines of the Sustainable Forestry Initiative.

Biobased Chemicals
Seventh Generation (Burlington, VT; seventhgeneration.com): Seventh Generation was one of the first recipients of the USDA BioPreferred Program's certification label. The company boasts a number of plant-based offerings, including disinfectants, hand soaps, laundry supplies, and surface cleaners.

USDA Rural Development Vermont Office

Ted Brady, State Director (www.rd.usda.gov/vt)
87 State Street Suite 324, P.O. Box 249, Montpelier, VT 05601
Phone: (802) 828-6080

Virginia

Total Jobs: 75,540
Direct Jobs: 38,920

Total Value Added: $6.456 Billion
Direct Value Added: $3.145 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	5,750	$309.0M
Biobased Chemicals	460	$135.9M
Biorefining	< 50	< $5M
Enzymes	50	$15.3M
Forest Products	29,430	$2.3B
Textiles	3,730	$401.9M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

45 Virginia companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Earth Friendly Chemicals (Virginia Beach, VA; efchem.com): Earth Friendly Chemicals manufactures "green" chemistry products valued by many markets seeking 100 percent biodegradable and non-toxic products. Biobased product offerings include residential and commercial cleaners, as well as industrial degreasers.

Forest Products
Blue Ridge Fiberboard (Danville, VA; blueridgefiberboard.com): Blue Ridge Fiberboard products are composed of all-natural, earth-friendly wood chips. The binding agent utilized in the manufacturing process is also all-natural, consisting of vegetable starch that contains no added formaldehydes.

uDo Inc. (Arlington, VA; udobrush.com): uDo manufactures eco-friendly, bamboo-handled toothbrushes that are 92 percent biobased.

USDA Rural Development Virginia Office

Basil I. Gooden, PHD, State Director (www.rd.usda.gov/va)
Culpeper Building, Suite 238, 1606 Santa Rosa Road, Richmond, VA 23229
Phone: (804) 287-1550

Washington

Total Jobs: 82,640
Direct Jobs: 41,140

Total Value Added: $7.867 Billion
Direct Value Added: $3.808 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	11,180	$890.2M
Biobased Chemicals	130	$23.3M
Biorefining	< 50	< $5M
Enzymes	< 50	$6.9M
Forest Products	27,780	$2.8B
Textiles	2,080	$89.2M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

175 Washington companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
WISErg Corporation (Redmond, WA; wiserg.com): WISErg harvests food scraps and turns them into fertilizer. The company sells Harvester machines in which the waste is collected and the resulting fertilizer products.

Forest Products
Weyerhaeuser NR Company (Federal Way, WA; woodbywy.com): Weyerhaeuser makes construction products such as lumber, oriented strand board, and joists. Sustainability policies adopted by Weyerhaeuser include using third-party certifications such as the Sustainable Forestry Initiative (SFI) and the ISO 14001 Environmental Management System.

Bioplastic Bottles & Packaging
Grow Plastics, Inc. (Bothell, WA; growplastics.com): Grow Plastics currently utilizes NatureWorks's Ingeo biobased polymer to produce a variety of biobased plastic products. With an ability to produce nearly any shape or size, Grow Plastic offers a number of custom options

USDA Rural Development Washington Office

Mario Villanueva, State Director (www.rd.usda.gov/wa)
1835 Blacklake Boulevard SW, Suite B, Olympia, WA 98512-5715
Phone: (360) 704-7740

West Virginia

Total Jobs: 17,490
Direct Jobs: 9,960

Total Value Added: $1.107 Billion
Direct Value Added: $601 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	1,920	$89.1M
Biobased Chemicals	210	$45.5M
Biorefining	< 50	< $5M
Enzymes	< 50	$6.5M
Forest Products	7,660	$463.8M
Textiles	200	$5.5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

One West Virginia company currently participates in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
AFP Lumber & Logs, LLC (Buckhannon, WV; afpcorp.com): AFP is a leading global provider of high-quality hardwood forest products, offering an array of lumber, timber, and forest products.

Allegheny Wood Products (Petersburg, WV; alleghenywood.com): Allegheny Wood Products offers a variety of wood products, suitable for the manufacturing of cabinets, flooring, furniture, moldings, and millwork. All of the company's facilities are Forest Stewardship Council Chain of Custody certified.

Forest Products
Carter Lumber (Ripley, WV; Parkersburg, WV; New Martinsville, WV; carterlumber.com): Carter Lumber, with three locations in West Virginia, is one of the nation's largest building materials suppliers, with product offerings including building supplies, lumber, flooring, and siding.

USDA Rural Development West Virginia Office

Robert Lewis, State Director (www.rd.usda.gov/wv)
1550 Earl Core Road, Suite 101, Morgantown, WV 26505
Phone: (304) 284-4860

Wisconsin

Total Jobs: 160,010
Direct Jobs: 68,250

Total Value Added: $13.542 Billion
Direct Value Added: $6.252 Billion

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	5,280	$202.5M
Biobased Chemicals	470	$136.5M
Biorefining	< 50	< $5M
Enzymes	130	$25.4M
Forest Products	60,760	$5.8B
Textiles	1,710	$112.1M
Bioplastic Bottles & Packaging	80	$6.7M

BioPreferred®

72 Wisconsin companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Biobased Chemicals
Virent (Madison, WI; virent.com): Virent converts soluble, biomass-derived sugars into products molecularly identical to those made with petroleum. Among its product offerings, Virent manufactured the first ever bio-polyester shirt produced from 100 percent renewable resources.

Enzymes
Enviro-Zyme International, LLC (Beloit, WI; envirozyme.com): Enviro-Zyme offers an assortment of products and services for residential, commercial, and industrial cleaning. Products are made with naturally occurring microbes.

Bioplastic Bottles & Packaging
Plastic Ingenuity (Cross Plains, WI; plasticingenuity.com): Plastic Ingenuity is one of the largest custom thermoformers in North America, offering packaging solutions that encompass every stage of packaging design and manufacturing. The Plastic Ingenuity team created new thermoforming methods that incorporate wood pulp into the packaging material, in addition to producing corn-based polylactic acid materials.

USDA Rural Development Wisconsin Office

Stan Gruszynski, State Director (www.rd.usda.gov/wi)
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Wyoming

Total Jobs: 2,350
Direct Jobs: 1,610

Total Value Added: $117 Million
Direct Value Added: $58 Million

The total jobs or value added is the sum of the direct, indirect, and induced effects.

Sector	Direct Jobs	Direct Value Added
Agriculture & Forestry	480	$13.6M
Biobased Chemicals	< 50	< $5M
Biorefining	< 50	< $5M
Enzymes	< 50	< $5M
Forest Products	1,020	$36.5M
Textiles	110	< $5M
Bioplastic Bottles & Packaging	< 50	< $5M

BioPreferred®

7 Wyoming companies currently participate in the BioPreferred Program.

Example Biobased Product Firms

Agriculture & Forestry
Bearlodge Forest Products, Inc. (Hulett, WY; bearlodgeforestproducts.com): Bearlodge Forest Products offers an array of wood products, including pallets, timber, lumber, and pellets and is certified with Timber Products Inspection.

Natures Composites (Torrington, WY; naturescomposites.com): Natures Composites manufactures sustainable, high-performing composite products, including fencing, decking, landscaping, lumber, and other composite building materials, produced from recycled high-density polyethylene reinforced with wheat straw cellulose.

Teton West Lumber Company (Cheyenne, WY; tetonwest.com): Teton West Lumber is committed to the health of Wyoming's forests by processing, and repurposing, beetle kill pine into useable lumber products, for both residential and commercial buildings.

USDA Rural Development Wyoming Office

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C1. Case Study: Michigan Biotechnology Institute

The Michigan Biotechnology Institute (MBI) was founded by the State of Michigan in the 1980s to help encourage start-ups in the biobased products industry with the goal of diversifying the State's economy away from the struggling automotive industry. According to Dr. Susanne Kleff, a biologist with a background in metabolic engineering who joined MBI 20 years ago, MBI's mission matured over the years to provide a not-for-profit entity that offered custom-tailored solutions to advance new biobased technologies for its own government-funded technologies and collaboratively for other companies all over the world.

MBI houses fermenters that range from lab-scale up to 1,000 gallons, and they provide the ability to manufacture products in the volumes required to support pre-commercial product development, application testing, and routine production. A general rule of thumb in the biobased products industry is that production at the 1,000-gallon scale identifies the technology's problems and demonstrates its robustness and viability. Other similar facilities in the United States have fermentation capacities in the range of 50 - 200 gallons.

