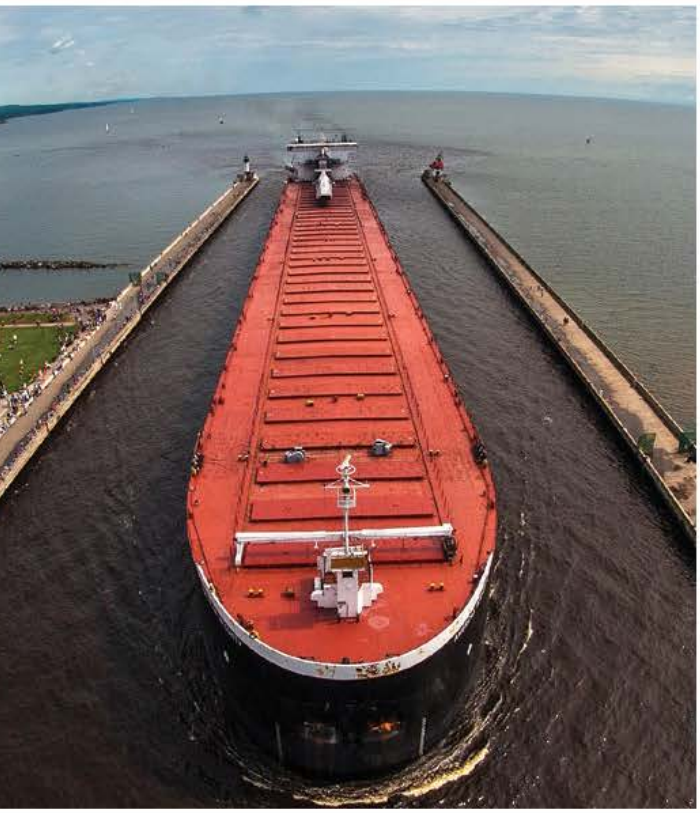
ECONOMIC IMPACT OF CURRENT AND 10-YEAR PROJECTIONS OF BIOFUELS PRODUCTION IN CANADA

January 15, 2021





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Executive Summary

Advanced Biofuels Canada, a national industry association established to promote the production and use of advanced biofuels, contracted with the Bureau of Business and Economic Research (BBER) at the University of Minnesota Duluth to identify and study the economic impact of increased biofuels production on six provinces in Canada pursuant to increased demand from federal and provincial fuel regulations.

The study includes the estimated economic impact of 2020 (baseline) biofuels production along with the projected (2030) economic impacts of additional biofuels production capacity based on two scenarios of lower and higher buildouts. Economic impacts are presented for the full study area (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec) as well the western (British Columbia, Alberta, Saskatchewan, and Manitoba) and central (Ontario and Quebec) regions individually. All results are shown in 2020 Canadian dollars. Inputs used in developing the economic impact models included baseline and projected production levels, revenue, and employment, as well as detailed industry spending for each biofuel type.

The two most common types of biofuels produced in Canada today are ethanol and biodiesel. However, some emerging technologies are likely to see increases in production levels in the coming years. These include hydrogenation-derived renewable diesel (HDRD, called renewable diesel in the U.S.) and coprocessing of vegetable oils, animal fats or pyrolysis oil (called biocrude), to produce renewable alternatives to diesel and gasoline. In addition, a number of firms are currently developing novel biofuel production technologies that are in the pre-production and demonstration phases; some of these are expected to achieve commercial production in the coming years.

Baseline Impacts (2020)

In 2020, there were 28 facilities located in the full study area that were actively producing biofuel or developing production capacity. Combined, these facilities produce approximately 2,500 million liters per year (MLY) of biofuels. Canada's central region (Ontario and Quebec) produced more than two-thirds of that total (1,700 MLY), primarily in the form of ethanol. By comparison, roughly half of the biofuels produced in the western provinces were biodiesel or coprocessed biofuels.

According to the results of modeling, biofuel production and pre-production facilities directly employed 1,585 workers in the study area in 2020 and supported another 11,441 jobs through indirect and induced effects, for a total contribution of more than 13,000 jobs to the study area's economy. Additionally, the industry annually supported $783 million in new labor income, nearly $1.7 billion in value added spending, and $5.3 billion in total output in the full study area.

Of the total effects, ethanol production supported nearly 8,800 jobs, $542 million in labor income, $1.2 billion in value added spending, and $3.7 billion in output to the study area's economy in 2020. This is more than half of the total effect for the industry overall. By comparison, biodiesel, biocrude, and coprocessing production supported roughly 3,750 jobs in the study area, added nearly $200 million in wages and benefits, contributed more than $400 million in value added, and added $1.5 billion in total output.

Projected Impacts (2030)

According to scenarios developed by the World Agricultural Economic and Environmental Services (WAEES) for Advanced Biofuels Canada, the biofuels industry could be producing between 4.6 and 6.1 billion liters annually by 2030, roughly double what was produced in 2020. The majority

of the fuel produced is expected to be from ethanol, but the WAEES results show significant growth in the production of HDRD, and adoption of coprocessing would also increase biocrude demand. Assuming that production/revenue and production/employment ratios hold constant, the research team estimates that the biofuels industry will directly employ between 3,184 and 4,450 workers by 2030.

This increased production will have a significant impact on Canada's economy. According to results of modeling, increased biofuel production could lead to an increase in economic impacts of anywhere from 97% to 188% by 2030, depending on the measure in question. For example, even assuming the more conservative estimate of production in 2030, the results suggest that expanded biofuel production in the full study area could create more than 12,600 new jobs, $842 million in additional labor income, $1.7 billion in additional value added spending, and $5.9 billion in additional output for the study area by 2030. This is over and above the baseline production levels. By comparison, if the industry were to expand more aggressively, additional biofuel production could create more than 21,800 new jobs, $1.3 billion in new wages and benefits, $2.7 billion in value added spending, and $10.0 billion in additional output in 2030, compared with the baseline.

Notably, HDRD production is expected to be established in the period and will likely see the strongest growth, leading to a sizable increase in the number of jobs supported. As the WAEES scenario modelling does not differentiate between biofuels production using HDRD or coprocessing technology platforms or associated impact on the production and use of biocrude feedstocks for these processes, we chose to represent the economic impact of these activities, collectively, as HDRD. By 2030, HDRD production could support between 8,000 and 13,000 jobs annually, overtaking biodiesel in terms of economic impacts. The biodiesel sector is expected to continue to expand and will see modest growth in the period. Biocrude feedstocks for HDRD, coprocessing, and biodiesel are expected to see strong growth in the period.

Ethanol is expected to lead biofuel production in 2030 in both scenarios. By 2030, ethanol production is projected to support between 14,000 and 17,000 jobs annually, an increase of 60% to 100% over current levels.

Regional Impacts

The research team also estimated the impacts of biofuel production on Canada's western (British Columbia, Alberta, Saskatchewan, and Manitoba) and central (Quebec and Ontario) provinces. In total, the biofuels industry contributed more than 7,700 jobs, $490 million in labor income, more than $1.0 billion in value added, and $3.3 billion in output to central Canada's economy in 2020. In the western region, the biofuels industry supported more than 4,100 jobs, $230 million in labor income, more than $500 million in value added, and $1.8 billion in output.

By 2030, the biofuels industry in central Canada could support between 7,600 and 13,000 additional jobs, $440 to $760 million in new labor income, $980 million to $1.7 billion in new value added spending, and $3.5 to $6.0 billion in additional output, over and above what is currently being produced. At the same time, increased production levels in western Canada could lead to 3,800 to 7,000 new jobs, $240 million to $420 million in additional labor income, $530 million to $930 million in new value added spending, and $2.0 billion to $3.6 billion in additional output for the four western provinces, over and above the baseline.

Economic Impact of Baseline and 10-Year Projections of Biofuels Production in Canada

I. Project Description

Advanced Biofuels Canada is a national industry associaton established to promote the production and use of advanced biofuels.[1] Advanced Biofuels Canada contracted with the Bureau of Business and Economic Research at the University of Minnesota Duluth's Labovitz School of Business and Economics to identify and study the economic impact of increased biofuels production in Canada pursuant to increased demand from federal and provincial fuel regulations.

The study includes the estimated economic impact of 2020 (baseline) biofuels production along with the projected (2030) economic impacts of two scenarios of lower and higher biofuels production capacity.

The study uses IMPLAN's 2012 Canadian dataset, which was prepared using Statistics Canada (Stat Can) as the main data source.[2] Compared to IMPLAN's 2015 Canadian dataset, the 2012 dataset allows the user to model impacts at the provincial level and provides a larger number of industries (103 versus 37), thereby giving the user more flexibility in modeling. All inputs and results are shown in 2020 Canadian dollars.

Figure 1. Canadian Provinces Included in Study Area

SOURCE: D-MAPS.COM, BBER

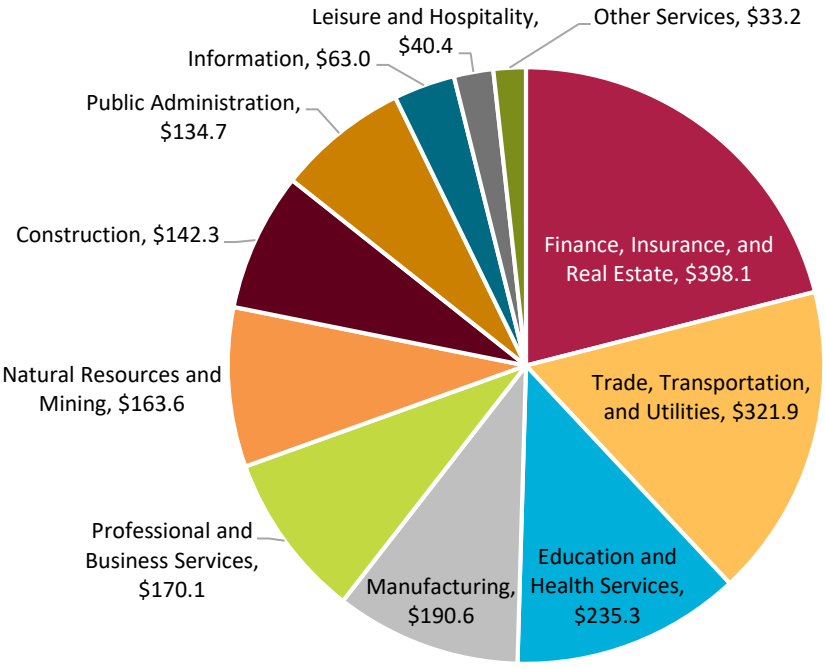
The geographic scope for this economic impact analysis includes the Canadian provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec. The analysis includes two groups of provinces based on region (the western provinces of British Columbia, Alberta, Saskatchewan, and Manitoba, and the central provinces of Ontario and Quebec), as well as both regions as a whole.

