

LABOUR MARKET INFORMATION

Bioenergy: An Exciting Opportunity for Canada

March 2021

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Bioenergy in Canada: Charting a Renewable Path

Bioenergy represents a tremendous opportunity for Canada given our ready supply of biomass feedstock. As a country with a relatively small domestic demand (compared to other nations), Canada is well-positioned to supply bioenergy to local and international markets. We also have experience innovating and commercializing bioenergy products.

Canada is fortunate to have an ample supply of biomass, yet only 4.5% of Canada's total energy supply came from biomass in 2016. Of that total, 82.2% of Canada's bioenergy was solid biofuels, and liquid biofuels accounted for 11.3%. On a volume basis, Canada ranked fifth internationally for liquid biofuel production in 2016.

Canada ranked second in global wood pellet exports in 2017. The largest importing country in that year was the United Kingdom, resulting in a wood pellet total export value exceeding \$263 million.

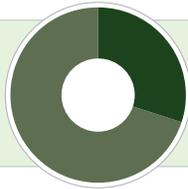
Although hydrogen is a small proportion of Canada's bioenergy supply, Canada is on the frontline of the hydrogen sector, with 86% of all global hydrogen facilities located in Canada.

Bioenergy is a form of energy that is derived from living organisms or their by-products (biomass). Compared to fossil fuels, bioenergy is a renewable energy source that generates less waste, emits a smaller amount of greenhouse gases, and provides on-site energy benefits.

Bioenergy products include solid biofuels, liquid biofuels, biogas, biomethane (renewable natural gas), and hydrogen. There are several existing and potential feedstocks, or sources, for bioenergy in Canada, including forestry and agricultural whole products, as well as organic residues and waste from industrial, agricultural, forestry and municipal processes.

The Canadian Bioenergy Landscape

The responses of 63 Canadian organizations with bioenergy as their primary or secondary business activity from a 2020 survey revealed a sector and its workforce primed for innovation and growth.



Of the 63 organizations responding, **19 identified bioenergy as a primary business activity, while 44 identified bioenergy as a secondary activity.**

Bioenergy respondents' operations primarily consist of:

- R&D for products and processes related to the bio-economy,
- Commercialization of products and processes related to the bio-economy, and
- Manufacturing of bio-economy related products.



Most bioenergy respondents are located in Ontario, British Columbia and Alberta.

57% of organizations are in Ontario.

Bioenergy respondents are primarily small enterprises.



83% of organizations employed fewer than 100 employees.



The R&D job function offers the highest rate of employment in bioenergy.

41% of bioenergy respondents' employment falls into the R&D job function.



Access to capital is the biggest issue identified by bioenergy respondents.

54% of organizations identified access to capital as the greatest barrier to development.

Many of bioenergy respondents' new hires are straight out of post-secondary studies.

39% of new hires are recent graduates of Canadian post-secondary institutions.



Canada's prospects for establishing a strong bioenergy sector on the global stage are significant. The pursuit for alternatives to fossil fuels nationally and internationally could lead to greater business and career opportunities for many Canadians. Through innovation, investment and commercialization, bioenergy can become a solid foundation for affordable and renewable solutions in the decades to come.



Introduction

The global bioenergy sector is advancing as we become more aware of the need to address both climate change and the depletion of non-renewable natural resources we use to power human activities.

Within the bioenergy sector, some technologies have been commercialized while others require additional investment and market development to advance their use as economically feasible alternative sources of energy. For example, biofuels such as ethanol and biodiesel are widely used in fuel, blending with gasoline and diesel. Others, such as bio coal, pyrolysis oil and algae fuel are still at the innovation phase.

Market and investment trends, both domestic and international, provide evidence of the opportunities for growth within Canada's existing bioenergy sector. The *2020 Canadian Bio-economy Employer Survey*, commissioned by BioTalent Canada, is combined with secondary information sources to develop a snapshot of the sector, reinforcing the sector's potential as a sustainable solution to rising international energy demands. The report provides insights that can be used by companies, investors, legislators, and the overall workforce when considering their courses of action associated with the bioenergy sector, either directly or indirectly. Through this report, we strive to provide an overview of the bioenergy sector and related trends, opportunities, and challenges and how they impact our ability to incorporate bioenergy sources into our sustainable energy mix.

This report explores the following topics:

- Global and Canadian trends in the bioenergy sector,
- Market and recruitment insights from the analysis of surveyed organizations and supplementary information,
- Future considerations of the bioenergy sector and the potential for increased adoption in Canada.



