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Economic Contribution of the Biobased Industrial Products Industry in Minnesota: A Look to the Future

AN ECONOMIC IMPACT ANALYSIS PROGRAM REPORT

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December 2014

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Executive Summary: Economic Contribution of the Biobased Industrial Products Industry in Minnesota: A Look to the Future

- *Background:* Based on a long history and tradition of agriculture and science, the biobased industrial products industry is poised for growth in Minnesota. This analysis examines the economic contribution of 14 biobased industry products facilities that are likely to be built in Minnesota. The facilities would produce renewable chemicals, advanced biofuels, N-butanol, cellulosic chemicals, cellulosic ethanol, and renewable plastics from sugar, wood, and biomass sources.

- *Direct Spending and Employment for Operations*: The 14 proposed biobased industrial facilities, at full capacity, will annually employ an estimated 590 individuals in Minnesota. They will pay an estimated $36.8 million in labor income annually to their employees. The facilities will spend an estimated $470.3 million annually in Minnesota to operate. Feedstocks constitute the largest expenditures for the facilities.

- *Economic Contribution of Operations*: If all 14 potential biobased industrial facilities become fully functional, the facilities will create an estimated $837.6 million in economic activity annually in the state of Minnesota. The facilities will annually support an estimated 3,190 jobs and $174.1 million in wages, salaries, and benefits for those employees. Operations impacts will be at these levels as long as the facilities maintain their projected levels of production.

- *Top Industries Impacted:* The proposed facilities will support an estimated 3,190 jobs in Minnesota. Of these, 590 jobs are at the facilities themselves, therefore, the facilities have the potential to support 2,600 jobs at other businesses in the state. The top industries that would benefit from the expansion of the biobased industrial products industry include commercial logging, food services and drinking places, and services to buildings and dwellings. While no new grain farming jobs would be created, because most suitable farm land is already in production, the model does indicate 510 grain farming jobs would be supported by the facilities.

- *Economic Contribution of Construction:* The total economic contribution of the construction of the 14 proposed biobased industrial product facilities would be an estimated $1.5 billion in Minnesota. The construction of the facilities would support an estimated 8,690 jobs. Workers in those jobs would earn an estimated $538.2 million in income, with impacts dispersed across the time period of construction. Once construction is complete, the impacts will dissipate.

Fourteen potential new biobased industrial products facilities in Minnesota have the potential to contribute an estimated $837.6 million in economic activity to the state's economy.

BACKGROUND OF THE STUDY

Agbioscience is defined as "a broad continuum of activity in the development, production, and value-added use of plant and animal organisms for food, health, fuel, and industrial applications" (Battelle, February 2013). Minnesota has a long history of being a leader in the fields of agriculture and science, giving the state a competitive position in the agbioscience industry.

A report on the core competencies of agbioscience in Minnesota identified four platforms of Minnesota's industry for future targeted investment and development (Battelle, November 2013). They are: microbial agbioscience; resilient, efficient and productive agricultural systems; biobased industrial products; and value-added food and health products.

Biobased industrial products are biofuels, materials, chemicals, and value-added forestry products primarily generated from farm and forestry outputs. Biobased industrial products utilize a wide range of feedstocks including traditional agricultural and forestry crops, newly developed or enhanced crops, and co-products generated from these crops (Battelle, November 2013).

The biobased industrial products industry in Minnesota appears to be poised for growth. A 2012 study (LifeScience Alley) concluded the biobased industrial products industry could grow by 12,000 new jobs by 2025.

Given these industry trends, the Great Plains Institute commissioned University of Minnesota Extension to quantify the potential economic contribution of the biobased industrial products industry. Specifically, the Great Plains Institute identified 14 opportunities for the development of new biobased industry product facilities in Minnesota. Establishment of these facilities assumes the adoption of new incentives by the State of Minnesota.

The facilities identified for development can be classified according to their primary feedstock. Three facilities would use sugar (corn or beet) as their primary input. Products produced in the facilities include renewable plastics, N-butanol, and advanced biofuels. Seven facilities would use wood or wood-based sugar as their primary input. Products produced in the facilities include cellulosic chemicals and renewable chemicals. The other four facilities would use biomass (i.e. poultry litter, swine manure, corn stover, switchgrass) as the primary feedstock. Products produced in the facilities include cellulosic ethanol and bioCNG.