[1] For a full list of definitions used in this report, see Appendix A.
[2] For more details on IMPLAN's dataset and the assumptions for accepting the impact model, see Appendix B.

Figure 2 shows the gross domestic product (GDP) in Canada in August 2020 and the contribution to GDP by each sector.[3] According to Stat Can, the provinces included in the study area contributed $1.85 trillion to the country's $1.97 trillion GDP in 2019,[4] or 94% of the total GDP.

Finance, insurance, and real estate was the largest sector in the Canadian economy, contributing nearly $400 billion to the country's economy. A close second was the trade, transportation, and utilities sector, at $321 billion. Of particular relevance to this study is the manufacturing sector, which contributed $190 billion to Canada's GDP in August 2020. This sector includes the industries most similar to biofuel manufacturing, such as soybean and oilseed processing (NAICS 311224), wet corn milling (311221), petroleum refineries (324110), and organic chemical manufacturing (325199).

Figure 2. Gross Domestic Product (GRP) in Canada by Sector (August 2020)



Gross Domestic Product (GDP): $1.9 trillion

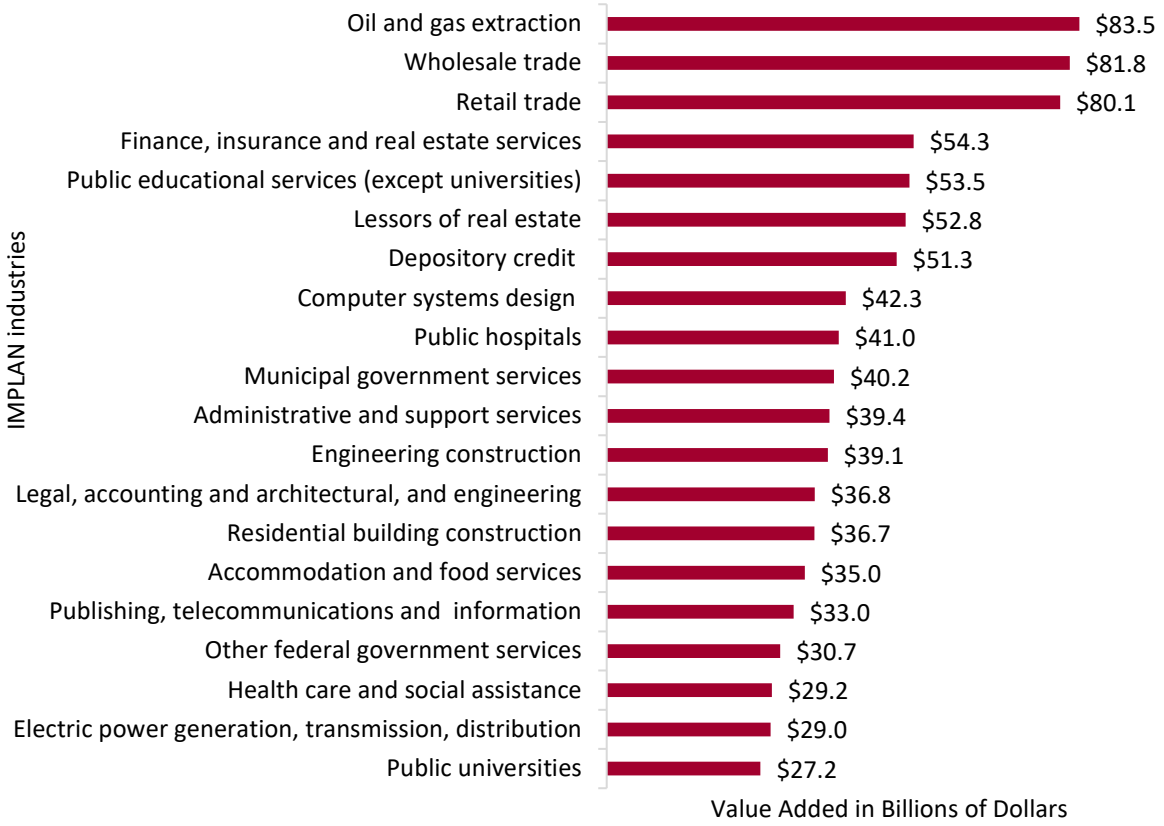
SOURCE: STAT CAN, 2020

Figure 3 on the following page shows the top twenty IMPLAN industries in the study area by value added, also known as the industry's contribution to gross regional product (GRP). The data shown come from

[3] Statistics Canada. Table 36-10-0434-02 gross domestic product (GDP) at basic prices, by industry, monthly, growth rates (x 1,000,000)
[4] Statistics Canada. Table 36-10-0402-01 gross domestic product (GDP) at basic prices, by industry, provinces and territories (x 1,000,000)

IMPLAN's 2012 Canadian dataset, which includes 103 industries in total. [5] Values shown were inflated to reflect 2020 Canadian dollars.[6]

Figure 3. Top 20 IMPLAN Industries in Study Area by Value Added (2012)



SOURCE: IMPLAN

These data are included to provide context for the results of modeling. For example, when comparing the economic impacts of the biofuels industry, we can compare the magnitude of the impact on certain industries, relative to the size of the industry in the study area overall.

[5] According to IMPLAN representatives, the most significant differences between the 2012 dataset and the current economic activity would relate to the relative share of intermediate expenditures/output and value added/output, which can fluctuate as other property income and proprietor income change. Employee compensation itself tends to be more stable, as does the composition of intermediate expenditures, which details the formula of commodities industries use to make their output.

[6] IMPLAN used an inflation rate of 1.564 to convert 2012 dollars into 2020 dollars.

II. Assumptions and Methodology

The following section describes the inputs required for modeling the impacts of the baseline (2020) and projected (2030) scenarios. Inputs include baseline and projected production levels, revenue, and employment, as well as detailed industry spending for each biofuel type.[7]

Baseline Production Levels (2020)

Table 1 shows 2020 biofuel production levels for the study area, broken out by type of biofuel (biodiesel, ethanol, pre-production) and region. The 2020 biodiesel category also includes small production volumes of coprocessing and biocrude production (one facility each). Additionally, the table shows the number of facilities producing each type of fuel and estimated total revenue or output[8] and employment.[9]

Table 1. Biofuel Production Levels, by Region, Type (2020)

Study Area	*Type of Biofuel*	*Number of Facilities*	*Est. Production (MLY)*	*Revenue/ Output (Millions of CAD)*	*Employees (FTE)*
Central	Biodiesel	4	170	$198.7	149
	Ethanol	7	1,529	$1,082.1	395
	Pre-production	4	0	$46.9	259
	Total	15	1,689	$1,327.7	803
West	Biodiesel	3	345	$326.3	440
	Ethanol	6	466	$329.7	251
	Pre-production	4	0	$16.4	91
	Total	13	811	$672.4	782
Combined	Biodiesel	7	515	$525.0	589
	Ethanol	13	1,995	$1,411.8	646
	Pre-production	8	0	$63.3	349
	Total	28	2,500	$2,000.1	1,584

SOURCE: BBER, ADVANCED BIOFUELS CANADA

As shown in the table, there were 28 facilities located in the study area in 2020 that were either actively producing some type of biofuel or were developing production capacity. Combined, these facilities are

[7] Production and employment estimates were provided by Advanced Biofuels Canada representatives, using the following data sources: NRCan ecoEnergy for Biofuels Program (https://www.nrcan.gc.ca/energy/alternative-fuels/programs/ecoenergy-biofuels/3599); NPRI: ECCC - GHG reporting National Pollutant Release Data (https://pollution-waste.canada.ca/national-release-inventory/archives/index.cfm?lang=en); Stat Can CIMT trade database (https://www5.statcan.gc.ca/cimt-cicm/home-accueil?lang=eng). In instances where data was not provided by the client, the research team relied on IMPLAN estimates and secondary data sources as inputs.

[8] Revenue = (reported 2019 production volume in liters * average 2019 wholesale price per liter * (1 + reported % income from co-products in 2019))

[9] Employment estimates for biofuel producers were reported in terms of full-time equivalent (FTE).

estimated to produce approximately 2,500 million liters per year (MLY) of biofuels, earn more than $2 billion in revenue, and employ more than 1,500 workers at their facilities.

The two most common types of biofuels in use today are ethanol and biodiesel, both of which represent the first large scale applications of biofuel technology.[10] Ethanol is a renewable alternative to gasoline that is predominantly made from various plant materials. In Canada, the most common feedstocks used for producing ethanol are corn and wheat. In 2020, there were 13 firms producing ethanol in the study area with a combined production level of nearly 2.0 billion liters. Biodiesel is often produced from new and used vegetable oils and animal fats and is a renewable, cleaner-burning replacement for petroleum-based diesel fuel.

Historically, Canadian biofuels production has been limited to the conventional biofuels of biodiesel and ethanol. In the past decade, the first commercial production of waste-based ethanol production, forest residue-based biocrude production, and coprocessing of animal fats and vegetable oils at a petroleum refinery were demonstrated in Canada. Other established and emerging technologies are expected to be brought into production in the coming years. These include establishing hydrogenation-derived renewable diesel (HDRD, called renewable diesel in the U.S.) production in Canada and further penetration of coprocessing of bio-based crude oils at Canadian refineries; these processes will produce lower carbon intensity diesel, jet, and gasoline products. In addition to animal fats and vegetable oils, coprocessing facilities may adopt pyrolysis oil (biocrude), derived from agriculture and forestry residues, or other non-fossil synthetic crude slates.[11] The benefit of HDRD and coprocessing is that both processes produce lower carbon fuels that essentially match or exceed the specifications for the fossil fuels they replace, giving them a drop-in capability.[12] For the purposes of the 2030 modelling, HDRD and coprocessing are considered as one production pathway (called HDRD herein). In 2020, there were seven firms producing biodiesel (5), biocrude (1), and coprocessing (1), with combined production levels of more than 500.0 MLY.