MBI has developed successful technologies of its own, such as processes for organic acid production, and its current focus is on ammonium fiber expansion technologies (AFEX™), but these technologies failed to use the pilot facility at its full potential. This led to MBI's offering to collaboratively advance and scale-up technologies for and with other companies worldwide. Many well-known companies that have biobased capabilities have worked with MBI, including Genomatica, Bolt Threads, DuPont, OPX BIO (acrylic acids), Novozymes, Tepha Medical Devices, and others. Over the past six years, MBI had a 100 percent success rate in technology scale-up.

Very recently, the Process Development and Scale-up Branch of MBI joined Michigan State University's Bioeconomy Institute (MSU-BI) and its sister facility in Holland, Michigan, to expand its downstream processing capabilities. The Holland plant was an old Pfizer pharmaceutical production facility, and it is capable of downstream recovery and chemical extractions. This addition of a chemical pilot plant to the fermentation facility in Lansing provides a unique set of scaling capabilities that is unparalleled in the United States.

Dr. Kleff explained that the process of taking a new product from an idea or concept to commercialization encompasses many hurdles that many start-up entrepreneurs are not aware of, "We had startups who came to us with ideas, but they have only produced their products in shakeflasks or two-liter fermenters. They come to us at a stage where they need to be able to produce a material for application testing, which means they need larger scale fermenters. Acquiring or constructing a facility of their own with larger fermenters would be time consuming, and would

require substantial additional funding to demonstrate whether the technology is scalable and viable. An organism may be sensitive to the differences in pressure, gas exchange rates, or mixing times at the larger scale. This is essentially the "de-risking" process, to ensure the technology can be scaled. Our team is also able to work with the start-up on the economics of the technology and can provide realistic feedback. Most of the people who come to us know the targets they have to achieve."

MBI also receives grants for some of its technologies. Nevertheless, MBI requires that startups that wish to run product scale-ups in its facility must do so on a fee-for-service basis. Today, representatives from MBI attend meetings seeking contacts, but they indicated that many of their clients approach them after others have recommended them. MBI provides both the facilities and skilled staff members who are well trained and very familiar with fermentation and recovery processes. This provides start-ups with a much lower cost alternative to building their own pilot facilities. Dr. Kleff observed that very few of the companies who come to MBI have the capital to build a platform for a new facility that often requires full capacity utilization to make it economical. As noted above, MBI does not limit itself to supporting only Michigan companies, but it works with many companies throughout the United States (e.g., Bolt Threads in California), and has also begun working with companies from Europe and Asia.

Dr. Kleff emphasized that, given the current low prices of oil, it is important for the biobased products industry to move away from commodity chemicals and focus on the specialty chemicals sector.

C2. Case Study: Agricultural Utilization Research Institute (AURI)

The Agricultural Utilization Research Institute (AURI) helps develop new uses for agricultural products through science and technology, and it collaborates with businesses and entrepreneurs to bring ideas to reality. AURI was founded by the State of Minnesota to help businesses take advantage of innovative opportunities in four areas: biobased products, renewable energy, coproducts, and food.

AURI has three laboratories located in Crookston, Marshall, and Wauseca, MN. AURI also works closely with the faculty at the University of Minnesota. AURI does not engage in research itself, they provide the space and opportunity for entrepreneurs and other scientists to do research. Researchers conduct applied research on new ideas, which leads to products and businesses that can grow in the State of Minnesota. A significant part of the activity done by AURI involves program evaluation to ensure that the institute is effective. The group also has a Director of Innovation and Commercialization who involves project managers and directors across a variety of innovation networks. AURI intends to make the results of applied research available to businesses and to work with entrepreneurs to facilitate product formulation, troubleshooting, scale-up, and commercialization. Most of AURI's activity involves working side by side with clients in the field, helping them find resources to bring their ideas to market, and helping them network with other providers in the industry.

AURI receives 80 percent of its funding from the State of Minnesota, which is augmented by contributions from a private foundation, research and promotion councils, and some Federal funding. The State of Minnesota is committed to finding new alternative product channels for the agricultural communities, and this funding is seen as being vital for the growth of the biobased products industry in Minnesota. AURI provides assistance, but it does not take equity or intellectual property positions on the projects, even though it has been named on several patents. The bulk of the AURI's work is simply to help businesses move from the laboratory scale to commercialization.

AURI has developed some laboratory space that it has made available to entrepreneurs to conduct early work on formulations. In the early stages of chemical development, there is a need to develop formulations and develop the intellectual property that will enhance the ability to get venture capital funding.

The biobased products facility is intended for use in processing agricultural commodities and co-products at the scale of 1 to 10 kg. Processes have been developed and demonstrated for producing increased value materials by fractionation, chemical conversion, and purification. Key processes that can be piloted include:

- Chemical processing of straw, stover, and other biomass materials
- Extraction and characterization of oils and high-value components from oilseed meal and other feedstocks

- Transesterification and esterification reactions for demonstration of biodiesel processing
- Small-scale fermentation and digestion processes for the production of fuels
- Distillation and evaporation for process development

The laboratory will host an "entrepreneur in residence", i.e., someone occupies laboratory space when it becomes available. The laboratory space is free of charge, and some analytical work will be provided for the entrepreneur. There may be scientific support as well. A representative noted that some entrepreneurs need R&D assistance beyond the capacity and experience of AURI. To help them, AURI has additional paid assistance available for different R&D efforts.

The process typically starts with a meeting between the entrepreneur and AURI staff, who will get a feel for the business, the concept, and what the entrepreneur is hoping to achieve. This can lead to a deeper conversation concerning AURI's services and programs and to the development of a team to assist with the client's concept. In one case, a client sought to add fibers to plastics to strengthen the material so it would qualify for Leadership in Energy and Environmental Design (LEED) construction:

We brought in different partners to help with funding the R&D that was needed, and we brought in partners who provided $200K. We helped connect them to potential users of the plastics in window manufacturing. We are committed to helping them in the idea stage and through research and prototype partners along the path to commercialization.

According to AURI staff members, there are only two criteria that must be met to qualify for these services. First, the product must fit into an area of service that requires the use of an agricultural commodity. Second, the science must be sound. The business must consider the competition and early discussions may involve evaluating the concept against the reality of the market through industry contacts. The idea must be technical viable and have and opportunities in the market before making further investments in the idea.

AURI also provides consulting to give business insight into other entities that should be part of the new business venture team. The Institute helps identify locations for commercialization and locations where contract packers can provide support. Moreover, the AURI provides introductions to a network of subject matter experts. For instance, the group will host Innovation Networks that focus on a supply net for a particular technology. AURI has held forums on paint stripping materials, duct coatings, and other areas. Users, vendors, and potential users are invited for half a day to share their experiences and to promote discussion. Individuals learn from the presenters, but there also are one-on-one conversations and product demonstrations.

As outlined in its annual report, AURI believes that the "Commercialization Chain" is very important to developing technologies. This is essential in creating a "technology cluster", which is a group of enterprises with common sets of knowledge and expertise that creates a network of support for growth. In a sense, Minnesota hopes to become the "Silicon Valley" for the biobased economy through its support of AURI.

In terms of the biobased products industry, AURI's staff members recognize that there is a strong need for high value uses for soy,

sugar, and corn beyond biodiesel and bioethanol. Examples include PLA, high value plastics, butanol, and other waste streams. AURI believes that public-private collaboration is essential to grow this industry. Partnerships with larger companies should be beneficial because they will provide the ability to leverage existing facilities. In any case, an AURI staff member we interviewed believes that a long-term perspective is needed:

We have been around for 26 years, and we were not doing in the beginning what we are doing today. We have evolved over time through lessons learned. Investors cannot expect to see a return on biobased products in two years, because the innovation spectrum can take as long as 10 years to get to full fruition. This is the building of an entirely new industry, and investors have to be patient. This is a tough quality to find in investors. However, the State of Minnesota is willing to invest in the long-term, to put money into it, and allow the industry to develop and progress. This is not an easy sell, but it is the key to success.

AURI and Minnesota stakeholders engaged the Battelle Technology Partnership to evaluate the state's potential for growth in the agbioscience sector. The study is a fascinating read, reflecting the development process, the benefits of public investment in growing the industry and the specific areas where Minnesota's core competencies could catalyze significant growth.