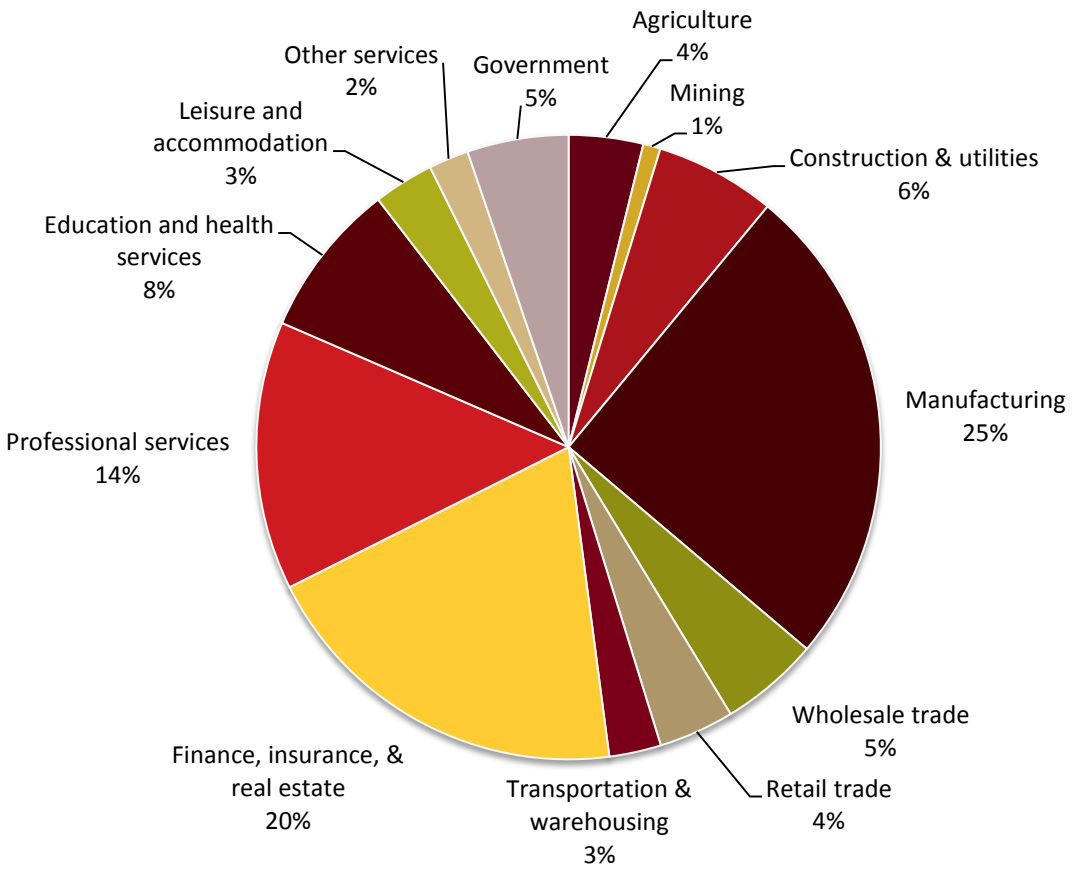
This report summarizes the results of the analysis of the economic contribution of the 14 potential biobased industrial products facilities in Minnesota. The research was conducted as part of University of Minnesota's Economic Impact Analysis program. The study has two deliverables: a written report and a presentation with facilitated discussion of the results.

PROFILE OF THE STUDY AREA ECONOMY

The primary focus of this study is to examine the economic contribution of potential biobased industrial product facilities on the economy of Minnesota. To provide context to that discussion, this report begins with an overview of Minnesota's economy.

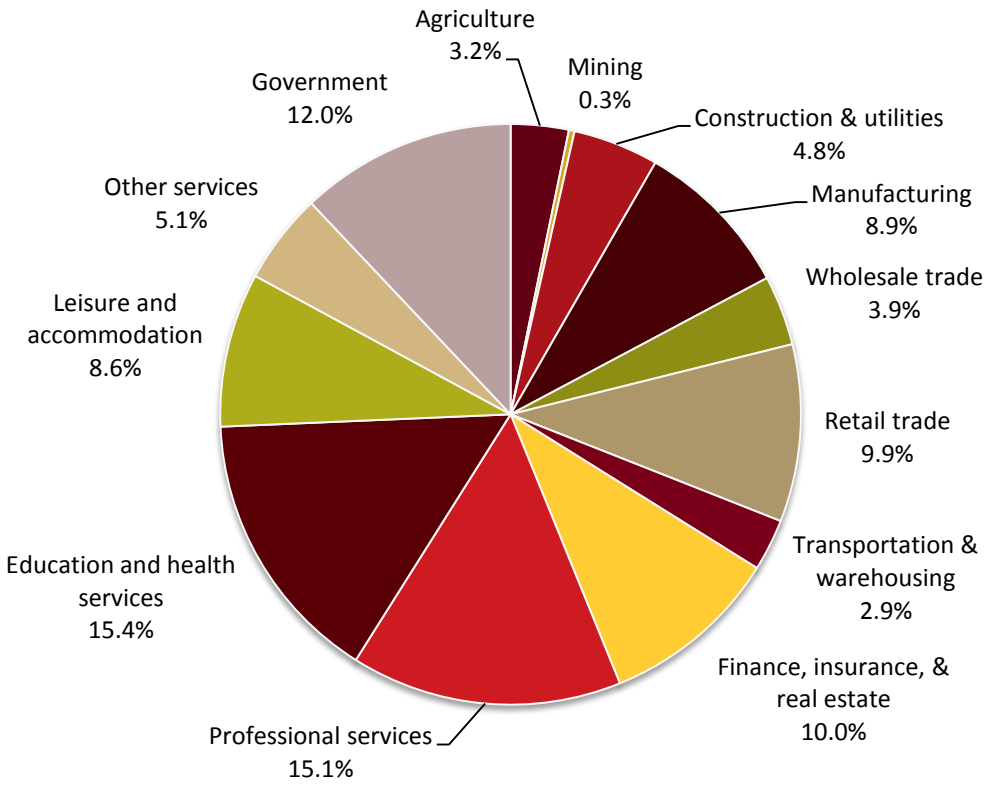
In 2012, the Minnesota economy produced $29.8 billion of output (chart 1). The manufacturing industry accounted for one-quarter of that output. Finance, insurance, and real estate services accounted for 20 percent, and professional services 14 percent. Biobased industrial products are included in the manufacturing sector.