In addition, a number of firms are currently in the pre-production phase of developing novel biofuel production technologies and are hoping to produce at the commercial level in the coming years. In 2020, there were eight facilities in the study area that fell into the pre-production category. These firms functioned more like research and development operations and were not producing biofuels in any significant quantities; combined, they employed nearly 350 workers in 2020.

Of the 2,500.0 MLY of biofuel produced in the study area, Canada's central region (Ontario and Quebec) produced more than two-thirds of that total (1,700 MLY) in 2020. Most of the biofuel produced in the central region was in the form of ethanol. By comparison, roughly half of the biofuel produced in the western provinces was biodiesel (including a small amount of coprocessed biofuels). Both regions employed a similar number of workers, despite the discrepancy in production levels.

[10] https://www.energy.gov/eere/bioenergy/biofuels-basics

[11] For the purposes of this study, HDRD and coprocessing production capacity is represented as a single facility type (HDRD). HDRD production facilities could be stand-alone biorefineries or integrated with petroleum refineries; the primary fuel produced is renewable diesel, with lesser amounts of renewable naphtha, propane, and butane. Coprocessing facilities coprocess biocrude or other bio-based feedstocks (e.g. fats, vegetable oils) at existing petroleum refineries or upgraders; coprocessing facilities may produce renewable diesel, renewable gasoline, renewable jet fuel, and various co-products.

[12]https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/Refiners%20Interest%20Renewable%20Fuels_ENG.pdf

Projected Production Levels (2030)

Table 2 shows two scenarios with a range of production levels for ethanol, biodiesel, and HDRD in the study area in 2030. In the 2030 results, biocrude production and coprocessing are represented within the HDRD values to model economic impacts. The production volume data in this table were calculated by the World Agricultural Economic and Environmental Services (WAEES) for Advanced Biofuels Canada using a combination of different design conditions for the federal Clean Fuel Standard. The WAEES modelling compared four scenarios under the influence of Canada's upcoming Clean Fuel Standard. The values in Table 2 on the following page reflect a lower and a higher estimate of biofuels production resulting from two of the four scenarios.

Table 2. World Agricultural Economic and Environmental Services Forecasted Biofuel Production (2030)

	Low	***High***
Ethanol	3,160	3,981
Biodiesel	581	702
HDRD	904	1,428

SOURCE: WORLD AGRICULTURAL ECONOMIC AND ENVIRONMENTAL SERVICES (WAEES) FOR ADVANCED BIOFUELS CANADA

Using the data in Table 2, the research team distributed the estimated biofuel production levels across each geographic region using distribution levels provided by WAEES.[13] From there, the research team calculated the revenue[14] and employment[15] levels required for modeling. These estimates are shown in Table 3 on the following page.

[13] WAEES estimated a 25.3% west/74.7% central geographic distribution for the production of grain ethanol, a 53.6% west/46.4% central distribution for biodiesel, including the single biocrude and coprocessing facilities.

[14] Revenue = (forecasted production volume in liters * forecasted price per liter * (1 + reported % income from co-products in 2020))

[15] Employment estimates are based on 2019 revenue/employment ratios for each fuel type. These are as follows: Biodiesel = $1.21 million/worker; Grain Ethanol = $2.19 million/worker; pre-production = $0.18 million/worker. HDRD was an emerging industry in 2019, and thus its 2019 revenue/employment ratio ($0.62 million) is anticipated to grow significantly as the industry ramps up production. Therefore, the research team used the overall revenue/employment ratio for the biodiesel industry ($1.21 million) to calculate 2030 HDRD employment levels.

As shown in Table 3, estimated production, revenue, and employment are again broken out by type of biofuel and region, but now, HDRD is shown as a separate category due to the projected growth in that particular class of fuels (i.e., HDRD and coprocessing will produce renewable diesel, renewable gasoline, renewable jet fuel). Also, to align with the WAEES estimates, a range of values (low and high) are shown to reflect the uncertainty in the scenario modeling.

Table 3. Projected Production Levels (Low and High), 2030

Study Area	*Biofuel Type*	*Estimated Production (MLY)*		*Revenue/Output (Millions of CAD)*		*Employment (FTE)*	
		Low	High	Low	High	Low	High
Central	HDRD	483.0	763.0	$747.5	$1,199.9	616	989
	Biodiesel	269.5	325.6	$235.6	$292.4	194	241
	Ethanol	2,361.3	2,974.7	$1,981.5	$2,508.1	907	1,148
	Pre-production	-	-	$48.2	$65.0	266	358
	Total	3,113.8	4,063.3	$3,012.7	$4,065.4	1,983	2,736
West	HDRD	421.0	665.0	$651.5	$1,045.9	537	862
	Biodiesel	311.5	376.4	$272.4	$338.1	225	279
	Ethanol	798.7	1,006.3	$670.3	$848.4	307	388
	Pre-production	-	-	$25.9	$36.3	143	200
	Total	1,531.2	2,047.7	$1,620.1	$2,268.7	1,211	1,729
Combined	HDRD	904.0	1,428.0	$1,399.0	$2,245.8	1,153	1,852
	Biodiesel	581.0	702.0	$508.0	$630.5	419	520
	Ethanol	3,160.0	3,981.0	$2,651.7	$3,356.5	1,213	1,536
	Pre-production	-	-	$74.1	$101.3	408	558
	Total	4,645.0	6,111.0	$4,632.8	$6,334.1	3,194	4,466

SOURCE: ADVANCED BIOFUELS CANADA, BBER

According to these estimates, by 2030, it is projected that the biofuels industry will be producing between 4.6 and 6.1 billion liters annually, roughly double what was produced in 2020. The majority of the fuel produced is expected to be from ethanol, but WAEES modeling demonstrated significant growth in the production of HDRD, which is expected to increase biomass-based feedstocks, including biocrude demand. Assuming that production/revenue and production/employment ratios hold constant, the research team estimates that the industry will likely support between 3,194 and 4,466 jobs by 2030.

Industry Spending Patterns

The next step in modeling the economic impacts of the biofuel industry is attributing the industry's annual spending and employment to an appropriate IMPLAN sector. Within the 2012 Canadian IMPLAN dataset, there are three IMPLAN sectors that have the most similarities with biofuel production. These include sector 23—miscellaneous food manufacturing, sector 34—petroleum and coal product manufacturing, and sector 35—basic chemical manufacturing. In addition, sector 80—computer systems design and other professional, scientific, and technical services is most similar to pre-production research and development. However, the research team concluded that none of these sectors is an ideal match for biofuel production or pre-production, particularly when comparing the annual expenditures, or spending, for those industries (HDRD, biodiesel, ethanol, and pre-production) with the spending patterns for these sectors.

Table 4 shows annual expenditures by category for each type of biofuel. The estimates shown in the table were determined by aggregating existing spending patterns from similar studies and then verifying those estimates with Canadian biofuel producers in the industry. Separate spending patterns for ethanol produced from corn and wheat reflect the different feedstock used in production. The research team was not able to obtain spending patterns for HDRD specifically, so the biodiesel spending pattern was used as a proxy for that fuel type.

Table 4. Annual Spending Estimates for Biofuel Producers (2020)

Category	*Biodiesel/HDRD*	*Ethanol (Corn)*	*Ethanol (Wheat)*	*Pre-production*
Feedstock (corn, wheat, fats, oils)	78.6%	64.0%	64.0%	9.2%
Chemicals (denaturant, enzymes, yeasts)	8.0%	7.0%	8.0%	0.2%
Water	0.2%	--	--	0.2%
Electricity	0.8%	2.5%	3.0%	0.2%
Natural gas	1.1%	4.5%	4.7%	--
Waste disposal	1.0%	--	--	0.2%
Maintenance (buildings and grounds)	1.1%	1.0%	2.0%	0.8%
Transportation (rail, truck)	1.9%	1.0%	1.0%	5.5%
Royalties/licensing fees	0.5%	--	--	9.2%
Professional services	0.2%	1.0%	1.3%	1.2%
Insurance	0.4%	<0.1%	<0.1%	13.8%
Other expenses	0.7%	--	--	9.2%
Employee compensation (wages and benefits)	2.1%	4.0%	7.0%	46.5%
Depreciation, taxes, profits	3.4%	15.0%	9.0%	3.7%
Total	100.0%	100.0%	100.0%	100.0%

SOURCE: BBER, ADVANCED BIOFUELS CANADA

As shown in the table, the largest expense by far among commercial producers is the cost of feedstock. For biodiesel producers, nearly 80% of their annual budget was spent on feedstock (e.g. fats and oils). Feedstock costs are slightly lower for ethanol producers but are still very high overall at 64% of annual revenue. Firms in the pre-production phase spent less than 10% of their budget on feedstock, while nearly half of their budget (46.5%) went to wages and benefits.

Because of the unique characteristics of the biofuels industry and because industry representatives were able to provide fairly detailed budget information for the Canadian facilities' operations, the research team modeled the economic impacts using a technique called analysis by parts.

Analysis by parts is the process of splitting or parsing an impact analysis issue into smaller and more specific parts, and it allows the analyst to create a customized industry based on an existing budgetary spending pattern. This technique also gives the analyst the flexibility to specify the amount of commodity inputs, the proportion of local labor income, and the proportion of local purchases. To complete the impact analysis using analysis by parts, all expenditures shown in Table 4 were re-categorized as IMPLAN commodities. A list of the commodities used to create the customized biofuel industries are shown in Table 5 on the following page. One unique industry spending pattern was developed for each of the four biofuel types (biodiesel, corn

ethanol, wheat ethanol, and pre-production).[16] The green checks indicate that the sector was used in the fuel's industry spending pattern, while the red X's indicate that the sector was not used.