SPOTLIGHT: Bioenergy Defined

Bioenergy is a form of renewable energy that is derived from living organisms or their by-products, referred to as “biomass”. Compared to fossil fuels, bioenergy is a renewable energy source that generates less waste and emits a reduced amount of greenhouse gases.

Bioenergy products, as identified by Natural Resources Canada (NRCan), include:

- 1 **Solid Biofuels**—biomass-derived fuels with a solid structure, such as firewood, wood pellets, wood chips and briquettes
- 2 **Liquid Biofuels**—biomass-derived fuels with a liquid form, such as fuel ethanol and biodiesel
- 3 **Biogas**—biomass that is converted to a synthetic gas through a process of gasification or anaerobic digestion
- 4 **Biomethane (Renewable Natural Gas [RNG])**—biogas that has been cleaned and contains only methane and small amounts of nitrogen
- 5 **Hydrogen**—a by-product of the gasification process for biogas

“We all agree that we must have cleaner or lower carbon energy options to heat our homes and move our vehicles. While traditional natural gas is the cleanest-burning conventional fuel, RNG is the first step in 'greening' the natural gas system.” (Enbridge Gas Distribution, July 20, 2018)

Cynthia Hansen
Executive Vice President &
President, Enbridge

“Affordably decarbonizing the production of heat is vital to achieve our long-term emissions and energy goals, particularly in our cold Canadian climate, and hydrogen can play a powerful role.” (ATCO Ltd., July 21, 2020)

Siegfried Kiefer
President & Chief Executive Officer,
Canadian Utilities Limited



Global and Canadian Trends in Bioenergy

Bioenergy is a viable option for renewable energy the world over. According to the International Energy Agency's *IEA Bioenergy Roadmap, 2017*, bioenergy is applicable to all energy sectors, can be integrated with existing infrastructure, and is available now.

Global Business and Market Trends

Europe has been, and is expected to continue to be, a dominant player in global bioenergy. At the same time, trends forecasted by the International Renewable Energy Agency (IRENA) show that high population countries such as the United States, China, and India will have the highest demand for bioenergy up to 2030. Globally, rapid urbanization will continue to drive up energy demands, and countries are looking for alternatives to existing energy sources that can potentially reduce the impact of human activity on the environment.

Large-scale deployment of biomass power projects is concentrated in relatively few countries. In 2019, just five countries accounted for 80% of new biomass power generation capacity (IEA, November 2020). Topping the list was China, which accounted for 60% of new global biomass power capacity that year, ten times that of the next country, Japan, followed by India, the UK and Brazil. The IEA forecasts that China will maintain its position as the global leader in new biomass power capacity through 2025, despite the expectation that China's new biomass capacity in 2021 will be roughly one-third of its 2019 capacity additions. Globally, biomass and waste-to-energy enjoyed significant investment in 2019, at \$9.7 billion, up 9% of 2018 totals (Frankfurt School UNEP Centre, 2020).

As many nations around the globe unite in the pursuit of a range of sustainability goals, some goals are falling short of their targets. **In 2019, the IEA found that, globally, bioenergy electricity generation was failing to reach its targeted 6% annual renewables growth rate, which is needed to reach levels agreed upon by the United Nations in 2015 for the year 2030** (IEA, June 1, 2020).

The outlook for biomass as a fuel source for renewable energy is good. *Global Bioenergy, Supply and Demand Projections* report by IRENA forecasts that, by 2030, biomass could account for 60% of total final renewable energy use and that biomass has the potential to be incorporated into all sectors of our economy. When forecasting the annual growth in demand for biomass between 2010 and 2030, the IRENA report identifies the U.S., China, Brazil, India, and Indonesia as the countries estimated to have the highest demand for bioenergy based on past demand and assumed growth rates. These countries generally see the greatest demand for bioenergy in the sectors of heat generation, transport, and industry. Although on a smaller scale, Canada also shows an increase in bioenergy demand in these sectors (IRENA, 2014).

China has led the world in biomass expansion since 2017 and is expected to continue through 2025. Due to rapid urbanization, China is focusing on generating bioenergy from clean-heat initiatives and waste-to-energy technology (mostly municipal solid waste), both of which are expected to drive faster growth of bioenergy internationally in the coming years.

From a supply perspective, Europe held the largest share in the global bioenergy market in 2018, and its dominance is expected to continue in the coming years. Bioenergy is expected to remain a vital factor over the next decade in global efforts to reach renewable energy targets, which is why the European Union member countries incorporated the bioenergy option in their National Renewable Energy Action Plans (Mordor Intelligence, 2019). India has been incentivizing bioenergy investment by providing capital subsidies for the expansions of ethanol plants. In Mexico and Turkey, the deployment of waste-to-energy and biogas operations are promising signs of a widely expanding bioenergy sector (IEA, June 1, 2020).