Chart 1: Output by Industry: Minnesota 2012



In 2012, there were 3.5 million jobs in Minnesota. Fifteen percent of those jobs were in education and health services and professional services. Publicly-owned businesses and government organizations accounted for 12 percent of all jobs.

Chart 2: Employment by Industry: Minnesota 2012



Manufacturing provides 25 percent of output and only 9 percent of employment. This is likely due to two factors. One, output per employee in the manufacturing sector is higher than many other industries. Each manufacturing worker can produce more output, as measured in dollars, than in other sectors. Two, in the dataset used in this analysis, one job is one job. A job is counted as one job regardless of whether it is full-time, part-time, or seasonal. Manufacturing jobs tend to be full-time, while more jobs in other industries, such as restaurants, tend to be part-time.

ECONOMIC CONTRIBUTION OF THE OPERATIONS OF BIOBASED INDUSTRIAL FACILITIES

This report quantifies the estimated economic contribution of ***14 potential*** biobased industrial product facilities in Minnesota. The economic contribution of these potential facilities is comprised of direct, indirect, and induced effects. Direct impact is quantified by measuring total expenditures the facilities will make in Minnesota. Once direct effects are quantified, indirect and induced effects can be calculated by using an input-output model.

Seven facilities currently under consideration for development in Minnesota were selected as representative case studies. Each case study was evaluated by the Great Plains Institute on its potential for similar facilities to be built in Minnesota. For some selected cases, only one facility is likely to be built. In other cases, multiple facilities could conceivably be developed. In this report, expenditures by each case study facility were provided to Extension by the private companies developing the projects. The seven individual case studies were then scaled to represent all 14 potential plants based on the likelihood of replicability.[1] For descriptive details of the case study facilities, please refer to appendix three.

Direct Effects of Operations

Direct effects are quantified in terms of output, labor income, and employment. Output is equal to total expected sales by the potential biobased industrial product facilities. Labor income includes wages, salaries, and benefits the facilities estimate spending for employees at the plant itself. Employment is the number of workers at the facility.

The modeling technique "analysis-by-parts" is implemented in this study to quantify total economic impact. Analysis-by-parts requires the major components be analyzed separately. In input-output theory, output is equal to sales. Since the input-output model is an accounting matrix, sales must also equal expenditures. Therefore, when using analysis-by-parts, one looks at the major expenses of the facilities to determine how to model the economic impact. The next section of the report explains how the major expenditures are classified and modeled in this analysis.

Feedstock Expenditures

A primary input into the production process for biobased industrial product facilities is feedstock. The potential biobased industrial product facilities included in this analysis can be classified in three broad groups based on their primary feedstock. The classifications include sugars, wood, and biomass. The case study companies include three using sugar as a primary feedstock, two using wood as a primary feedstock, and two using biomass as a primary feedstock.

The type of feedstock used by each facility affects how the direct effect of the operation is calculated. Facilities using sugar as their primary feedstock are, at this time, primarily relying on corn-based sugar. New facilities being developed will increase demand for corn-based sugar. However, this will not lead to a significant increase in the amount of corn produced in Minnesota, since most land suitable for agriculture is already in production. Therefore, the impacts of increased demand are not modeled as increases in production. It is possible, however, that new investment in retrofitting existing ethanol plants to produce advanced biofuels or renewable chemicals may prevent a loss of production in currently marginally profitable plants, thus preventing a loss of jobs and economic output. Facilities using wood as their primary feedstock do have the possibility to

[1] For clarity, the 14 potential facilities include both the 7 case study facilities plus 7 additional potential facilities not yet under consideration.

increase logging activity in Minnesota. Therefore, increases in demand for wood are modeled to increase logging activity.[2] Finally, facilities using biomass, or residual products from other farming activities, are also not expected to increase demand for the primary farm commodity. For example, using corn stover will not increase demand for corn. However, farmers will likely receive payments for a previously unused product, therefore, increasing farm incomes. Thus, demand for corn stover was modeled as an increase in farm income.

Table 1 shows how the feedstock expenditures were incorporated into the model. The 14 potential facilities are projected to spend $273.4 million annually to purchase feedstock. Following the methodology outlined above, $18.7 million in increased farm incomes from sales of biomass and $72.3 million in additional logging activity were modeled in this analysis.