Table 5. Inputs Used in Each Industry Spending Pattern

Industry Description	*Biodiesel /HDRD*	*Ethanol (Corn)*	*Ethanol (Wheat)*	*Pre-Production*
3001 Crop and animal production	✓	✓	✓	✓
3005 Oil and gas extraction	✓	✓	✓	✗
3009 Support activities for mining and oil and gas extraction	✓	✗	✗	✓
3010 Electric power generation, transmission and distribution	✓	✓	✓	✓
3011 Natural gas distribution, water, sewage and other systems	✓	✓	✓	✓
3023 Miscellaneous food manufacturing	✓	✓	✓	✓
3030 Wood product manufacturing	✗	✗	✗	✓
3034 Petroleum and coal product manufacturing	✓	✓	✓	✓
3035 Basic chemical manufacturing	✓	✓	✓	✓
3039 Miscellaneous chemical product manufacturing	✓	✓	✓	✓
3044 Primary metal manufacturing	✓	✓	✓	✓
3045 Fabricated metal product manufacturing	✓	✓	✓	✓
3060 Wholesale trade	✓	✓	✓	✓
3063 Rail transportation	✓	✓	✓	✓
3064 Water transportation	✓	✗	✗	✓
3065 Truck transportation	✓	✓	✓	✓
3066 Transit, ground passenger and sightseeing, and support activities for transportation	✓	✗	✗	✓
3067 Pipeline transportation	✓	✓	✓	✗
3073 Depository credit intermediation and monetary authorities	✓	✓	✓	✓
3074 Insurance carriers	✓	✗	✗	✓
3075 Lessors of real estate	✓	✓	✓	✓
3077 Rental and leasing services and lessors of non-financial intangible assets	✓	✓	✓	✓
3079 Legal, accounting and architectural, engineering and related services	✓	✓	✓	✓
3080 Computer systems design and other professional, scientific and technical services	✓	✓	✓	✓
3083 Waste management and remediation services	✓	✗	✗	✓
3088 Repair and maintenance	✓	✓	✓	✓
3101 Other provincial and territorial government services	✓	✗	✗	✓

SOURCE: BBER AND IMPLAN

[16] In situations where values weren't available from producers (e.g. industry profits, proprietor income, etc.), the research team relied on IMPLAN averages from the related industries in both Canada and the U.S.

Using the four industry spending patterns shown in the table, the research team modeled the baseline (2020) and projected (2030 high and low) impacts of ethanol, biodiesel, HDRD, and pre-production through the analysis-by-parts method using. All results of modeling are shown in the following section.

III. Findings

Biofuel production, estimated at roughly 2,500 million liters per year (MLY) in 2020, has had a significant economic impact on Canada's economy. This section outlines the economic impacts of the industry's baseline and projected biofuel production levels. Results are shown first for the full study area of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec followed by the results for the two geographic regions (western and central provinces).[17]

Results first highlight the baseline production levels for the industry (2020) and are followed by projected economic impacts based on the scenario production levels in 2030. For all forecast impacts, a range of estimates (i.e. sensitivity analysis) is provided to show the possible range of impacts that could occur given the uncertainty surrounding the projections. Results are measured in employment, labor income, value added, and total output.[18] All results are shown in 2020 Canadian dollars (CAD).

Full Study Area

Baseline Production Levels (2020)

Table 6 shows the detailed economic impacts of the biofuels industry in the study area for the most recent year (2020). Rows in the table show the direct, indirect, induced, and total effects of the biofuels industry. The columns in the table represent employment,[19] labor income, value added, and output. All results are shown in 2020 dollars.

Table 6. Detailed Economic Impacts from Biofuel Production in Full Study Area, Millions of CAD (2020)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	1,585	$107.9	$319.6	$2,000.1
Indirect Effect	7,901	$480.7	$979.2	$2,543.7
Induced Effect	3,541	$195.0	$393.0	$740.6
Total Effect	13,026	$783.6	$1,691.7	$5,284.4
Multiplier	8.2	7.3	5.3	2.6

*Totals may not sum due to rounding

SOURCE: BBER

The first row of Table 6, labeled direct effects, represents the employment and spending coming from the biofuels industry itself on wages, equipment, and supplies. These estimates are based on the 2020 production estimates provided by Advanced Biofuels Canada and the corresponding employment and revenue estimates as shown in Table 1 on page 4. Indirect effects measure increased inter-industry spending on the part of regional businesses and suppliers as a result of the industry's direct spending. Induced effects

[17] Impacts were also modeled for each of the six provinces individually.
[18] For data sources and assumptions used in IMPLAN's input-output model, please see Appendix B.
[19] Employment is measured in terms of headcount, not full-time equivalent.

reflect an increase in household spending by employees at biofuel production facilities as well that for the employees of businesses that support the biofuels industry. Total effects are the sum of direct, indirect, and induced effects.

In addition to the three effect components, results are also shown in terms of employment, labor income, value added, and output. The column labeled employment in Table 6 shows the number of jobs that the industry supported directly and through induced and indirect effects. In 2020, biofuel production and pre-production employed over 1,500 workers. In addition, the biofuels industry supported another 11,441 jobs within the study area through indirect and induced effects. In total, the biofuels industry supported just over 13,000 jobs in Canada.

The column labeled labor income is the total of all employee compensation. This includes wages, benefits, and payroll taxes for full- and part-time workers. In 2020, the biofuels industry directly paid $107.9 million in wages and benefits to its employees. Additionally, the industry supported roughly $675 million in indirect and induced labor income during 2020 for a total of $783.6 million in labor income annually.

The column labeled value added refers to the contribution to the GDP made by an individual producer, industry, or sector. In this case, it's the biofuel industry. Value added includes employee compensation, proprietor income, and other property income and taxes. In 2020, the biofuels industry directly contributed $319.6 million to the study area's GDP, and it supported almost $1.4 billion in additional value added (the sum of the induced and indirect effects) in other industries, for a total value added effect of almost $1.7 billion. For reference, the amount of value added spending that biofuel production contributed in 2020 was roughly 1% of the total GDP in the study area.

Output, the last column in the table, is the total value of all local production required to sustain activities. In 2020, the biofuels industry created just over $2.0 billion annually in direct output. That, along with almost $3.3 billion in induced and indirect output, shows the biofuels industry created almost $5.3 billion in total output.

The last row in the table shows the multipliers associated with each effect. A multiplier indicates how much additional spending is added to the study area's economy for each dollar in new spending. For example, for every dollar in wages, benefits, and payroll taxes that was paid to biofuels employees, another $6.30 was paid to employees in other industries through indirect and induced spending effects. Likewise, for every dollar the biofuels industry spent in the study area (output) another $1.60 was spent in supporting industries.

It should be noted that the employment and labor income multipliers, in particular, are higher than is typical for most industries. There are a few explanations for this occurrence.

The first reason for the higher-than-average employment multipliers is related to discrepancies in how employment data are being reported. Employment estimates for biofuel producers were available only in terms of full-time equivalent (FTE). However, IMPLAN reports jobs in terms of workers, both full- and part-time. So, in the findings shown, direct employment effects represent FTE, while indirect and induced employment effects represent the total numbers of full- and part-time jobs supported in affected industries. This means that the multipliers shown are slightly higher than what would be the case if all jobs were being measured with the same units.

Second, as shown in Table 4 (annual spending estimates), biofuel producers reported fairly low profit margins and low employee wages/benefits relative to their overall annual spending, so a large majority of their revenue (90%+) was spent on intermediate expenditures (IE). In IMPLAN modeling, high rates of intermediate expenditures lead to higher indirect effects. Compounding this, a significant portion of the industry's annual spending (between 65% to 80%) goes to feedstock purchases (e.g. corn, wheat, fats, oils). These feedstock-

producing industries (e.g. farming, oilseed processing, corn milling) also spend a very high proportion of their revenue on intermediate expenditures, making indirect effects even larger. According to IMPLAN representatives, large labor income (and employment) multipliers are fairly common and tend to occur in industries with high IE/output rates.

The research team did, however, make some manual adjustments to the indirect effects which reduced the multipliers slightly.[20] According to Advanced Biofuels Canada, increased biofuel production has historically had a non-linear relationship to expansion in cropland and/or increases farm worker employment, as feedstock yields have increased over time. In the crop and animal production sectors, additional employment that is generated from higher yields is minimal, and may include some additional staff for trucking or crushing for vegetable oil, but experts would not expect to see a linear increase in employment, as the IMPLAN model assumes. To correct for these assumptions, the research team manually reduced the indirect effects for the crop and animal production sector, so that the new indirect effects in that sector reflect a higher output per worker.[21]

Table 7 shows total effects for each type of biofuel. According to the results of modeling, the production of biodiesel (including some volumes of biocrude and coprocessing) in 2020 supported 3,746 jobs in the study area, added $197.6 million in wages and benefits, contributed more than $413 million in value added, and added just over $1.50 billion in output (see Table 7). By comparison, ethanol production supported nearly 8,800 jobs, roughly $542 million in labor income, $1.22 billion in value added, and almost $3.67 billion in output to the study area's economy.

Table 7. Total Effects from Biofuel Production in Full Study Area, by Type of Biofuel, Millions of CAD (2020)

Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
Biodiesel	3,746	$197.6	$413.4	$1,501.9
Ethanol	8,717	$542.1	$1,221.6	$3,669.2
Pre-production	562	$43.9	$56.8	$113.3
Total Effect	13,026	$783.6	$1,691.7	$5,284.4