IV. ENVIRONMENTAL BENEFITS

A broad analysis of the biobased products industry was performed using Economic Input-Output Life Cycle Assessment (EIO-LCA) modeling to determine an estimate of the petroleum use savings and GHG emissions reductions resulting from the production and use of biobased products. Using the EIO-LCA methodology, calculated sector sales, and literature, GHG emissions reductions are estimated to be up to 10 million metric tons of CO_2 equivalents in 2014. The estimated petroleum savings from biobased product production and use are up to 6.8 million barrels of oil in 2014. Other environmental impact categories that are not estimated in this report could produce different impacts for biobased products as compared to petroleum-based products. Further analysis should include modeling of additional impact categories and the implications of other parameters such as land use change.

A. Economic Input-Output LCA

The EIO-LCA methodology was developed by Carnegie Mellon University's Green Design Institute as a method to estimate materials and energy resources required for various activities and the subsequent resulting emissions. The EIO-LCA method is one of several techniques used to examine the environmental impacts of a product over its lifecycle. In contrast to a process LCA, which examines a single process or product quantifying flows unique to that product, the EIO-LCA process uses "industry transactions – purchase of materials by one industry from other industries – and the information about direct environmental emission of industries, to estimate the total emissions throughout the supply chain".[55]

The EIO-LCA methodology builds upon the economic impact modeling methods developed by Nobel Prize winner Wassily Leontief, whose original work aimed to create a model of the U.S. economy and was expanded to include environmental metrics by Carnegie Mellon University. The EIO-LCA model and extensive documentation are available at www.eiolca.net.

B. Objectives and Methodology

The production and use of biobased products has the potential to reduce GHG emissions and petroleum use.[56] The reductions in environmental impacts and resource use depend on both product type and other factors influencing the production supply chain and products' lifecycles. Conducting an LCA for thousands of biobased products making up the bioeconomy was not feasible for this report. As a way to estimate the potential GHG emissions and petroleum use reductions, a range of GHG emissions and petroleum use reductions of 0 to 100 percent as compared to petroleum-based alternatives was used. A 0 percent reduction would indicate no difference as compared to petroleum-based products and a 100 percent reduction would indicate no fossil fuel use by biobased products. In reality, most of the biobased products will lie somewhere between 0 and 100 percent reduction; however, it is not possible to determine this for all the products making up the industrial sectors.

Only the biobased chemicals, biorefining, and bioplastic bottles and packaging sectors were considered as they can directly replace

[55] Carnegie Mellon University Green Design Institute, "About the EIO-LCA Method", *Carnegie Mellon University Green Design Institute*, http://www.eiolca.net/Method/index.html.

[56] Cherubini, F., and Ulgiati, S., "Crop residues as raw materials for biorefinery systems–A LCA case study," *Applied Energy* 87, no. 1, (2010): 47-57.

petroleum-based products. Other industry sectors, such as enzyme production, were not examined in this part of the study because the chemicals or products that enzymes directly replace are not always clear, as opposed to bioplastics, which generally displace other petroleum-based plastic products. This direct replacement assumption was required to perform the analysis described in this section.

The environmental metrics of GHG emissions and petroleum use are two key indicators of interest, but there are other important environmental impacts that should also be considered when making policy decisions. In a previous report by Golden et al., the authors examined a broader suite of environmental impacts in addition to GHG emissions specific to the biobased products industry.[57] These additional impact categories are important to consider and are acknowledged here, but the scope of this work is limited to GHG emissions and petroleum use reductions resulting from the use of biobased products as a substitute for petroleum-based products.

As each biobased product and production process will produce different environmental impacts, this work does not seek to give one number that represents all products; instead, a range of GHG emissions savings and petroleum displacement was determined based on percent reductions compared to petroleum-based materials. The calculated range of reductions was also compared to the peer-reviewed literature, which describes reductions in environmental impacts. The values used to determine the estimated impact reductions were determined using EIO-LCA with the TRACI impact assessment method to calculate the GHG emission equivalents and petroleum use.[58] Economic data used in the environmental analysis was based on 2014 U.S. national data as reported in previous sections of this report.

C. Results Overview

The petroleum saved by the biobased products industry are estimated to be as much as 6.8 million barrels of oil. In terms of GHG emissions reductions, the biobased products industry are estimated to be as much as 10 million metric tons of CO_2 equivalents. The avoided GHG emissions and petroleum use associated with direct replacement of petroleum-based products with biobased products are shown in Figures 10 and 11, respectively. The EIO-LCA model results were generated in terms of kg CO_2 equivalents and terajoules of petroleum, however, the petroleum use was converted to barrels of oil using a heating value of 6.077 MMBTU per barrel of oil.[59] For both impact measures, lines show the potential avoided impacts as a function of percent reduction compared to the petroleum-based alternative ranging from 0 to 100 percent. In addition to the range of avoided impacts, percent reductions from the peer-reviewed literature were also applied to the EIO-LCA output and reported in the following sections.

[57] Golden, J.S., Handfield, R.B., Daystar, J., and McConnell, T.E, An Economic Impact Analysis of the U.S. Biobased Products Industry: A Report to the Congress of the United States of America, A Joint Publication of the Duke Center for Sustainability & Commerce and the Supply Chain Resource Cooperative at North Carolina State University, 2015.

[58] Carnegie Mellon University Green Design Institute, "Economic Input-Output Life Cycle Assessment (EIO-LCA) U.S. 1997 Industry Benchmark Model", *Carnegie Mellon University Green Design Institute*, http://www.eiolca.net/Models/index.html.

[59] http://www.eia.gov/totalenergy/data/monthly/pdf/sec13_2.pdf

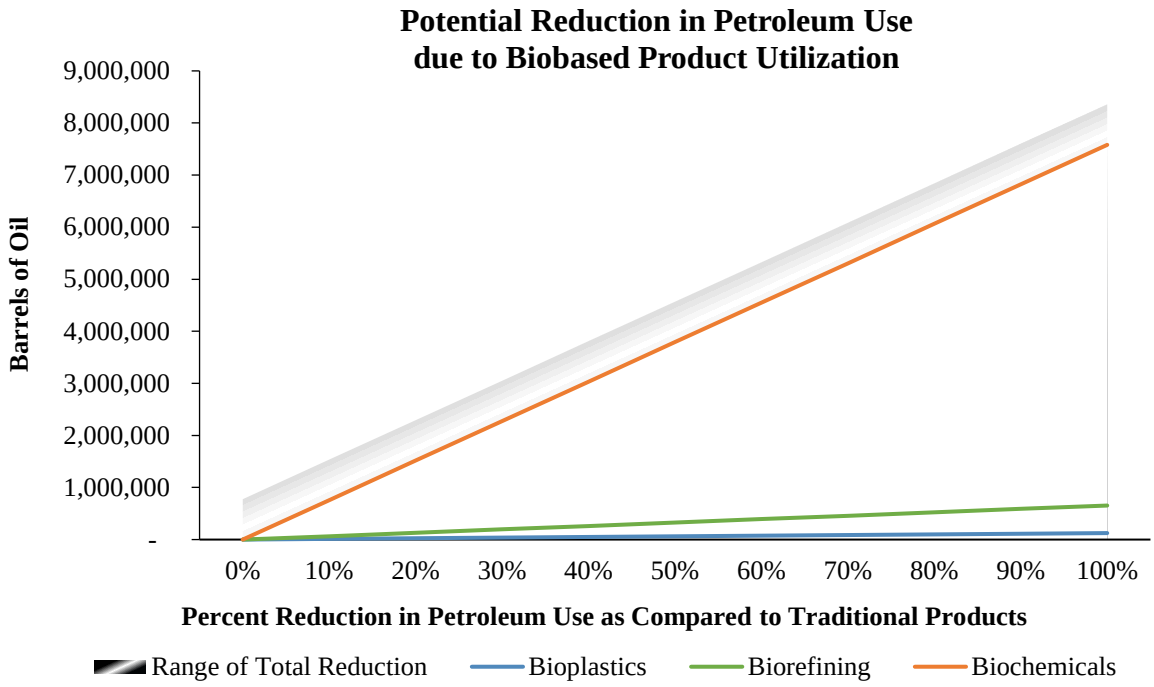

Figure 10: Potential Reductions in Petroleum Use by Biobased Products Manufactured in the United States with a Range of 0% to 100% Reduction in Petroleum Use as Compared to Non-Biobased Product Alternatives (note: assuming a heating value of 6.077 MMBTU per barrel of oil).[60, 61, 62, 63]