Table 1: Estimated Direct Impact of Annual Feedstock Purchases by 14 Potential Biobased Industrial Product Facilities in Minnesota

Feedstock Type	Total Feedstock Purchases (millions)	Included in Analysis?	Direct Impact Modeled (millions)
Sugar	$132.0	No, no impact on corn production	$0
Biomass	$51.1	Yes, through increase in farm incomes	$18.7
Wood	$90.3	Yes, as increase in logging activity	$72.3
Total	$273.4		$91.0

Estimates by University of Minnesota Extension Center for Community Vitality. Data for individual facilities submitted by seven companies. Assumes 14 proposed projects are completed, all of similar magnitude to seven case study companies.

These assumptions give rise to a series of caveats that should be considered in interpreting this analysis. Change in demand for corn, for example, may not increase corn production. However, it may drive changes in the price of corn. In addition, some by-products of the farming industry that may be diverted into biomass facilities may require farmers to adapt in other ways. Corn stover plays a role in maintaining soil health and preventing erosion. Excessive removal may necessitate paying to add nutrients back that were lost.

Operational Input Expenditures

While feedstocks comprise the largest portion of a biobased industrial product facility's budget, a facility will also make purchases for other inputs; i.e., utilities; maintenance and repair of equipment and buildings; and rent.

Table 2 shows the projected expenditures for operational inputs for the 14 potential facilities. In total, the facilities expect to spend $160.0 million dollars annually on operations beyond feedstock and labor costs.

[2] This analysis assumes 80 percent of wood projected to be used in production by the facilities is logged in Minnesota.

Table 2: Estimated Annual Direct Effect of Operational Input Expenditures of 14 Potential Biobased Industrial Product Facilities in Minnesota

Feedstock Type	Total Input Expenditures (Millions)
Sugar	$35.1
Biomass	$66.9
Wood	$58.0
Total	$160.0

Estimates by University of Minnesota Extension Center for Community Vitality. Data for individual facilities submitted by seven companies. Assumes 14 proposed projects are completed, all of similar magnitude to seven case study companies.

Labor Expenditures and Employment

A final component of expenditures by biobased industrial product facilities is payments to labor. The potential facilities, if fully operational at projected levels, would employ 590 people (table 3). The facilities would pay $36.8 million in wages, salaries, and benefits annually to those employees.

Table 3: Estimated Annual Direct Effect of Labor Expenditures and Employment of 14 Potential Biobased Industrial Product Facilities in Minnesota

Feedstock Type	Total Labor Expenditures (Millions)	Projected Number of Employees at Facilities
Sugar	$11.4	205
Biomass	$10.3	175
Wood	$15.1	210
Total	$36.8	590

Estimates by University of Minnesota Extension Center for Community Vitality. Data for individual facilities submitted by seven companies. Assumes 14 proposed projects are completed, all of similar magnitude to seven case study companies.

Indirect and Induced Effects

Now that the direct effects are quantified, the data can be entered into an input-output model. Input-output models trace the flow of dollars throughout a local economy and can capture the indirect and induced, or ripple, effects of economic activity. This study uses the input-output model called IMPLAN.

Indirect effects are those associated with a change in economic activity due to spending for goods and services directly tied to a business or industry. In this case, these are the changes in the local economy that will occur because the proposed biobased industrial product facilities need to purchase supplies (electricity, equipment, real estate, for example) and related services (training and

building maintenance, for example). Facility purchases create an increase in purchases across the supply chain. Indirect effects are the summary of these changes across an economy.

Induced effects are those associated with a change in economic activity due to spending by employees of businesses (labor) and by households. In this study, these are primarily economic changes related to expected spending by employees of the proposed facilities. It also includes household spending related to indirect effects. As employees make purchases locally, this triggers increases in purchases on that supply chain.

More information on direct, indirect, and induced effects is provided in appendix one.

Total Effect of Operations

If all 14 potential biobased industrial product facilities become fully functional, the facilities will create an estimated $837.6 million in economic activity annually in the state of Minnesota. The facilities will support 3,190 jobs and $174.1 million annually in wages, salaries, and benefits for those employees (table 4).

Operations impacts are annual, as long as the facilities maintain their projected levels of production. The impact will begin once the plants are operational, typically one to two years after construction begins. In some cases, the facilities will require a few years to reach full capacity, which these results represent. In general, impacts in table 4 reflect the situation about five years after the facilities begin construction.

Table 4: Estimated Annual Economic Contribution of the Operations of 14 Potential Biobased Industrial Product Facilities in Minnesota, On-Going Impacts

Impact Type		Employment	Labor Income (millions)	Output (millions)
Direct	At the 14 biobased facilities	590	$ 36.8	$ 470.3
Indirect	Supply chain related to inputs	2,150	$ 115.8	$ 304.0
Induced	Supply chain related to employee spending	450	$ 21.5	$ 63.3
Total		**3,190**	**$ 174.1**	**$ 837.6**

Estimates by University of Minnesota Extension Center for Community Vitality. Data for individual facilities submitted by seven companies. Assumes 14 proposed projects are completed, all of similar magnitude to those seven companies.