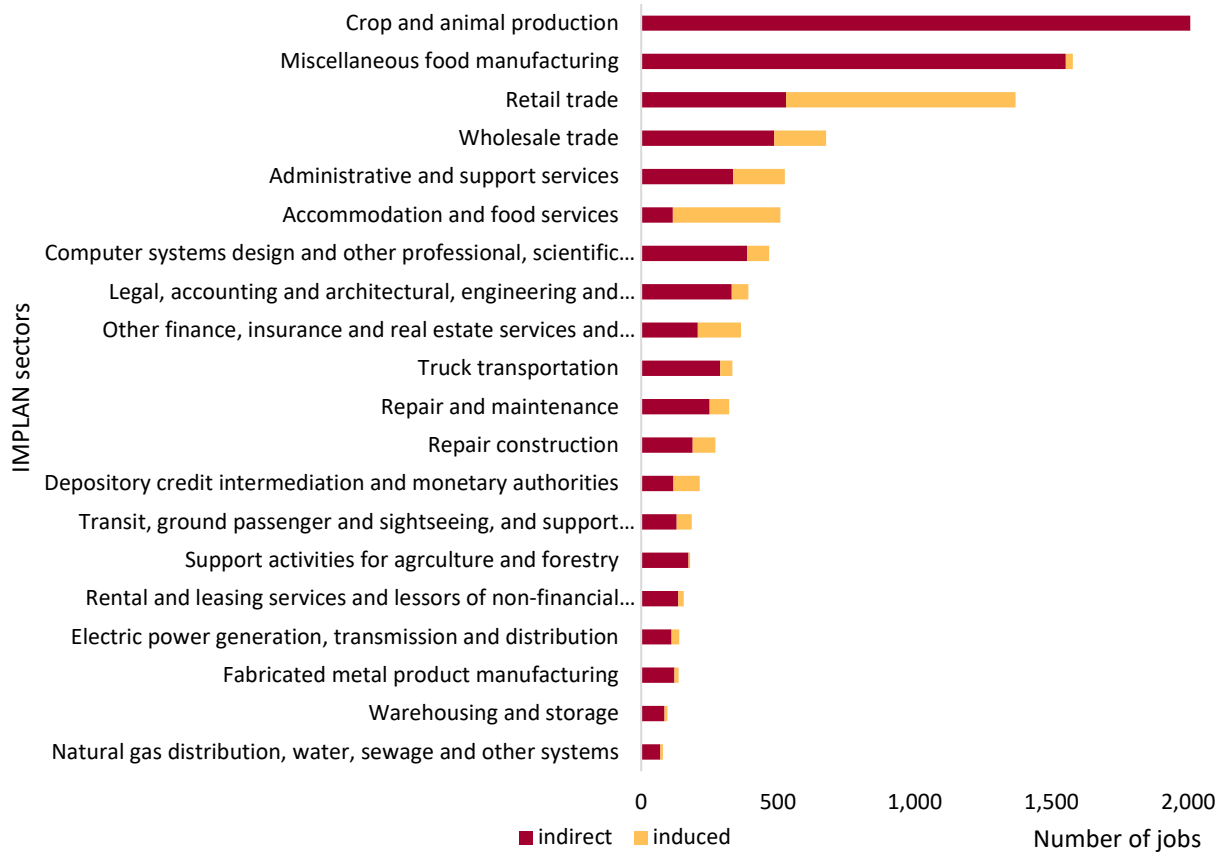
SOURCE: BBER

[20] The adjustments described here were made for all models in the report.

[21] IMPLAN's output per worker for the crop and animal production sector was $255,558 per worker, and the research team increased it to $1,022,242, an increase of 400%, based on recommendations from Advanced Biofuels Canada and other industry representatives.

Figure 4 shows the estimated employment impacts in the top twenty industries most impacted by biofuel production as measured by number of employees. Only indirect and induced impacts are shown in the chart as all direct effects are felt only within the biofuels industry. Heavily impacted industries include crop and animal production (n=2,145), miscellaneous food manufacturing (n=1,578), retail trade (n=1,410), and wholesale trade (n=676). The crop and animal production and miscellaneous food manufacturing sectors are both heavily affected from the purchase of feedstocks. The miscellaneous food manufacturing industry, for example includes wet corn milling, soybean and other oilseed processing, and fats and oils refining and blending. Crop and animal production includes the sale of all raw grains and seeds.

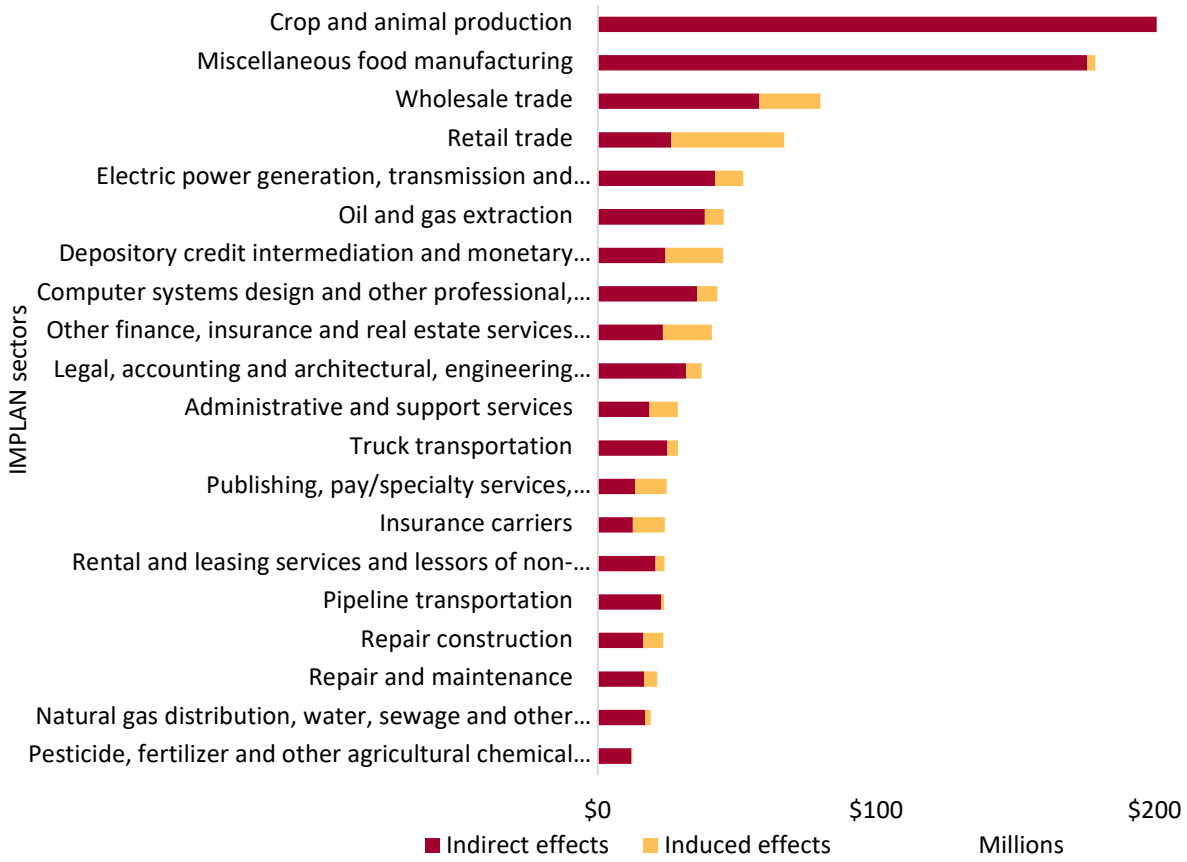
Figure 4. Top 20 Industries Impacted by Biofuel Production in Full Study Area, by Employment (2020)



SOURCE: IMPLAN

Figure 5 shows the top 20 industries impacted by biofuel production in terms of value added spending within the study area. Most of the same industries are shown in this chart, including miscellaneous food manufacturing, crop and animal production, and support activities for mining and oil and gas extraction, but there are some sectors that are more heavily impacted in terms of value added spending than employment. These include electric power transmission and distribution and oil and gas extraction, among others. For reference, the amount of value added spending that the biofuels industry contributed to the retail trade sector in 2020 was roughly 1.2% of that sector's value overall ($80.1 billion).

Figure 5. Top 20 Industries Impacted by Biofuel Production in Full Study Area, by Value Added, Millions of CAD (2020)



SOURCE: IMPLAN

Projected Production Levels (2030)

The biofuels industry is projected to increase production significantly in the coming decade. According to the World Agricultural Economic and Environmental Services (WAEES) modeling for Advanced Biofuels Canada, total biofuel production could increase from baseline levels of 2,500 MLY in 2020 to between 4,645 and 6,111 MLY in 2030. This increased production will have a significant impact on Canada's economy. This section outlines the projected economic impacts of the industry's projected biofuel production levels.

Tables 8 and 9 include the detailed economic impacts of low and high estimated production levels for 2030. Even assuming the more conservative estimate of production (Table 8), the biofuels industry could support

almost 26,000 jobs, over $1.6 billion in labor income, $3.4 billion in value added spending, and over $11.2 billion in total output in the study area by the year 2030. If the industry were to expand more aggressively (Table 9), those impacts could reach highs of nearly 35,000 jobs, just over $2.0 billion in labor income, almost $4.4 billion in value added spending, and nearly $15.2 billion in output for the study area.

Table 8. Detailed Economic Impacts of Biofuel Production in Full Study Area, Millions of CAD (2030, Low Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	3,188	$202.0	$636.2	$4,632.8
Indirect Effect	15,056	$1,015.4	$1,942.0	$5,028.2
Induced Effect	7,406	$407.9	$822.0	$1,549.2
Total Effect	25,650	$1,625.3	$3,400.3	$11,210.2
Multiplier	8.0	8.0	5.3	2.4

SOURCE: BBER

Table 9. Detailed Economic Impacts of Biofuel Production in Full Study Area, Millions of CAD (2030, High Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	4,465	$269.2	$687.1	$6,334.1
Indirect Effect	20,901	$1,272.2	$2,612.8	$6,904.1
Induced Effect	9,462	$521.2	$1,050.3	$1,979.3
Total Effect	34,828	$2,062.5	$4,350.2	$15,217.5
Multiplier	7.8	7.7	6.3	2.4

SOURCE: BBER

Table 10 compares the total effects of the baseline (2020) scenario with those of the projected (2030) scenarios. As shown in the table, by 2030, increased biofuel production could lead to an increase in economic impacts of anywhere from 97% to 188%, depending on the measure in question.

Table 10. Total Effects of Biofuel Production by Scenario for Full Study Area (and Change over Baseline), Millions of CAD

Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	13,026	$783.6	$1,691.7	$5,284.4
2030 Low Estimate	25,650	$1,625.3	$3,400.3	$11,210.2
Increase over Baseline	12,624	$841.7	$1,708.6	$5,925.8
% Change over Baseline	97%	107%	101%	112%
2030 High Estimate	34,828	$2,062.5	$4,350.2	$15,217.5
Increase over Baseline	21,802	$1,278.9	$2,658.5	$9,933.1
% Change over Baseline	167%	163%	157%	188%

SOURCE: BBER

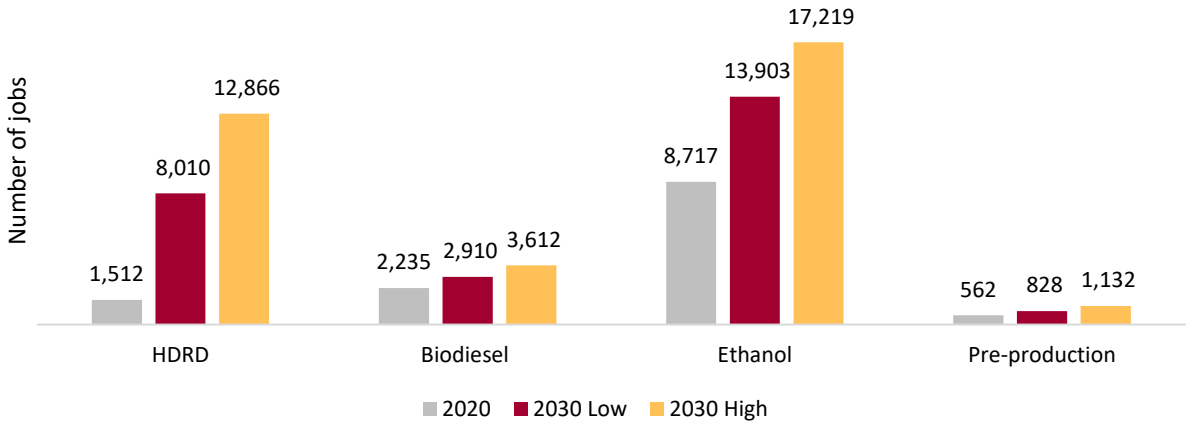
For example, even assuming the more conservative estimate of production in 2030, the results of modeling suggest that expanded biofuel production in the full study area could create roughly 12,600 new jobs, $841.7

million in additional labor income, over $1.7 billion in additional value added spending, and over $5.9 billion in total output for the study area by 2030, compared with the baseline.