1. Avoided Petroleum Use

The avoided petroleum use resulting from biobased product use instead of petroleum counterparts would create petroleum savings up to 6.8 million barrels of oil. The potential petroleum use avoided by direct displacement with biobased chemicals was the largest, as the biobased chemicals market size is significantly larger than the other two sectors. Cherubini and Ulgiati determined that biobased chemicals produced at a biorefinery using a switchgrass feedstock reduced fossil fuel usage well beyond 80 percent as compared to petroleum-based chemical production methods and corresponds to 6 million barrels of oil.[60] The biorefining industry producing biochemicals are reported to use 80 percent less petroleum as traditional refineries and could generate petroleum savings of up to 552,000 barrels of oil.[60] The bioplastic bottles and packaging avoided petroleum use potential was the lowest of the three sectors examined. Using data from Yu and Chen and Harding et al., bioplastic bottles and packaging displacement of petroleum plastics corresponded to a petroleum savings up to 77,000 and 61,000 barrels of oil, respectively.[61] [62] The previous economic impact report estimated a petroleum use reduction of 200,000 average passenger cars for a year. [63] This previous

[60] Cherubini, F., and Ulgiati, S., "Crop residues as raw materials for biorefinery systems–A LCA case study," *Applied Energy* 87, no. 1, (2010): 47-57.
[61] Yu, J., and Chen, L.X.L., "The Greenhouse Gas Emissions and Fossil Energy Requirement of Bioplastics from Cradle to Gate of a Biomass Refinery," *Environmental Science & Technology* 42, no. 18, (2008): 6961-6966, doi: 10.1021/es7032235.
[62] Harding, K. G., Dennis, J. S., Von Blottnitz, H., and Harrison, S.T.L., "Environmental analysis of plastic production processes: Comparing petroleum-based polypropylene and polyethylene with biologically-based poly-β-hydroxybutyric acid using life cycle analysis", *Journal of Biotechnology* 130, no. 1, (2007): 57-66.
[63] Golden, J.S., Handfield, R.B., Daystar, J., and McConnell, T.E, An Economic Impact Analysis of the U.S. Biobased Products

estimate corresponds to a 26 percent reduction of petroleum use when biobased products are used instead of petroleum-based products. Given the data from the literature shown in this analysis, 26 percent appears to be a reasonable and conservative number.

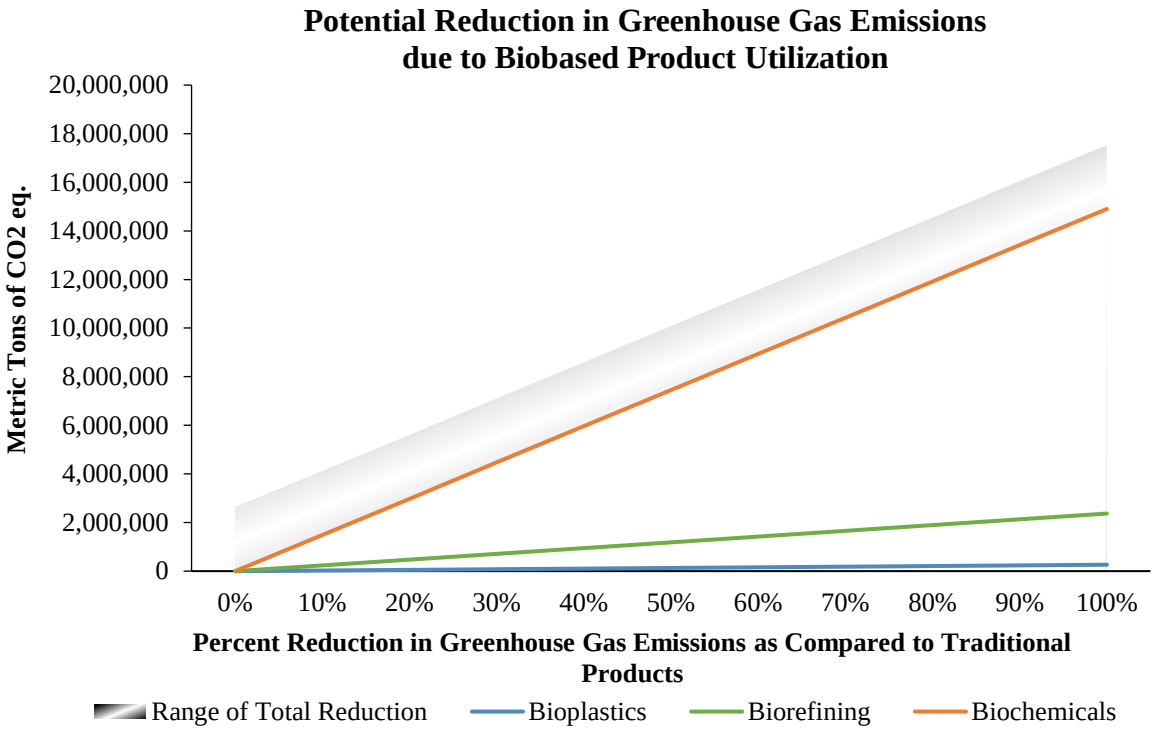

Figure 11: Potential Reductions in Greenhouse Gas Emissions by Biobased Products Manufactured in the United States with a Range of 0% to 100% Reduction in GHG Emissions as Compared to Non-Biobased Product Alternatives.[60, 61, 62, 63]

2. Avoided GHG Emissions

The production and use of biobased products replacing petroleum-based products had the potential to reduce GHG emissions up to 10 million metric tons of CO_2 equivalents in 2014. The potential avoided GHG emissions for each sector grouping are shown in Figure 11. Since the biobased chemicals sector is the largest of the three sectors, it has the highest potential to reduce GHG emissions due to the higher volume of sales. Cherubini and Ulgiati estimated that chemicals produced from switchgrass at a biorefinery reduced GHG emissions compared to petroleum-based chemicals by 49 percent, which corresponds to approximately 7.5 million metric tons of CO_2 equivalents per year. The biorefining sector, with less industrial output than chemical production, has a lower potential to offset GHG emissions. With the same percent reduction of 49 percent, biorefining has the potential to offset GHG emissions up to 1.1 million metric tons per year.[64]

The bioplastic bottles and packaging sector was the smallest by sales of the three

Industry: A Report to the Congress of the United States of America, A Joint Publication of the Duke Center for Sustainability & Commerce and the Supply Chain Resource Cooperative at North Carolina State University, 2015.

[64] Cherubini, F., and Ulgiati, S., "Crop residues as raw materials for biorefinery systems–A LCA case study," *Applied Energy* 87, no. 1, (2010): 47-57.

examined, but it had the highest GHG emission reductions reported in the literature. Yu and Chen reported an 80 percent reduction of GHG emissions compared to petroleum-based plastics, and Harding et al. reported a 65 percent reduction compared to petroleum-based plastic.[65] [66] When considering these two GHG reduction percentages, GHG emission reductions from bioplastics could correspond to 210,000 and 170,000 metric tons of CO_2 equivalents for the 65 percent and 80 percent reduction scenarios, respectively.

D. Limitations

While the EIO-LCA model is useful in many regards, it is dated and has limitations. The data describing the inter-industry transactions was developed from the 2002 benchmark U.S. input-output table and have likely changed considerably since then.

Additionally, the emissions associated with the various industries also have likely changed due to increased emissions regulations and changing energy production systems. For this study, the U.S. 2002 (428-sector) Producer model was used, and the adjusted industry output was deflated from 2013 dollars to 2002 dollars. For each of the three sectors examined (biobased chemicals, bioplastic bottles and packaging, and biorefining), a custom model was created by entering the adjusted output considered biobased for each of the sector groupings. In addition to the issues with the EIO-LCA model, there is also uncertainty surrounding the percentages of biobased products that make up the total industrial sectors. Because of these ambiguities, the results presented in this study are estimates and should be used cautiously in context. The aim of this analysis was to provide a range of estimates for GHG emission and petroleum use reductions. Additional work in this area is recommended but is outside the scope of the current study.

[65] Yu, J., and Chen, L.X.L., "The Greenhouse Gas Emissions and Fossil Energy Requirement of Bioplastics from Cradle to Gate of a Biomass Refinery," *Environmental Science & Technology* 42, no. 18, (2008): 6961-6966, doi: 10.1021/es7032235.

[66] Harding, K. G., Dennis, J. S., Von Blottnitz, H., and Harrison, S.T.L., "Environmental analysis of plastic production processes: Comparing petroleum-based polypropylene and polyethylene with biologically-based poly-β-hydroxybutyric acid using life cycle analysis", *Journal of Biotechnology* 130, no. 1, (2007): 57-66.

V. RECOMMENDATIONS

The following recommendations are based on literature reviews, conducting individual and group interviews through conference proceedings, individual meetings with representatives from the biobased products industry, and various non-governmental organizations. This includes workshops hosted by the authors in California, North Carolina, and Washington, D.C. in 2015 and 2016.