Top Industries Impacted

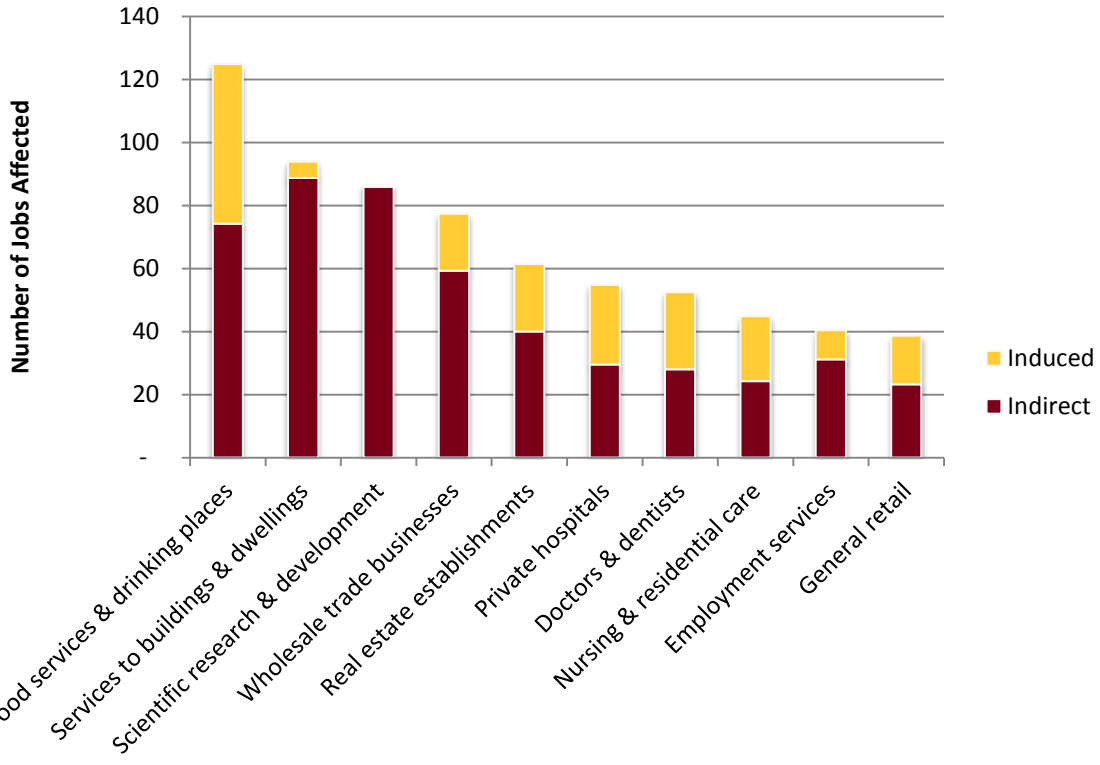
The 14 proposed biobased industrial product facilities will support an estimated 3,190 jobs in Minnesota. Of these, 590 jobs are at the facilities themselves. Thus, the facilities could potentially support 2,600 jobs at other businesses in the state. Of these 2,600 jobs, 920 are projected to be in the logging industry. As described above, the modeling assumptions allow for increased logging activity, but not for additional production of corn. However, corn producers will be making sales to the facilities, supporting their jobs. Highlighting logging jobs without describing the links to

agriculture potentially distorts the results. Given this complexity, this next section will examine the indirect effects related to feedstocks separately from the effects related to all other purchases for goods, services, and labor.

Chart 3 illustrates the top ten industries with jobs supported by expenditures from the potential biobased industry product facilities *for labor and for all non-feedstock goods and services*. These impacts are influenced by the kind of local expenditure. For example, one facility has its headquarters in Minnesota. As it reinvests its profits in research and development, jobs will be supported in that industry as well. Therefore, there are an estimated 85 jobs supported in research and development.

Induced effects are generated as a result of the potential facilities' employees spending their wages and salaries in the local economy. Health care is a major expenditure for most households; therefore, it is not surprising to see high induced impacts in those industries.

Chart 3: Top Industries Impacted by Potential Biobased Industrial Products Facilities: Indirect and Induced Impacts Created by Non-Feedstock Purchases