By comparison, if the industry were to expand more substantially, additional biofuel production could create nearly 22,000 new jobs, $1.3 billion in new wages and benefits, $2.6 billion in value added, and nearly $10.0 billion in additional output in 2030, compared with the baseline.

Notably, HDRD/coprocessing production is expected to be established in the period and have the strongest growth, leading to a sizable increase in the number of total jobs supported (including direct, indirect, and induced effects). By 2030, HDRD and coprocessing production could support more than 8,000 to 13,000 jobs annually (see Figure 6), overtaking biodiesel in terms of total economic impacts. The biodiesel sector is expected to see more modest growth in the period, with employment rising to support 2,900 to 3,600 jobs by 2030. Ethanol is expected to lead biofuel production in 2030 in both forecast scenarios. By 2030, ethanol production is projected to support between 14,000 and 17,000 jobs annually, an increase of 60% to 100% over 2020 levels (see Figure 6).

Figure 6. Projected Total Employment Impacts for Full Study Area, by Type of Biofuel Production (2020, 2030 Low and High Estimates)



SOURCE: BBER

Central Canada

Baseline Production Levels (2020)

This section provides the direct, indirect, and induced economic impacts for the biofuels industry on the Canadian provinces of Quebec and Ontario (central Canada). Results highlight the baseline (2020) impacts of the industry's operations. Results are shown in 2020 Canadian dollars (CAD).

Table 11 on the following page shows the detailed economic impacts of the biofuels industry in the study area. In total, the biofuels industry contributed more than 7,700 jobs, nearly $500.0 million in labor income, more than $1.0 billion in value added, and nearly $3.3 billion in output to central Canada's economy in 2020. Also, the jobs multiplier for the industry was 9.7, meaning that, for every job added in the biofuels industry, another 8.7 jobs (part- and full-time) are supported elsewhere in the region in other related industries.

Table 11. Detailed Economic Impacts from Biofuel Production in Central Region, Millions of CAD (2020)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	803	$72.5	$239.0	$1,327.7
Indirect Effect	4,671	$292.0	$572.9	$1,497.3
Induced Effect	2,286	$126.6	$251.0	$472.2
Total Effect	7,760	$491.0	$1,062.8	$3,297.2
Multiplier	9.7	6.8	4.4	2.5

SOURCE: BBER

Table 12 shows the total effects for the different types of biofuel in the central region of the study area. Based on the model results, ethanol production for the central region had the highest overall effects. Ethanol production supported more than 6,000 jobs, nearly $400 million in labor income, nearly $900 billion in value added, and almost $2.7 billion in output to the study area's economy. Biodiesel and biocrude production in 2020 supported 1,314 jobs in the study area, added $72.6 million in wages and benefits, contributed almost $150 million in value added, and added $540.9 million in output.

Table 12. Total Effects from Biofuel Production in Central Region, by Type of Biofuel, Millions of CAD (2020)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Biodiesel	1,314	$72.6	$147.3	$540.9
Ethanol	6,055	$387.7	$876.7	$2,679.1
Pre-production	391	$30.7	$38.8	$77.2
Total Effect	7,760	$491.0	$1,062.8	$3,297.2

SOURCE: BBER

Projected Production Levels (2030)

Tables 13 and 14 show the projected range of economic impacts from biofuel production in the central provinces in 2030. Table 13 contains the more conservative estimates, while Table 14 shows the projected impacts of more substantial production. By 2030, the biofuels industry in central Canada could support between 15,000 and 20,000 jobs, between $0.92 billion and $1.26 billion in additional labor income, between $2.0 billion and $2.7 billion in value added, and between $6.8 billion and $9.3 billion in total output for the two central provinces of Ontario and Quebec.

Table 13. Detailed Economic Impacts from Biofuel Production in Central Region, Millions of CAD (2030, Low Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	1,983	$128.0	$449.7	$3,012.7
Indirect Effect	9,043	$560.5	$1,106.7	$2,920.8
Induced Effect	4,402	$243.7	$483.3	$909.5
Total Effect	15,428	$932.2	$2,039.8	$6,843.0
Multiplier	7.8	7.3	4.5	2.3

SOURCE: BBER

Table 14. Detailed Economic Impacts from Biofuel Production in Central Region, Millions of CAD (2030, High Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	2,736	$169.3	$583.7	$4,065.5
Indirect Effect	12,277	$759.6	$1,501.8	$3,972.4
Induced Effect	5,950	$329.4	$653.3	$1,229.2
Total Effect	20,963	$1,258.3	$2,738.8	$9,267.1
Multiplier	7.7	7.4	4.7	2.3

SOURCE: BBER

Table 15 compares the total effects of the baseline (2020) scenario with those of the projected (2030) scenarios for the central region. The first row in the table shows the total economic impacts of biofuel production in the geographic region in 2020, while rows two and five show the 2030 low and high estimates, respectively. The shaded rows represent the increase in economic impacts over the baseline, both as the difference and a percentage change. As shown in the table, by 2030, increased biofuel production could lead to an increase in economic impacts of anywhere from 90% to 181%, depending on the measure in question.

Table 15. Total Effects of Biofuel Production by Scenario for Central Region (and % Change over Baseline), Millions of CAD

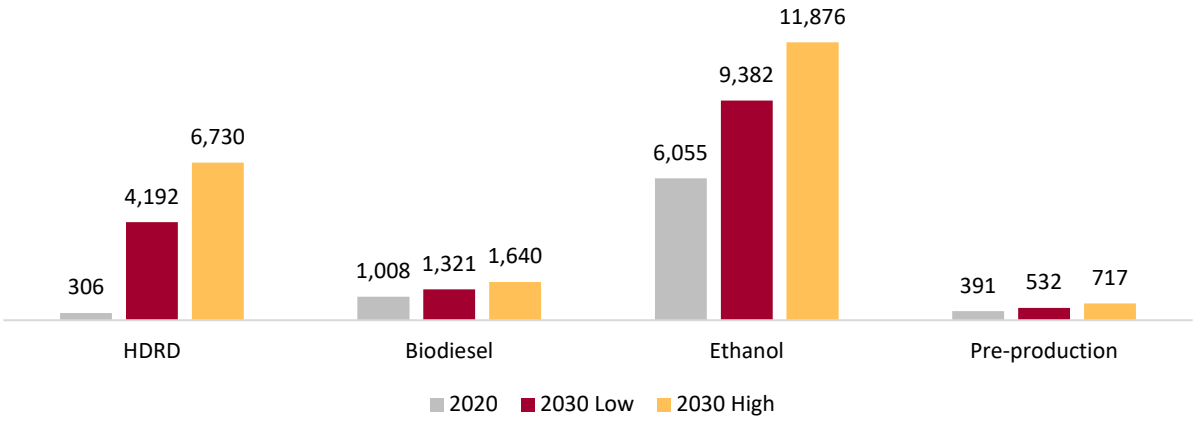
Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	7,760	$491.0	$1,062.8	$3,297.2
2030 Low Estimate	15,428	$932.2	$2,039.8	$6,843.0
Increase over Baseline	7,668	$441.2	$977.0	$3,545.8
% Change over Baseline	99%	90%	92%	108%
2030 High Estimate	20,963	$1,258.3	$2,738.8	$9,267.1
Increase over Baseline	13,203	$767.3	$1,676.0	$5,969.9
% Change over Baseline	170%	156%	158%	181%

SOURCE: BBER

By 2030, the biofuels industry in Ontario and Quebec provinces could support between 7,700 and 13,200 additional jobs, between $440 and $760 million in new labor income, between $980 million and $1.7 billion in new value added spending, and between $3.5 billion and $6.0 billion in additional output for the two central provinces, over and above what is currently being produced.

In the central region, the growth in economic impacts is expected to come primarily from the establishment and rapid expansion of HDRD, coprocessing, and ethanol, with moderate growth in biodiesel production, as shown in Figure 7. By 2030, ethanol production is projected to support between 9,400 and 11,900 jobs annually (including direct, indirect, and induced effects), an increase of 50% to 100% over baseline levels.

Figure 7. Projected Total Employment Impacts for Central Region, by Type of Biofuel Production (2020, 2030 Low and High Estimates)



SOURCE: BBER

Western Canada

Baseline Production Levels (2020)

This section provides the direct, indirect, and induced economic impacts for the biofuels industry on the western Canadian provinces of British Columbia, Alberta, Saskatchewan, and Manitoba. Results are based on baseline (2020) production estimates and are shown in 2020 dollars.

Table 16 shows the detailed economic impacts of the biofuels industry in terms of employment, labor income, value added, and output. In 2020, 782 jobs were supported directly by the biofuels industry, and 3,344 additional jobs were indirectly supported by the industry in the western provinces for a total employment effect of 4,126 jobs in 2020 (5.3 multiplier). In total, the biofuels industry added more than $231 million in labor income, $506 million in value added spending, and nearly $1.8 billion in output to the western provinces' economy in 2020.