To be successful in driving the growth of this national industry will require the active participation of three distinct segments of our society. The first are consumers who we believe that upon being educated on the performance, economic and job benefits at the national and community level in addition to environmental benefits can be the voice to motivate retailers and brands to increase their use of biological feedstocks.

Second are the brands and retailers who can use their purchasing power, supply chains, and marketing strength to promote the industry. Finally, the federal government and especially the USDA BioPreferred Program has the ability to support education of the benefits of biobased products to consumers, retailers, and brands.

These recommendations reflect the opinions of the authors of the study based on their research and interviews. They do not necessarily reflect the opinions of the USDA.

Recommendation 1: Congress should continue to advance the biobased products industry for National Security and Domestic Industrial Strength.

The biobased products industry must be seen through the lens of National Security and Domestic Industrial Strength. This is a non-partisan approach and domestic need. Through continued and increased support of the sectors, we are reducing our reliance on foreign supplies of oil used in petroleum-based products as well as creating needed American jobs throughout the country as has been presented in this report. Additionally, many of these jobs are being created in rural regions of our country where economic development needs are paramount.

It is telling that the Department of Defense considers the biobased products industry a matter of national security and important part of the U.S. economy. Former Deputy Secretary of Defense Gordon England said, "To be clear, this is not like the latest health food fad, where you go to a specialty shop and you buy a lot of additional expensive supplements and ingredients. This is about substituting an equally effective product or approach to meet a requirement you have that may well end up costing less in the end… Our strategy also supports our long-term national security interests by protecting and preserving the environment for the future generations, so they can enjoy life, liberty and the pursuit of happiness to the fullest here in America."[67]

Recommendation 2: Congress should enact a Short-term Production Tax Credit.

Tax policy needs to be changed throughout the supply chain to level the playing field with petroleum-based products. A national short-term Production Tax Credit (PTC) in the United States, coupled with a stronger commitment to market pull policies, would send a strong message to companies in the

[67] U.S. Department of Defense (DOD), "Bio-Based Products Enhance National Security", U.S. DOD, last updated 9/12/06, http://archive.defense.gov/news/newsarticle.aspx?id=818.

biobased products industry that the United States is serious about wanting to expand the domestic biobased products industry. More importantly, it would give companies in the biobased products industry the money and support they need to challenge the petroleum industry and the preferential tax treatment it receives. Increasing numbers of companies (including BASF, DSM, BioAmber, Elevance, and Amyris) are exploring global site options for commercial facilities because of the challenges of competing with the petroleum industry in the United States. PTCs would ensure that the United States is a competitive site for these new facilities and new jobs. In fact, the Union of Concerned Scientists documented[68] that between 2007 and 2014 in large part to a PTC, the United States wind capacity almost quadrupled and more than 550 manufacturing facilities located in 43 states produced 70% of the wind turbine and components installed in the United States.

The oil and natural gas sectors have long benefited from PTCs, which has provided great benefits for petroleum-based products as compared to biobased-sourced products. Some of the oil and gas credits include[69]:

- Deductions for the costs of drilling wells 26 U.S.C. 263 (c)
- Deduction for oil and gas production 26 U.S.C.-199

Deductions for the costs of oil shale exploration and development 26 U.S.C. 617 The tax incentives offered to the biobased products industry needs to place them on a level playing field with the petroleum industry, if biobased products are expected to compete on the market. If Congress creates PTCs for biobased product manufacturers, the United States could revitalize the manufacturing and plastics industries.

For a range of biobased product companies, a short-term PTC would provide collateral to help finance plants in the United States. This has been successfully done at the state level in Iowa. In July of 2016, Iowa's Biorenewable Chemical Tax Credit Program was enacted. The program provides a tax credit of up to $100 million over the next 10 years for products that are over 50% biobased, and intended for uses other than food, feed, and fuel.[70] However, there remains a need for PTCs at a national level to support biobased businesses throughout the United States.

On a national level, the Renewable Chemicals Act of 2015 was introduced to the Senate in November of 2015. If enacted, this bill would give a tax credit of $0.15 per pound of biobased content for producers of renewable chemicals who meet certain criteria. This credit would have an aggregate limit of $500 million and would be distributed over five years.[71]

Recommendation 3: Congress should direct the U.S. Department of Commerce to work with the USDA to Develop NAICS Codes in support of the biobased products industry.

The NAICS codes do not currently provide

[68] Union of Concerned Scientists, "Production Tax Credit for Renewable Energy", *Union of Concerned Scientists*, accessed August 2016, http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/production-tax-credit-for.html#.V7r_0rsrKM9.

[69] Center for American Progress, "It Is Time to Phase Out 9 Unnecessary Oil and Gas Tax Breaks", *Center for American Progress*, accessed August 2016, https://www.americanprogress.org/issues/green/report/2016/05/26/138049/it-is-time-to-phase-out-9-unnecessary-oil-and-gas-tax-breaks/.

[70] Cultivation Corridor, "Biorenewable Chemicals: The Iowa Advantage", *Cultivation Corridor*, accessed 6/1/16, http://www.cultivationcorridor.org/biochem/.

[71] 114th Congress (2015-2016), "S.2271 - Renewable Chemicals Act of 2015", *Congress.gov*, accessed August 2016, https://www.congress.gov/bill/114th-congress/senate-bill/2271/text.

an effective means of tracking the economic and job contributions of the biobased products industry in the United States. This results from a lack of biobased products industry-specific codes that are representative of the biobased products sectors of the economy. Many economists and industry groups have recommended that NAICS codes be developed for biobased product sectors and that reporting requirements be established to allow more effective tracking of purchases by Federal agencies. The codes are a necessary first step, but the goal should also be to improve data on the production, import, and export of biobased products. The incorporation of NAICS codes for the biobased product industry should be extended to Federal surveys of U.S. Industrial activity and trade. The appropriate U.S. agencies and industry should add biobased product NAICS codes similar to the biobased products industry specific codes that have been added in Europe (Nomenclature of Economic Activities-NACE codes) and are being added in Canada.

Recommendation 4: Congress should Fund the USDA BioPreferred Program at levels similar to its counterparts.

Federal agencies are required to purchase biobased products designated for mandatory federal purchasing by the USDA BioPreferred® Program, except as provided by Federal Acquisition Regulation (FAR) Part 23.404(b). In general, federal agencies are required to give preference to qualified biobased products over non-biobased alternatives, as prescribed by Title 7 of the U.S. Code of Federal Regulations, section 3201.3.

In addition to the mandatory Federal purchasing initiative, the 2002 Farm Bill authorized USDA to implement an initiative to certify biobased products that are deemed eligible to display the USDA Certified Biobased Product label. The presence of the label indicates that the products have been tested by a third party and verified for biobased content, thus meeting the established minimum biobased content requirement for the product category applicable to that product. The BioPreferred Program was reauthorized and expanded under subsequent U.S. Farm Bills in 2008 and 2014. Increasing the coverage and public awareness of the USDA Certified Biobased Product label is critical. Increasing funding for the BioPreferred Program would give the necessary funding for marketing and to educate consumers on the benefits and availability of biobased products. With additional resources, the BioPreferred Program could increase tracking and use of biobased products. Currently, the BioPreferred Program's budget is about 2.7 million dollars annually. This is very small compared to the budgets of some other government programs like the EPA's Energy Star (about 50 million dollars annually) or the USDA's National Organic Program (about 10 million dollars annually).

In addition to the BioPreferred Program, there are other government drivers in the biobased products industry. For example, on March 19, 2015, President Obama released Executive Order 13693, "Planning for Federal Sustainability in the Next Decade",[72] which includes provisions to increase Federal agencies' accountability for achieving qualified biobased product purchasing requirements. Federal agencies have been directed to establish annual targets for the number of contracts awarded with biobased criteria and to report the dollar value of biobased products under those contracts.

[72] The President, "Executive Order 13693 – Planning for Federal Sustainability in the Next Decade," *Federal Register*, accessed April 2015, https://www.federalregister.gov/articles/2015/03/25/2015-07016/planning-for-federal-sustainability-in-the-next-decade.

Federal agencies also have been directed to ensure that contractors submit timely annual reports of their biobased purchases.

Recommendation 5: Congress should ensure Federal Policies Strengthen the Biobased Products Industry.

In terms of Federal policy, some of the ideas recommended from our interviews include:

- Fund and administer the USDA BioPreferred Program.
- Fund and administer the USDA Biorefinery Assistance Program, recently expanded to include facilities producing biobased chemicals and biobased products.
- Fund and administer the USDA Biomass Crop Assistance Program.
- Fund and administer the USDA/DOE's Biomass Research and Development Program.
- Work towards promoting the enactment of tax legislation for a biobased chemical Production Tax Credit (PTC), an Investment Tax Credit (ITC), Master Limited Partnerships (MLP), and Research & Development (R&D).
- Ensure biogenic CO_2 emissions related to biobased products are treated as carbon neutral in EPA's carbon accounting framework.