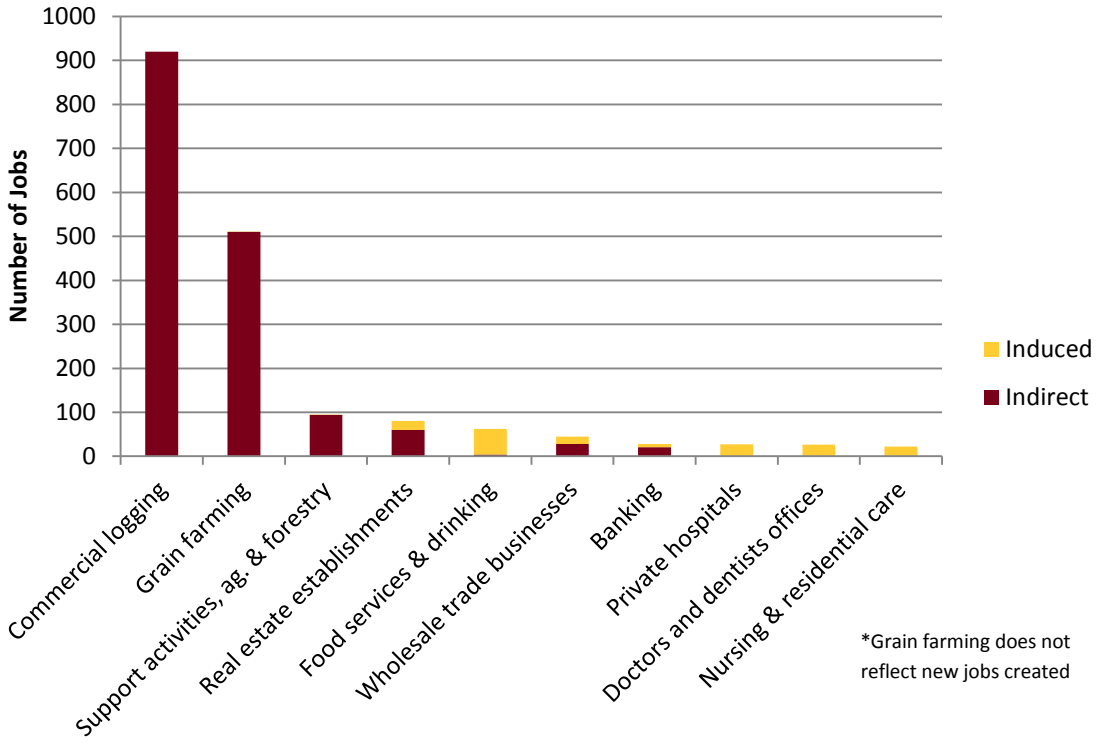
Many economic impact studies show relatively high employment impacts on the food services and drinking places industry. Expenditures here include restaurants and catering services. Since employment in this industry is often part-time, and in the model, one job is one job (regardless of full- or part-time status), employment impacts tend to be higher in this particular industry.

Chart 3 highlights the impacts driven by non-feedstock purchases. The proposed biobased industrial products facilities, however, will make significant expenditures for feedstocks. As discussed in this report, while increased demand for wood as a feedstock will likely drive increased logging activity,

increased demand for corn-based sugar will not necessarily increase corn production. Although corn production will not increase, corn producers' incomes will rely on sales to the biobased industrial products facilities. Chart 4 shows the indirect and induced effects related to the purchase of wood and corn in Minnesota. The number of corn producer jobs are not included in the total economic impact, but this chart illustrates the ties to agriculture of these facilities.[3]

The proposed biobased industrial products facilities would create an estimated 920 jobs in the logging industry in Minnesota. These are anticipated to be new jobs, as logging would increase to meet new demand for timber resources. The facilities would also support an estimated 510 grain farming jobs. These would not be new jobs, but rather the number of farm jobs tied to the production of grain feeding the proposed facilities. The proposed facilities would also support 94 jobs in industries supporting agriculture and forestry.

Chart 4: Top Industries Affected by Potential Biobased Industrial Products Facilities: Indirect and Induced Impacts Created by Feedstock Purchases



[3] Since biomass was modeled as an increase in farm incomes, the impact on grain production is not reflected in chart 4.

ECONOMIC CONTRIBUTION OF CONSTRUCTION OF BIOBASED INDUSTRIAL FACILITIES

The operations of the 14 proposed biobased industrial products facilities will create annual, on-going contributions to the economy of Minnesota once the facilities are fully operational. In the short-term, facilities will contribute to the economy of the state during the construction phase.

Direct Effects of Construction

The seven case study facilities provided to Extension estimated proposed construction costs to build their facilities. Construction costs were categorized by site acquisition, site preparation, construction of physical infrastructure, and purchases of equipment. Economic impact theory dictates that site acquisition does not create economic impact because it is a transfer of assets. Site preparation and construction of physical infrastructure were modeled as construction impacts. Since the equipment used in these facilities is highly specialized, and often not manufactured in Minnesota, equipment purchases in Minnesota were modeled at 25 percent of total projected costs.[4]

Construction of the proposed biobased industrial product facilities will result in an estimated $867.8 million of construction-related spending in Minnesota (direct effect in table 5). The construction activity will employ an estimated 4,380 workers and pay $303.4 million in labor income.

Total Effects of Construction

The total economic contribution of the construction of the 14 proposed biobased industrial product facilities would be an estimated $1.5 billion in Minnesota. Construction of the facilities would support an estimated 8,690 jobs. Workers in those jobs would earn an estimated $538.2 million in income.

Table 5: Estimated Potential Economic Contribution of the Construction of 14 Proposed Biobased Industrial Product Facilities in Minnesota, Temporary Impacts

Impact Type		Employment	Labor Income (millions)	Output (millions)
Direct	At the 14 biobased facilities	4,380	$ 303.4	$ 867.8
Indirect	Supply chain related to inputs	1,690	$ 112.7	$ 306.2
Induced	Supply chain related to employee spending	2,620	$ 122.1	$ 357.4
Total		**8,690**	**$ 538.2**	**$ 1,531.4**

Estimates by University of Minnesota Extension Center for Community Vitality. Data for individual facilities submitted by seven companies. Assumes 14 proposed projects are completed, all of similar magnitude to those seven companies.