Table 16. Detailed Economic Impacts from Biofuel Production in Western Region, Millions of CAD (2020)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	782	$35.4	$80.6	$672.4
Indirect Effect	2,353	$143.5	$316.9	$892.0
Induced Effect	991	$52.5	$108.5	$201.8
Total Effect	4,126	$231.4	$506.0	$1,766.2
Multiplier	5.3	6.5	6.3	2.6

SOURCE: BBER

Table 17 shows the total effects for the different types of biofuel in the western region of the study area. Based on the model results, the production of biodiesel and coprocessing in 2020 supported 2,151 jobs in the study area, added $106 million in wages and benefits, contributed $232.2 million in value added, and added

almost $900 million in output. Ethanol production accounted for 1,819 jobs, $113.5 million in labor income, $258.0 million in value added, and $834.9 million in output to the study area's economy.

Table 17. Total Effects from Biofuel Production in Western Region, by Type of Biofuel, Millions of CAD (2020)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Biodiesel	2,151	$106.0	$232.2	$899.7
Ethanol	1,819	$113.5	$258.0	$834.9
Pre-production	156	$11.9	$15.8	$31.6
Total Effect	4,126	$231.4	$506.0	$1,766.2

SOURCE: BBER

Projected Production Levels (2030)

Tables 18 and 19 show the projected range of economic impacts from biofuel production in the western provinces in 2030. Table 18 contains the more conservative estimates, while Table 19 shows the projected impacts if production ramps up more substantially. By 2030, the biofuels industry in western Canada could support between nearly 8,000 and 11,100 jobs, between $468 million and $650 million in additional labor income, between $1.04 billion and $1.44 billion in value added, and between $3.81 billion and $5.35 billion in total output for the four western provinces of British Columbia, Alberta, Saskatchewan, and Manitoba.

Table 18. Detailed Economic Impacts from Biofuel Production in Western Region, Millions of CAD (2030, Low Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	1,212	$74.0	$186.5	$1,620.1
Indirect Effect	4,811	$289.5	$635.4	$1,788.2
Induced Effect	1,976	$104.7	$216.4	$402.2
Total Effect	7,999	$468.2	$1,038.2	$3,810.5
Multiplier	6.6	6.3	5.6	2.4

SOURCE: BBER

Table 19. Detailed Economic Impacts from Biofuel Production in Western Region, Millions of CAD (2030, High Estimate)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	1,729	$99.9	$248.5	$2,268.6
Indirect Effect	6,625	$402.1	$888.5	$2,520.7
Induced Effect	2,764	$146.5	$302.8	$562.9
Total Effect	11,118	$648.5	$1,439.8	$5,352.2
Multiplier	6.4	6.5	5.8	2.4

SOURCE: BBER

Table 20 compares the total effects of the baseline scenario in 2020 with the projected total effects for 2030 (low and high estimates). According to the results of modeling, employment in biofuel production could increase anywhere from 94% to 169% from 2020 to 2030, labor income could increase anywhere from 102% to 180%, value added could increase by more than 100%, and output could increase between 116% and 203% from 2020 to 2030 in Canada's western region.

Table 20. Total Effects of Biofuel Production by Scenario for Western Provinces (and % Change over Baseline), Millions of CAD

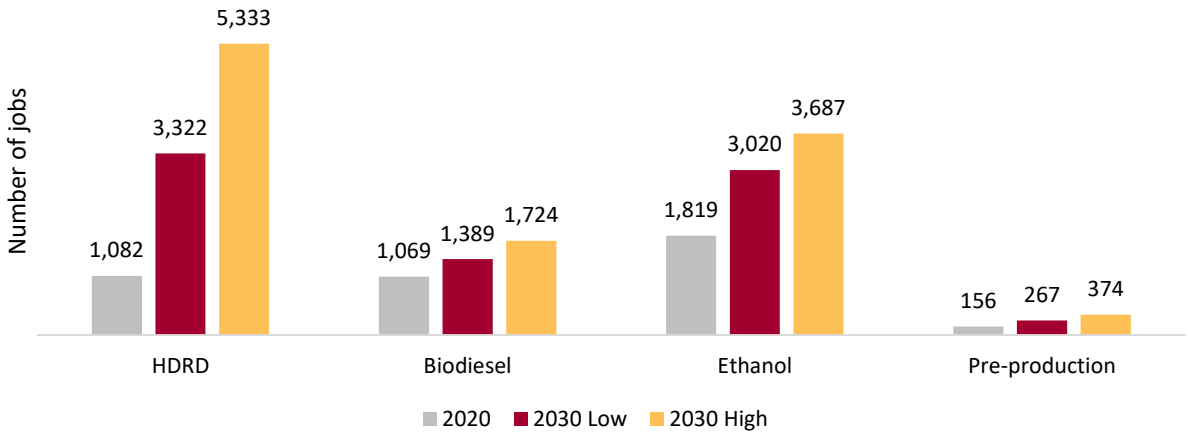
Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	4,126	$231.4	$506.0	$1,766.2
2030 Low Estimate	7,999	$468.2	$1,038.2	$3,810.5
Increase over Baseline	3,873	$236.8	$532.2	$2,044.3
% Change over Baseline	94%	102%	105%	116%
2030 High Estimate	11,118	$648.5	$1,439.8	$5,352.2
Increase over Baseline	6,992	$417.1	$933.8	$3,586.0
% Change over Baseline	169%	180%	185%	203%

SOURCE: BBER

Based on the forecast growth for the biofuels industry, increased production levels in western Canada could lead to between 3,800 and 7,000 new jobs, between $236 million and $417 million in additional labor income, between $532 million and $934 million in new value added spending, and between $2.0 billion and $3.6 billion in additional output for the four western provinces, over and above the baseline.

Figure 8 shows the projected total employment impacts (sum of direct, indirect, and induced effects) for each type of biofuel production in 2030. According to the results of modeling, HDRD and coprocessing production could expand to support between 3,300 and 5,300 jobs annually, potentially surpassing ethanol in terms of job creation in the western provinces. Biodiesel production is projected to support between 1,100 and 1,700 jobs and pre-production is projected support between 150 and 380 jobs in 2030.

Figure 8. Projected Total Employment Impacts for Western Region, by Type of Biofuel Production (2020, 2030 Low and High Estimates)



SOURCE: BBER

IV. Conclusions

In 2020, biofuel production and pre-production facilities directly employed 1,585 workers in the study area and supported another 11,441 jobs through indirect and induced effects, for a total contribution of over 13,000 jobs to the economy of the full study area (see Table 21). Additionally, the industry supported almost $784 million in labor income, nearly $1.7 billion in value added spending, and almost $5.3 billion in total output in the full study area. For every dollar in wages, benefits, and payroll taxes paid to biofuels employees, another $6.30 was paid to employees in other industries through indirect and induced spending effects (7.3 multiplier). Likewise, for every dollar the biofuels industry spent in the study area (output) another $1.60 was spent in supporting industries as a result.

Table 21. Economic Impacts of All Biofuel Production, Full Study Area (2020 Baseline, in Millions of CAD)

Impact Type	*Employment*	*Labor Income*	*Value Added*	*Output*
Direct Effect	1,585	$107.9	$319.6	$2,000.1
Indirect Effect	7,901	$480.7	$979.2	$2,543.7
Induced Effect	3,541	$195.0	$393.0	$740.6
Total Effect	13,026	$783.6	$1,691.7	$5,284.4
Multiplier	8.2	7.3	5.3	2.6

SOURCE: BBER

The biofuels industry is projected to increase production significantly in the coming decade. According to the World Agricultural Economic and Environmental Services (WAEES) estimates for Advanced Biofuels Canada, total biofuels production could increase from its baseline levels of 2,500 million liters per year (MLY) in 2020 to somewhere between 4,645 and 6,111 MLY in 2030. This increased production will have a significant impact on Canada's economy. For example, even assuming the more conservative projection of production in 2030, the results of modeling suggest that expanded biofuel production in the full study area could create nearly 12,600 new jobs, $840 million in additional labor income, $1.7 billion in additional value added spending, and $5.9 billion in total output for the study area by 2030, compared with the baseline (see Table 22).

Table 22. Total Effects of Biofuel Production by Scenario for Full Study Area (and Change over Baseline), Millions of CAD

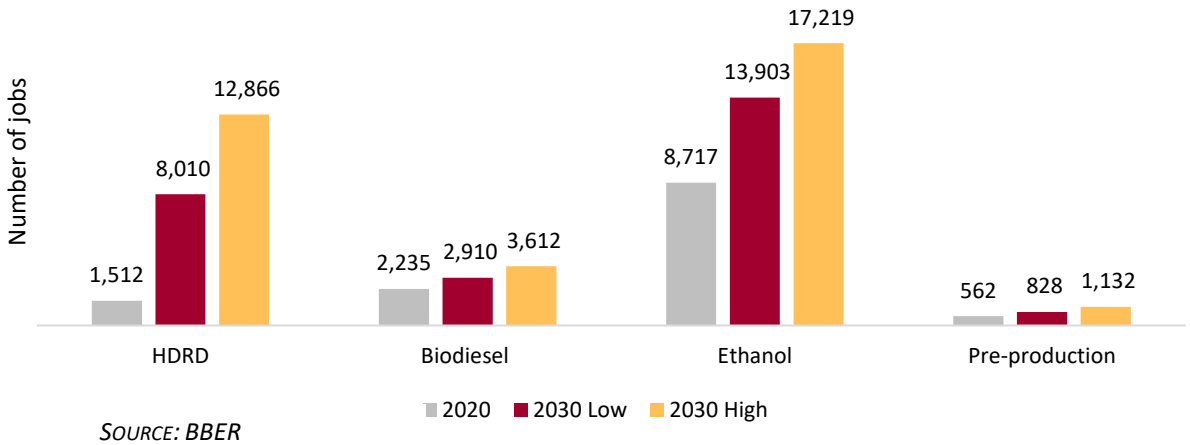
Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	13,026	$783.6	$1,691.7	$5,284.4
2030 Low Estimate	25,650	$1,625.3	$3,400.3	$11,210.2
Increase over Baseline	12,624	$841.7	$1,708.6	$5,925.8
% Change over Baseline	97%	107%	101%	112%
2030 High Estimate	34,828	$2,062.5	$4,350.2	$15,217.5
Increase over Baseline	21,802	$1,278.9	$2,658.5	$9,933.1
% Change over Baseline	167%	163%	157%	188%

SOURCE: BBER

By comparison, if the industry were to experience greater expansion, additional biofuel production could create more than 21,000 new jobs, almost $1.3 billion in new wages and benefits, almost $2.7 in value added, and just over $9.9 billion in additional output in 2030, compared with the baseline.