Recommendation 6: Biobased Products Industry Participants Should Work Together on the Challenges Facing Their Industry.

Based on our interviews, we identified six major challenges that should be addressed in the biobased products industry.

1. Examine Public Perceptions vs. Scientific Evidence. Undertake an extensive analysis concerning how the public, NGOs, policy makers, scientists, and institutional buyers perceive the spectrum of biobased feedstocks and biobased products. This includes quantifying the science or lack of science to provide clarity concerning which perceptions are inaccurate, which have a scientific basis, and which need additional research.

2. LCAs and Land-Use Studies. There is a need to create a common LCA structure that provides easy way to compare values and relates LCA results to both consumer and industry audiences. Stakeholders state that there is a need for shared life cycle inventory data and standardized definitions. A shared lifecycle inventory would reduce costs to individual firms and reduce the person-hours required to conduct lifecycle assessments.

3. Supply Chain Mapping and Location Analyses. Existing biobased product supply chains are limited by transportation disparities related to the location of biofuel producing sources. Government influence in the form of grants and tax rebates at the state and local levels can be used to help promote investments to streamline supply chain execution, create more integrated and collaborative facility designs, create shared facilities, and help to stimulate industry development and investment. Industry leaders should work to reduce the burden on upstream supply chain participants and drive more co-development activities to promote biobased in lower tiers of supply chain. Since suppliers source to different types of industries, there is a need to create a common vehicle for marketing products. An example would be a company deciding between two distinct marketing messages. A common platform for messaging would create efficiencies and improve opportunities for aligned investments. If suppliers and industries could work together to identify potential inefficiencies and work to solve

them using a common approach, it could be easier to implement biobased products across the supply chain.

4. Marketing Messaging and Impact Scores. There is a need to conduct biobased products marketing research and develop marketing materials that support and promote the biobased products message, downstream, upstream, in industrial, and in government procurement processes. An example is an impact score that can translate LCA information to the end consumer to drive and influence buying behavior and decision-making via a standardized scorecard.

Another example might be a biobased material identifier that could be used to award new business to sustainability-focused suppliers as part of a procurement initiative. Better communication with retailers through value-chain maps that provide a clear definition and value proposition for biobased products would create differentiated products that excel in performance.

5. Government Policy and Acquisition Recommendations. Biobased products industry stakeholders should provide input to government policies regarding grants and tax incentives to foster "downstream pull" investments in biobased product development, research, and innovation. Government policy makers should strive to create consistency across regulations and incentives for the biobased products industry, and incentives to drive increased utilization of biobased contracts, especially in light of the new General Services Administration focus on Category Management. Since plants sequester carbon, carbon credits could be given for using biobased products instead of petroleum-based products. Create more access to opportunities for industry to tap into tax incentives, tax credits, and producer credits, and to highlight the availability of these programs to biobased producers. Policy makers need education on biobased products that demystifies the misconceptions about the industry with solid data. Additionally, there is a need for education on how to sell to the government within the context of the biobased products industry, as legislative requirements have not meshed well with acquisition actions, and tracking has been problematic. The DOE's support also could be sought to drive additional support at various points in the value chain. Companies could commit to a certain percentage of biobased sources or get the government to enact policy like CAFE standards.

6. Identify and Model Risks Facing the Biobased products Sector. The interviewees also identified risks that should be considered for the biobased products industry. First, low oil prices may continue for several years, given the current reserves of oil and fracking, leading to a sustained lower price of oil and reduced desire to explore the potential of biobased products. This is problematic considering the amount of time it takes to develop a biobased product. In addition, the amount of venture capital available for biobased products is decreasing. Scaling up new projects and the time required to bring capital investments to scale also are significant challenges.

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Appendix A
The Economic Input-Output Model (IMPLAN)

The Economic Input-Output Model

IMPLAN is an economic impact modeling system that uses input-output analysis to quantify economic activities of an industry in a predefined region. IMPLAN was designed in 1976 by the Minnesota IMPLAN Group Inc. under the direction of the U.S. Forest Service to help meet the reporting requirements for Forest Service land management programs. IMPLAN is now used extensively to quantify the economic impacts of various industrial activities and policies. The IMPLAN system is now managed by IMPLAN Group LLC of Huntersville, North Carolina.

IMPLAN quantifies the economic impacts or contributions of a predefined region in terms of dollars added to the economy and jobs produced (IMPLAN Group LLC 2004).[73] Data are obtained from various government sources including agencies and bureaus within the Departments of Agriculture, Commerce, and Labor.

The IMPLAN system's input-output model currently defines 536 unique sectors in the U.S. economy (which are North American Industry Classification System [NAICS] sectors, except in some cases in which aggregates of multiple sectors are used). The IMPLAN system uses its database to model inter-sector linkages, such as sales and purchases between forest-based industries and other businesses. The transactions table within IMPLAN quantifies the number of dollars each sector makes (sales) and uses (purchases). The table separates processing sectors by rows and purchasing sectors by columns; every sector is considered both a processor and purchaser. Summing each row quantifies an industry's output, which includes sales to other production sectors along with those sales to final demand. The total outlay of inputs, which are the sums of the columns, includes purchases from intermediate local production sectors, payments to local value added, and imports (both intermediate and value added inputs) from outside the study region. The transactions table can be used to explain a sector's economic relationships based on the value of the commodities exchanged between the industry of interest and other sectors.

Leontief (1936) defined the relationship between output and final demand as shown below:

$$x = (I - A)^{-1} y$$

where x is the column vector of industrial output, I is an identity (unit) matrix, A is the direct requirements matrix relating input to output, and y is the final demand column vector. The term $(I - A)^{-1}$ is the total requirements matrix or the "multiplier" matrix. Each element of the matrix describes the amount needed from sector i (row) as input to produce one unit of output in sector j (column) to satisfy final demand. The output multiplier for sector j is the sum of its column elements, or sector j's total requirements from each individual sector i. Employment and value added multipliers also can be derived by summing the column's elements.

Employment in IMPLAN is represented as the number of both full time and part time

[73] IMPLAN, Computer Software, IMPLAN, IMPLAN Group LLC, http://www.implan.com.

jobs supported within an industry to meet final demand. Value added is composed of labor income, which includes employees' compensation and sole proprietor (self-employed) income, other property income (OPI), and taxes on production and imports, less subsidies (TOPI, formerly was labeled 'indirect business taxes')[74]. OPI in IMPLAN includes corporate profits, capital consumption allowance, payments for rent, dividends, royalties, and interest income. TOPI primarily consist of sales and excise taxes paid by individuals to businesses through normal operations. Output is the sum of value-added and the cost of buying goods and services to produce the product.

Key terms:

- Value added: Value added describes the new wealth generated within a sector and is its contribution to gross domestic product (GDP).
- Output: Output is an industry's gross sales, which includes sales to other sectors (where the output as used by that sector as input) and sales to final demand.

When examining the economic contributions of an industry, IMPLAN generates four types of indicators:

1. Direct effects: effects of all sales (dollars or employment) generated by a sector.
2. Indirect effects: effects of all sales by the supply chain for the industry under study.
3. Induced effects: A change in dollars or employment within the study region that represents the influence of the value chain employees spending wages in other sectors to buy services and goods.
4. Total effect: the sum of the direct, indirect, and induced effects.

Economic multipliers quantify the spillover effects, i.e., the indirect and induced contributions. The Type I multiplier describes the indirect effect, which is described by dividing the direct effect into the sum of the direct and indirect effects.[75] A Type I employment multiplier of 2.00 for example, means that for every job in the industry of interest, one additional job is supported in that sector's supply chain.

Type II multipliers are defined as the sum of the direct, indirect, and induced effects divided by the direct effect (Equation 1). The Type II multiplier operates by extending the input-output model to include any contributions induced by final demanders. Type II multipliers differ by how they define value added and account for any of its potential endogenous components. A particular Type II multiplier, the Type social accounting matrix (SAM) multiplier, considers portions of value added to be both endogenous and exogenous to a study region (Equation 2). This generally incorporates labor payments to the households and their subsequent consumption of goods and services. These multipliers indicate the extent to which total activity is generated in the economy due to the sectors under study. A Type SAM value added multiplier of 1.50, for example, indicates that for every $1.00 of value added produced in an industry under study, $0.50 of additional value added would be generated elsewhere in the economy by other industries.