[4] Twenty-five percent is consistent with other economic contribution studies done on biofuels by Extension. In the previous study, Extension had access to detailed records regarding the source of the equipment.

The economic effects of the construction in this analysis are cumulative. These impacts will be experienced in the state as the construction activities occur. Since these are *proposed* facilities, there is no measure of when they might be constructed or how long these construction activities may take. One would expect a fraction of these impacts in any given year, depending on which facilities are in progress. Further, these impacts are temporary. When construction activities are complete, the economic contribution will dissipate.

SUMMARY

Biobased industrial products are one component of the agbioscience industry in Minnesota. Given Minnesota's long history and tradition in the fields of agriculture and science, the state is positioned to be competitive in the agbioscience industry. Research conducted in 2012 (LifeScience Alley) indicated the biobased industrial product industry has the potential to add 12,000 jobs to the state economy by 2025.

This analysis examines the economic contribution of 14 potential biobased industry products facilities in Minnesota. Seven facilities currently under consideration for development in Minnesota were selected as representative case studies. The seven individual case studies were then scaled to represent 14 potential plants based on the likelihood of replicability. The facilities considered in the analysis would produce renewable chemicals, advanced biofuels, N-butanol, cellulosic ethanol, and renewable chemicals from sugar, wood, and biomass sources.

The 14 proposed biobased industrial facilities, at full capacity, will directly employ an estimated 590 individuals in Minnesota. They will pay an estimated $36.8 million annually in labor income to their employees. The facilities will spend an estimated $470.3 million annually in Minnesota to operate.

Expenditures by the 14 proposed facilities can be classified into three main categories: feedstock purchases, operational input purchases, and payments for labor. Feedstock expenditures constitute the most significant share of a biobased industrial product facility's spending. For each of the case study facilities, expenditures for feedstocks and the potential economic ripples associated with the purchase were carefully considered.

If all 14 potential biobased industrial facilities become fully functional, the facilities will contribute an estimated $837.6 million in economic activity in the state of Minnesota each year. The facilities will support an estimated 3,190 jobs and $174.1 million in wages, salaries, and benefits for those employees. This economic contribution includes output and employment at the facilities themselves, but also at businesses throughout the state that supply the facilities and their employees. Operations impacts will be annual, as long as the facilities maintain their projected levels of production.

The proposed facilities will support an estimated 3,190 jobs in Minnesota. Of these, 590 jobs are at the facilities, thus, the facilities have the potential to support 2,600 jobs at other businesses in the state. The top industries that would benefit from the expansion of the biobased industrial products industry include commercial logging; food services and drinking places; and services to buildings and dwellings. While no new farming jobs will be created, the model does indicate that 510 grain farming jobs will be supported by the new facilities. It also indicates an estimated 920 commercial logging jobs would be supported.

The total economic contribution of the construction of the 14 proposed biobased industrial product facilities would be an estimated $1.5 billion in Minnesota. The construction of the facilities would support an estimated 8,690 jobs. Workers in those jobs would earn an estimated $538.2 million in income. Construction impacts will be dispersed over the time period of construction activities. Once construction ends, the effects will dissipate.

The 14 potential biobased industrial products facilities have the potential to contribute an estimated $837.6 million in economic activity and 3,190 jobs to the state's economy.

APPENDIX ONE: METHODOLOGY

Special models, called input-output models, exist to conduct economic impact analysis. There are several input-output models available. IMPLAN (IMpact Analysis for PLANning, Minnesota IMPLAN Group)[5] is one such model. Many economists use IMPLAN for economic contribution analysis because it can measure output and employment impacts, is available on a county-by-county basis, and is flexible for the user. IMPLAN has some limitations and qualifications, but it is one of the best tools available to economists for input-output modeling. Understanding the IMPLAN tool, its capabilities, and its limitations will help ensure the best results from the model.

One of the most critical aspects of understanding economic impact analysis is the distinction between the "local" and "non-local" economy. The local economy is identified as part of the model-building process. Either the group requesting the study or the analyst defines the local area. Typically, the study area (the local economy) is a county or a group of counties that share economic linkages. In this study, the study area is the state of Minnesota.

A few definitions are essential in order to properly read the results of an IMPLAN analysis. The terms and their definitions are provided below.

Output

Output is measured in dollars and is equivalent to total sales. The output measure can include significant "double counting." Think of corn, for example. The value of the corn is counted when it is sold to the mill, again when it is sold to the dairy farmer, again as part of the price of fluid milk, and yet again when it is sold as cheese. The value of the corn is built into the price of each of these items and then the sales of each of these items are added up to get total sales (or output).