Notably, HDRD and coprocessing production is expected to be established in the timeframe and will likely see the strongest growth, leading to a sizable increase in the number of jobs supported. The biodiesel sector is expected to continue to expand and will see modest growth in the period. Biocrude feedstocks for HDRD, coprocessing, and biodiesel are expected to see strong growth in the period. Ethanol is expected to lead biofuel production in 2030 in both forecast scenarios. By 2030, ethanol production could support between 14,000 and 17,000 jobs annually, an increase of 60% to 100% over baseline levels (see Figure 9).

Figure 9. Projected Total Employment Impacts for Full Study Area, by Type of Biofuel Production (2020, 2030 Low and High Estimates)



SOURCE: BBER

Lastly, Tables 23 and 24 show the total effects for the western (British Columbia, Alberta, Saskatchewan, and Manitoba) and central (Ontario and Quebec) regions individually. Total effects represent the sum of direct, indirect, and induced effects. The first row in each table shows the total economic impacts of biofuel production in the geographic region in 2020. In 2020, the biofuels industry supported roughly 7,700 jobs and over $3.2 billion in output in the central provinces and roughly 4,100 jobs and almost $1.8 billion in output in the western provinces.

Table 23. Total Effects of Biofuel Production in Central Provinces, by Year (Millions of CAD)

Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	7,760	$491.00	$1,062.80	$3,297.20
2030 Low Estimate	15,428	$932.20	$2,039.80	$6,843.00
2030 High Estimate	20,963	$1,258.30	$2,738.80	$9,267.10

SOURCE: BBER

Table 24. Total Effects of Biofuel Production in Western Provinces, by Year (Millions of CAD)

Total Effects	*Employment*	*Labor Income*	*Value Added*	*Output*
2020 Baseline	4,126	$231.40	$506.00	$1,766.20
2030 Low Estimate	7,999	$468.20	$1,038.20	$3,810.50
2030 High Estimate	11,118	$648.50	$1,439.80	$5,352.20

SOURCE: BBER

The second row shows the economic impacts of a conservative projection of production in 2030 (low projection), while the last row in each table shows the economic impacts of a higher demand projection for the industry. By 2030, the biofuels industry in central Canada could support between 15,400 and 20,900 jobs, between $900 million and $1.26 billion in additional labor income, between $2.0 billion and $2.7 billion in value added, and between $6.8 billion and $9.3 billion in total output for the two central provinces of Ontario and Quebec. By comparison, the industry in western Canada could support between 8,000 and 11,100 jobs, between $468 million and $650 million in additional labor income, between $1.0 billion and $1.4 billion in value added, and between $3.8 billion and $5.4 billion in total output for the four western provinces.

Appendix A. Definitions Used in this Report

Biocrude – A liquid, intermediate bio-based fuel that must be upgraded by chemical or biological processes for use as a finished fuel.

Biodiesel – A renewable alternative to diesel, biodiesel is produced from new and used vegetable oils and animal fats and is a cleaner-burning replacement for petroleum-based diesel fuel.

Biofuels – Any fuels derived from biomass—that is, plant or algae material or animal waste. Biofuel is considered to be a source of renewable energy.

Commodity – A product or service. It may be produced by one or multiple Industries or institutions.

Coprocessed – The act of processing something with or at the same time as something else. Coprocessing animal fats, vegetable oil, or biocrude will yield renewable finished fuels, such as renewable gasoline, renewable diesel, and renewable jet fuel.

Corn milling – Breaking down corn into its components of corn oil, protein, cornstarch, and fiber.

Direct effects – A set of expenditures, either positive or negative, applied to the I-O multipliers for impact analysis. Direct effects represent the initial new spending in the study area resulting from the project in question.

Ethanol – A colorless volatile flammable liquid, C_2H_5OH, which is the intoxicating agent in liquors and also used as a solvent and in fuel.

Feedstock – Raw material supplied to a machine or processing plant. Feedstock used to produce biofuels include sugars/starches, fibers/grasses, oil, crop residues, manures and organic wastes, and wood and woody biomass.

Gross Domestic Product (GDP) – The final market value of all goods and services produced by labor and property in a nation in a certain time frame (typically a year).

Gross Regional Product (GRP) – The final market value of all goods and services produced by labor and property in a region in a certain time frame (typically a year).

HDRD – Hydrogenation-derived renewable diesel (HDRD), a renewable diesel produced by hydrotreating animal fats or oil-based feedstock.

IMPLAN – An economic impact assessment modeling system. IMPLAN allows the user to easily build economic models to estimate the impacts of economic changes in their states, counties, or communities, such as when a new firm enters a study area.

Indirect effect – Economic effects stemming from business-to-business purchases in the supply chain. For example, increased sales in linen supply firms resulting from more motel sales would be an indirect effect of visitor spending.

Induced effect – Economic effects stemming from household spending of labor income after removal of taxes, savings, and commuter income. For example, motel employees spend the income they earn from increased tourism on housing, utilities, groceries, and other consumer goods.

Industry – A group of establishments engaged in the same or similar types of economic activity.

Intermediate Expenditures – Purchases of non-durable goods and services that are used to produce other goods and services rather than for final consumption.

Jobs – An industry-specific mix of full-time, part-time, and seasonal employment. An annual average that accounts for seasonality. In IMPLAN, employment is not equal to full time equivalents.

Labor income –All forms of employment income, including employee compensation (wages and benefits) and proprietor income.

Multipliers – Multipliers are rates of change that describe how a given change in a particular industry generates impacts in the overall economy (e.g. for every dollar spent in the economy an additional $0.25 of economic activity is generated locally, implying a multiplier of 1.25). Multipliers may be constructed for output, employment, and every component of value added.

Oilseed – A seed or crop grown mainly for oil.

Other Property Income (OPI) – Calculated as gross operating surplus minus proprietor income; OPI includes consumption of fixed capital (CFC), corporate profits, and business current transfer payments (net).

Petroleum – A mixture of hydrocarbons with small amounts of other substances that makes an oily flammable bituminous liquid.

Proprietor income – The current-production income of sole proprietorships, partnerships, and tax-exempt cooperatives—excluding dividends, monetary interest received by nonfinancial business, and rental income received by persons not primarily engaged in the real estate business.

Sector – The institutional units that make up the total economy in the national economic accounts: business, households and institutions, and general government. In the North American Industry Classification System (NAICS), sectors are one of the 20 major areas of economic activity.

Taxes on Production & Imports (TOPI) – Includes sales and excise taxes, customs duties, property taxes, motor vehicle licenses, severance taxes, other taxes, and special assessments. Because TOPI is net of subsidies, it can be negative for a given Industry in a given year if that Industry received more subsidies from the government than it paid out in these specific taxes in that year.

Value added – The difference between an industry's (or establishment's) total output and the cost of its intermediate inputs; it is a measure of the contribution to GDP. Value added is a large portion of output, as it encompasses labor income (LI), other property income (OPI), and taxes on production and imports (TOPI).

Appendix B. Input-Output Modeling

Data Sources

This study uses the IMPLAN Group's input-output modeling data and software (IMPLAN version 3.1). The study uses IMPLAN's 2012 Canadian dataset, which was prepared using Statistics Canada (Stat Can) as the main data source.[22] Compared to IMPLAN's 2015 Canadian dataset, the 2012 dataset allows the user to model impacts at the provincial level and provides a larger number of industries (103 versus 37), thereby giving the user more flexibility in modeling. All inputs and results are shown in 2020 Canadian dollars.

IMPLAN data files consist of the following components: employment, industry output, value added, institutional demands, national structural matrices, and inter-institutional transfers.

Economic impacts are made up of direct, indirect, and induced impacts. The following are suggested assumptions for accepting the impact model: IMPLAN input/output is a production-based model, and employment numbers (from Stat Can) treat both full- and part-time individuals as being employed.

Regional data for the impact models for value added, employment, and output are supplied by IMPLAN for this impact. Employment assumptions were provided to the model to enable construction of the impact model. From these data, social accounts, production, absorption, and byproducts information were generated from the national level data and was incorporated into the model. All region study definitions and impact model assumptions were agreed on with Advanced Biofuels Canada before work with the models began.

Modeling Assumptions

The following are suggested assumptions for accepting the impact model:[23]

Backward-Linkages: IMPLAN is a backward-linkage model, meaning that it measures the increased demand on industries that produce intermediate inputs as a result of increases in production. However, if an industry increases production, there will also be an increased supply of output for other industries to use in their production. Models that measure this type of relationship are called forward-linkage models. To highlight this concept, consider the example of a new sawmill beginning its operations in a state. The increased production as a result of the sawmill's operations will increase the demand for forest fiber, creating an increase in activity in the logging industry as well as other supporting industries such as electric transmission and distribution. IMPLAN's results will include those impacts but will exclude effects on any wood product manufacturers located nearby that might be impacted by the new competitor consuming forest fiber.

Employment: IMPLAN input-output is a production-based model, and employment numbers treat both full- and part-time individuals as being employed.

Fixed prices and no supply constraints: IMPLAN is a fixed-price model. This means that the modeling software assumes no price adjustment in response to supply constraints or other factors. In other words, the model assumes that firms can increase their production as needed and are not limited by availability of labor or inputs and that firms in the local economy are not operating at full capacity.

Fixed production patterns: Input-output (I-O) models assume inputs are used in fixed proportion, without any substitution of inputs, across a wide range of production levels. This assumption assumes that an

[22] For more details on IMPLAN's dataset and the assumptions for accepting the impact model, see Appendix B.
[23] Bureau of Economic Analysis https://www.bea.gov/papers/pdf/WP_IOMIA_RIMSII_020612.pdf

industry must double its inputs (including both purchases and employment) to double its output. In many instances, an industry will increase output by offering overtime, improving productivity, or improvements in technology.

Industry homogeneity: I-O models typically assume that all firms within an industry have similar production processes. Any industries that fall outside the typical spending pattern for an industry should be adjusted using IMPLAN's Analysis-by-Parts technique.

Leakages: A small area can have a high level of leakage. Leakages are any payments made to imports or value added sectors, which do not in turn re-spend the dollars within the region. What's more, a study area that is actually part of a larger functional economic region will likely miss some important linkages. For example, workers who live and spend outside the study area may actually hold local jobs.