Contributions Analyses of Biobased Products Sectors

[74] IMPLAN refers to value added in this context as "total value added".

[75] U.S. Department of Commerce Bureau of Economic Analysis (BEA), Interactive Data Application, BEA web site, http://www.bea.gov/itable/index.cfm, accessed April 2015.

A contributions analysis describes the economic effects of an existing sector, or group of sectors, within an economy. The results define the extent to which the economy is influenced by the sector(s) of interest. Changes in final demand, which generally are marginal or incremental, are not assumed here as they are in traditional impact analysis. Based on the number of sectors contained within each industry group, multiple sector contributions analyses were conducted. The bioeconomy at the national level was modeled using IMPLAN's 2013 and 2014 national databases. These models were constructed using the Supply/Demand Pooling method. The 50 states and District of Columbia were modeled using IMPLAN's 2013 database for each economy; these models were constructed using the IMPLAN National Trade Flows Model method. The models were closed with respect to households only in all cases. Output was the basis by which contributions were assessed, but had to be adjusted to eliminate sales and purchases internal to the sectors to avoid double counting. This required five steps using Microsoft Excel: 1) compile the total requirements matrix of detailed Type SAM output multipliers from IMPLAN for the respective economy; 2) from this matrix, build a truncated matrix of the biobased industrial groups' sectors and invert it; 3) calculate the direct contributions vector by multiplying the inverted contributions matrix by the groups' sector outputs found in the economy's transactions table; 4) multiply the economy's total requirements matrix by the direct contributions vector to obtain total output contributions; 5) calculate employment and value added contributions based their respective sectoral output shares. Use of this method avoided the structural changes that result from customizing the model, and at the same time, it preserved the original relationships found in the modeled economy's transactions table.

$$\frac{\text{Direct Effect} + \text{Indirect Effect}}{\text{Direct Effect}} = \text{Type I Multiplier}$$

Equation 1: Type I multiplier calculation

$$\frac{\text{Direct Effect} + \text{Indirect Effect} + \text{Induced Effect}}{\text{Direct Effect}} = \text{Type SAM Multiplier}$$

Equation 2: Type SAM multiplier calculation

Appendix B
Products Participating in the BioPreferred® Program by Category – 2016

Number of Products	Category
36	2-Cycle Engine Oils
61	Adhesive and Mastic Removers
14	Adhesives
71	Agricultural Spray Adjuvants
136	Air Fresheners and Deodorizers
38	Aircraft and Boat Cleaners - Aircraft Cleaners
31	Aircraft and Boat Cleaners - Boat Cleaners
4	Allergy and Sinus Relievers
5	Animal Bedding
337	Animal Cleaning Products
46	Animal Habitat Care Products
2	Animal Medical Care Products
37	Animal Odor Control and Deodorant
130	Animal Repellents
1	Animal Skin, Hair, and Insect Care Products
1	Anti-Slip Products
2	Aromatherapy
4	Art Supplies
38	Asphalt and Tar Removers
13	Asphalt Restorers
76	Automotive Care Products
26	Baby and Kids
1,176	Bath Products
270	Bathroom and Spa Cleaners
172	Bedding, Bed Linens, and Towels
5	Biodegradable Foams
172	Bioremediation Materials
15	Blast Media
2	Body Powders

Number of Products	Category
526	Candles and Wax Melts
114	Carpet and Upholstery Cleaners - General Purpose
120	Carpet and Upholstery Cleaners - Spot Removers
104	Carpets
117	Chain and Cable Lubricants
4	Clothing
1	Clothing – Utility Gloves
51	Composite Panels - Acoustical
35	Composite Panels - Countertops
68	Composite Panels - Interior Panels
22	Composite Panels - Plastic Lumber
26	Composite Panels - Structural Interior Panels
18	Composite Panels - Structural Wall Panels
30	Compost Activators and Accelerators
78	Concrete and Asphalt Cleaners
63	Concrete and Asphalt Release Fluids
1	Concrete Curing Agents
2	Concrete Repair Materials
69	Corrosion Preventatives
1	Cosmetics
96	Cuts, Burns, and Abrasions Ointments
8	De-Icers - Specialty
83	Deodorants
14	Dethatchers
66	Diesel Fuel Additives
148	Dishwashing Products
5	Disinfectants
439	Disposable Containers
539	Disposable Cutlery
692	Disposable Tableware
1	Durable Cutlery
13	Durable Tableware
35	Dust Suppressants
10	Electronic Components Cleaners
75	Engine Crankcase Oil

Number of Products	Category
247	Erosion Control Materials
2	Expanded Polystyrene (EPS) Foam Recycling Products
9	Exterior Paints and Coatings
1	Fabric Stain Preventers and Protectors
14	Facial Care Products
16	Feminine Hygiene
545	Fertilizers
106	Films - Non-Durable
43	Films - Semi-Durable
2	Filters
2	Fingernail/Cuticle Products
2	Fire Retardants
8	Fire Starters, Logs, or Pellets
21	Firearm Cleaner
43	Firearm Lubricants
163	Floor Cleaners and Protectors
357	Floor Coverings (Non-Carpet)
14	Floor Strippers
6	Fluid-Filled Transformers - Synthetic Ester-Based
5	Fluid-Filled Transformers - Vegetable Oil-Based
5	Foliar Sprays
35	Food Cleaners
92	Foot Care Products
23	Forming Lubricants
28	Fuel Conditioners
46	Furniture Cleaners and Protectors
111	Gasoline Fuel Additives
107	Gear Lubricants
29	General Purpose De-Icers
272	General Purpose Household Cleaners
187	Glass Cleaners
327	Graffiti and Grease Removers
23	Greases - Food Grade
48	Greases - Multipurpose
17	Grease - Other

Number of Products	Category
16	Greases - Rail Track
12	Greases - Truck
2	Greases - Wheel Bearing and Chassis Greases
19	Hair Care Products - Conditioners
472	Hair Care Products - Shampoos
1	Hair Styling Products
470	Hand Cleaners and Sanitizers - Hand Cleaners
130	Hand Cleaners and Sanitizers - Hand Sanitizers
11	Heat Generating Products
1	Heat Transfer Fluid - Additive
68	Heat Transfer Fluids
389	Industrial Cleaners
3	Industrial Enamel Coatings
32	Ink Removers and Cleaners
21	Inks - News
66	Inks - Printer Toner (Greater Than 25 Pages Per Minute)
43	Inks - Printer Toner (Less Than 25 Pages Per Minute)
19	Inks - Sheetfed (Black)
41	Inks - Sheetfed (Color)
52	Inks - Specialty
50	Interior Paints and Coatings - Latex and Waterborne Alkyd
26	Interior Paints and Coatings - Oil-based and Solventborne Alkyd
148	Intermediate Feedstocks
9	Intermediates - Binders
100	Intermediates - Chemicals
17	Intermediates - Cleaner Components
35	Intermediates - Fibers and Fabrics
14	Intermediates - Foams
43	Intermediates - Lubricant Components
20	Intermediates - Oils, Fats, and Waxes
45	Intermediates - Paint & Coating Components
33	Intermediates - Personal Care Product Components
87	Intermediates - Plastic Resins
5	Laboratory Chemicals
2	Laundry - Dryer Sheets

Number of Products	Category
223	Laundry Products - General Purpose
75	Laundry Products - Pretreatment/Spot Removers
6	Lavatory Flushing Fluid
79	Leather, Vinyl, and Rubber Care Products
179	Lip Care Products
8	Loose-Fill and Batt Insulation
856	Lotions and Moisturizers
14	Lumber, Millwork, Underlayment, Engineered Wood Products
2	Massage Oils
5	Medical Supplies
23	Metal Cleaners and Corrosion Removers - Corrosion Removers
36	Metal Cleaners and Corrosion Removers - Other Metal Cleaners
27	Metal Cleaners and Corrosion Removers - Stainless Steel
63	Metalworking Fluids - General Purpose Soluble, Semi-Synthetic, and Synthetic Oils
50	Metalworking Fluids - High Performance Soluble, Semi-Synthetic, and Synthetic Oils
99	Metalworking Fluids - Straight Oils
286	Microbial Cleaning Products - Drain Maintenance Products
177	Microbial Cleaning Products - General Cleaners
197	Microbial Cleaning Products - Wastewater Maintenance Products
228	Mobile Equipment Hydraulic Fluids
265	Mulch and Compost Materials
459	Multipurpose Cleaners
79	Multipurpose Lubricants
11	Oral Care Products
21	Other
9	Other Lubricants
30	Oven and Grill Cleaners
78	Packing and Insulating Materials
60	Paint Removers
14	Paper Products - Non-writing paper
184	Paper Products - Office Paper
73	Parts Wash Solutions
75	Penetrating Lubricants
1	Perfume