Employment

Employment includes full- and part-time workers and is measured in annual average jobs, not full-time equivalents (FTE's). IMPLAN includes total wage and salaried employees, as well as the self-employed, in employment estimates. Because employment is measured in jobs and not in dollar values, it tends to be a very stable metric.

Labor Income

Labor income measures the value added to the product by the labor component. So, in the corn example when the corn is sold to the mill, a certain percentage of the sale goes to the farmer for his/her labor. Then when the mill sells the corn as feed to dairy farmers, it includes some markup for its labor costs in the price. When dairy farmers sell the milk to the cheese manufacturer, they include a value for their labor. These individual value increments for labor can be measured, which amounts to labor income. Labor income does *not* include double counting.

Direct Impact

Direct impact is equivalent to the initial activity in the economy. In this study, it is spending by the proposed biobased industry product facilities in Minnesota.

[5] IMPLAN Version 3.0 was used in this analysis. The trade flows model with SAM multipliers was implemented.

Indirect Impact

The indirect impact is the summation of changes in the local economy that occur due to **spending for inputs** (goods and services) by the industry or industries directly impacted. For instance, if employment in a manufacturing plant increases by 100 jobs, this implies a corresponding increase in output by the plant. As the plant increases output, it must also purchase more inputs, such as electricity, steel, and equipment. As the plant increases purchases of these items, its suppliers must also increase production, and so forth. As these ripples move through the economy, they can be captured and measured. Ripples related to the purchase of goods and services are indirect impacts. In this study, indirect impacts are those associated with spending by biobased manufacturers for their supplies and inputs.

Induced Impact

The induced impact is the summation of changes in the local economy that occur due to **spending by labor**. For instance, if employment in a manufacturing plant increases by 100 jobs, the new employees will have more money to spend to purchase housing, buy groceries, and go out to dinner. As they spend their new income, more activity occurs in the local economy. Induced impacts also include spending by labor generated by indirect impacts. So, if the biobased facilities purchase services from a local tax preparer, spending of the tax preparer's wages would also create induced impacts. Primarily, in this study, the induced impacts are those economic changes related to spending by biobased industrial product facilities' employees.

Total Impact

The total impact is the summation of the direct, indirect, and induced impacts.

Input-Output, Supply and Demand, and Size of Market

Care must be taken when using regional input-output models to ensure they are being used in the appropriate type of analysis. If input-output models are used to examine the impact or the contribution of an industry that is so large that its expansion or contraction results in such major shifts in supply and demand that prices of inputs and labor change, input-output can overstate the impacts or contributions. This may be a concern in this study, as when these facilities come into full production, they do have the potential to change commodity prices. Care should be taken when interpreting the results. Further research may be warranted on this point.

APPENDIX TWO: WORKS CITED

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APPENDIX THREE: DESCRIPTION OF CASE-STUDY FACILITIES

This appendix provides descriptive detail about the proposed facilities selected as case studies. The facilities are categorized based on their primary feedstock: sugar, wood, or biomass. As case study data was provided confidentially to University of Minnesota Extension, the descriptions provided here are broad, but do give indications into the types of facilities considered.

Sugar-Based Feedstock Facilities

Three case study facilities propose to use sugar as their primary feedstock. These facilities will produce various renewable chemicals designed to replace petroleum-based equivalents. These case study facilities would use 60 to 280 million pounds of sugar per year, depending on the size of the facility and the product they will produce. The facilities are projected to produce 50 to 220 million pounds of final product per year, also depending on size and product. Investments in the projects are estimated to be between $35 and $200 million per facility.

Wood-Based Feedstock Facilities

Two case study facilities are projected to use wood as the primary feedstock. One case study facility is designed to provide community-scale heating from wood. The facility could serve both residential and commercial consumers. Total investment is the facility is anticipated to be $10 million. The other case study facility is designed to turn forest resources into cellulosic sugars which are then used to produce fuels and/or renewable chemicals. The novel renewable chemicals produced are designed to replace current petroleum-derived chemicals and renewable fuels in compliance with the federal Renewable Fuel Standard. The facility would use 100,000 to 500,000 tons of biomass (forest resources) per year depending on the size of the facility. Investment would be between $100 and $250 million.

Biomass-Based Feedstock Facilities

Two case study facilities plan on using biomass (non-forest resource) as their primary feedstock. One of the facilities proposes to use anaerobic digestion of agricultural processing and production residues to produce renewable fuels and agricultural crop nutrient products. The residues under consideration for use include chicken poultry litter, ethanol by-product, packing plant by-product, dairy farm waste, swine manure, and milk processing waste. The proposed facility will use approximately 450,000 tons of residue. Total investment is expected to be approximately $40 million. The other case study facility is designed to turn agricultural biomass into cellulosic sugars which are then used to produce fuels and/or renewable chemicals. This facility would be similar in general nature to the wood-based facility described above. The novel renewable chemicals produced are designed to replace current petroleum-derived chemicals and renewable fuels in compliance with the federal Renewable Fuel Standard. The facility would use 100,000 to 500,000 tons of biomass (such as corn stover, wheat straw, and switchgrass) per year depending on the size of the facility. Investment would be between $100 and $250 million.