Number of Products	Category
3	Pest Control-Fungal-Agricultural
5	Pest Control-Fungal-Home and Garden
2	Pest Control-Insect-Agricultural
6	Pest Control-Insect-Home and Garden
2	Pest Control-Insect-Industrial
1	Pest Control-Weeds-Home and Garden
3	pH Neutralizing Products
2	Phase Change Materials
2	Plant Washes
48	Plastic Insulating Foam for Residential and Commercial Construction
21	Plastic Products
37	Pneumatic Equipment Lubricants
12	Polyurethane Coatings
27	Product Packaging
33	Roof Coatings
3	Rugs and Floor Mats
5	Safety Equipment
72	Sanitary Tissues
577	Shaving Products
1	Shipping Pallets
12	Slide Way Lubricants
3	Solid Amendments
1	Solid Fuel Additives
139	Sorbents
7	Specialty Fuels
38	Specialty Precision Cleaners and Solvents
20	Sponges, Scrub Pads, and Cleaning Tools
241	Stationary Equipment Hydraulic Fluids
202	Sun Care Products
2	Thermal Shipping Containers - Durable
1	Thermal Shipping Containers - Non-Durable
58	Topical Pain Relief Products
6	Toys and Sporting Gear
6	Traffic and zone marking paints
2	Transmission Fluids

Number of Products	Category
5	Turbine Drip Oils
4	Wall Coverings - Commercial
10	Wastewater Systems Coatings
13	Wastewater Treatment Products
37	Water Clarifying Agents
8	Water Tank Coatings
11	Water Turbine Bearing Oils
36	Wood and Concrete Sealers - Membrane Concrete Sealers
90	Wood and Concrete Sealers - Penetrating Liquids
28	Wood and Concrete Stains
12	Woven Fiber Products
2	Writing Utensils - Pens

Note: If applicable, a product may be listed in up to four categories.
Source: USDA BioPreferred Program, May 2016.

Appendix C
States Ranked by Direct Jobs in the Biobased Products Industry – 2013

Rank	Direct Jobs	State
1	145,080	California
2	90,040	North Carolina
3	88,680	Texas
4	80,520	Georgia
5	71,360	Pennsylvania
6	68,250	Wisconsin
7	52,930	Ohio
8	52,300	New York
9	49,650	Alabama
10	47,690	Florida
11	46,480	Oregon
12	46,050	Indiana
13	44,850	Tennessee
14	41,140	Washington
15	40,350	Mississippi
16	39,940	Illinois
17	38,920	Virginia
18	38,430	South Carolina
19	37,790	Michigan
20	35,850	Minnesota
21	31,400	Arkansas
22	27,290	Missouri
23	27,290	Kentucky
24	22,440	Louisiana
25	21,950	New Jersey
26	20,500	Maine
27	20,110	Iowa
28	19,140	Massachusetts
29	14,790	Arizona
30	13,250	Idaho
31	11,500	Colorado
32	10,770	Utah
33	10,320	Oklahoma
34	9,960	West Virginia

Rank	Direct Jobs	State
35	9,570	Maryland
36	9,080	Kansas
37	8,970	Connecticut
38	7,090	New Hampshire
39	6,500	Vermont
40	6,340	Montana
41	6,160	South Dakota
42	6,020	Nebraska
43	4,210	New Mexico
44	3,840	Nevada
45	3,500	Rhode Island
46	3,360	North Dakota
47	2,140	Delaware
48	1,930	Hawaii
49	1,610	Wyoming
50	1,420	Alaska
51	220	Washington D.C.

Appendix D
States Ranked by Direct Value Added by the Biobased Products Industry – 2013

Rank	Direct Value Added	State
1	9,862,930,000	California
2	8,237,608,000	Georgia
3	6,828,425,000	Texas
4	6,522,151,000	Pennsylvania
5	6,437,140,000	North Carolina
6	6,252,403,000	Wisconsin
7	4,977,941,000	Alabama
8	4,429,804,000	Tennessee
9	4,276,668,000	Ohio
10	4,227,162,000	South Carolina
11	4,159,173,000	Oregon
12	3,848,271,000	New York
13	3,807,744,000	Washington
14	3,737,850,000	Florida
15	3,543,046,000	Illinois
16	3,391,516,000	Minnesota
17	3,165,255,000	Arkansas
18	3,144,753,000	Virginia
19	2,882,370,000	Michigan
20	2,842,703,000	Indiana
21	2,692,484,000	Mississippi
22	2,648,699,000	Louisiana
23	2,506,357,000	Missouri
24	2,127,702,000	Kentucky
25	1,877,652,000	New Jersey
26	1,735,341,000	Iowa
27	1,599,745,000	Maine
28	1,416,696,000	Massachusetts
29	995,033,000	Oklahoma
30	963,248,000	Utah
31	912,261,000	Arizona
32	885,697,000	Idaho

Rank	Direct Value Added	State
33	845,697,000	Connecticut
34	800,959,000	Maryland
35	634,553,000	Colorado
36	601,223,000	West Virginia
37	503,890,000	Kansas
38	425,733,000	Nebraska
39	403,884,000	New Hampshire
40	346,817,000	Delaware
41	333,014,000	Montana
42	331,892,000	South Dakota
43	277,682,000	Vermont
44	237,667,000	North Dakota
45	228,664,000	Nevada
46	227,704,000	Rhode Island
47	208,297,000	New Mexico
48	66,937,000	Alaska
49	65,890,000	Hawaii
50	57,902,000	Wyoming
51	18,364,000	Washington D.C.

Appendix E
Number of Companies Participating in the BioPreferred® Program, Direct Jobs, and Direct Value Added in Each State (Alphabetical)

State	Number of Companies Participating in the BioPreferred Program (June 2016)	Direct Value Added (2013)	Direct Jobs (2013)
Alabama	16	$4,977,941,000	49,650
Alaska	5	$66,937,000	1,420
Arizona	32	$912,261,000	14,790
Arkansas	14	$3,165,255,000	31,400
California	286	$9,862,930,000	145,080
Colorado	62	$634,553,000	11,500
Connecticut	28	$845,697,000	8,970
Delaware	7	$346,817,000	2,140
Florida	130	$3,737,850,000	47,690
Georgia	79	$8,237,608,000	80,520
Hawaii	8	$65,890,000	1,930
Idaho	13	$885,697,000	13,250
Illinois	132	$3,543,046,000	39,940
Indiana	30	$2,842,703,000	46,050
Iowa	79	$1,735,341,000	20,110
Kansas	28	$503,890,000	9,080
Kentucky	13	$2,127,702,000	27,290
Louisiana	8	$2,648,699,000	22,440
Maine	16	$1,599,745,000	20,500
Maryland	25	$800,959,000	9,570
Massachusetts	56	$1,416,696,000	19,140
Michigan	57	$2,882,370,000	37,790
Minnesota	97	$3,391,516,000	35,850
Mississippi	19	$2,692,484,000	40,350
Missouri	52	$2,506,357,000	27,290
Montana	10	$333,014,000	6,340
Nebraska	25	$425,733,000	6,020
Nevada	15	$228,664,000	3,840
New Hampshire	19	$403,884,000	7,090
New Jersey	70	$1,877,652,000	21,950

State	Number of Companies Participating in the BioPreferred Program (June 2016)	Direct Value Added (2013)	Direct Jobs (2013)
New Mexico	8	$208,297,000	4,210
New York	95	$3,848,271,000	52,300
North Carolina	71	$6,437,140,000	90,040
North Dakota	5	$237,667,000	3,360
Ohio	105	$4,276,668,000	52,930
Oklahoma	9	$995,033,000	10,320
Oregon	54	$4,159,173,000	46,480
Pennsylvania	90	$6,522,151,000	71,360
Rhode Island	7	$227,704,000	3,500
South Carolina	19	$4,227,162,000	38,430
South Dakota	11	$331,892,000	6,160
Tennessee	29	$4,429,804,000	44,850
Texas	147	$6,828,425,000	88,680
Utah	11	$963,248,000	10,770
Vermont	9	$277,682,000	6,500
Virginia	50	$3,144,753,000	38,920
Washington	77	$3,807,744,000	41,140
Washington D.C.	3	$18,364,000	220
West Virginia	2	$601,223,000	9,960
Wisconsin	78	$6,252,403,000	68,250
Wyoming	7	$57,902,000	1,610

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