Though we are seeing an overall increase in bioenergy around the world, the trends in demand and supply vary greatly by country.

On the supply side, according to the IRENA report, Canada, Malaysia, Nigeria, Russia, and Ukraine can meet their bioenergy needs from local sources; in fact, domestic demand is less than half of the supply in these countries. In contrast, countries with growing energy demands (e.g., India, Indonesia, Mexico, South Africa) may require more biomass than their local sources can provide. These countries would turn to those with a bioenergy surplus to import renewable energy sources like solid and liquid biofuels, biogas, and hydrogen if they cannot meet national demands (IRENA, September 2014).

The bioenergy sector was gaining momentum in the years leading up to the 2020 pandemic, with more than a handful of countries leading the charge. Notably, the COVID-19 pandemic had a significant impact on bioenergy development in China, Brazil, Japan, and the United Kingdom. Bioenergy projects around the globe were directly impacted by restrictions to operations intended to limit the spread of the virus—including regional lockdowns—and factors related to economic uncertainty, plus real and projected reductions in energy demand overall. Even considering the pandemic, the IEA forecasts that biofuel production should increase by 25% over the next five years.



SPOTLIGHT: COVID-19 Impacts on the Global Bioenergy Sector

The COVID-19 pandemic sharply focussed the world's attention on health and economic factors. As a result, the momentum that was building for bioenergy met several roadblocks: lack of government and investment funding and reduced economic activity overall.

With the financial strain placed on governments due to their COVID responses and economic declines, many nations have had to scale back their intended investments in bioenergy projects.

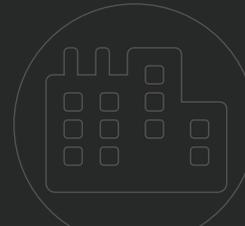
Growth in bioenergy relies in large part on government funding and program support. In countries where bioenergy was not yet ingrained as a reliable and cost-effective energy source, and therefore not considered essential, government lockdowns halted or slowed the operations of bioenergy producers and their supply chains.



The lack of government funding was compounded by a decline in other sources of financing, with investors shying away from energy projects given the uncertainty brought on by the economic recession.



A significant drop in consumer demand and supply in most sectors severely disrupted economic activity and the demand for most forms of energy, including renewables.



Canadian Business and Market Trends

Bioenergy represents a tremendous opportunity for Canada given our ready supply of biomass feedstock. IRENA predicts that countries like Canada, which can meet national bioenergy demands from local sources, will provide countries with growing energy demands with surplus bioenergy. Canada is considered a country with lower domestic demand, but is well-positioned to supply bioenergy to local and international markets for the following reasons:



A \$33 billion forestry export market with by-products that can be used as inputs to bioenergy production (Natural Resources Canada, 2020).



An agricultural industry with exports of \$56 billion has by-products that can be used as inputs of bioenergy production (Agriculture and Agri-Food Canada, 2017).



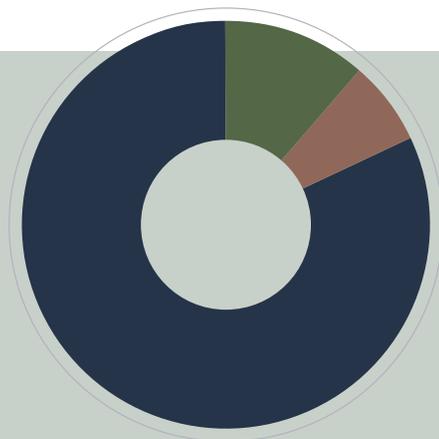
Municipal, provincial, and federal policies that are geared towards supporting clean energy alternatives.



Public and academic institutions that have committed resources to the bioenergy sector (FPAC, n.d.).

The Canadian government is championing Canada's ability to increase domestic usage and exportable sources of bioenergy generation. Whereas Canada is fortunate enough to have an ample supply of biomass, only about 4.5% of Canada's total energy supply came from biomass in 2016 (IEA Bioenergy, September 2018). Of that total, 82.2% of Canada's bioenergy was solid biofuels, and liquid biofuels accounted for 11.3% (IEA Bioenergy, September 2018). Although hydrogen is a small proportion of Canada's bioenergy supply, Canada is on the frontline of the hydrogen sector, with 86% of all global hydrogen facilities located in Canada (CHFCA, November 2018).

In an analysis conducted by Natural Resources Canada (NRCan), Canada ranked second in wood pellet exports in 2017 at 11.9%, based on its percentage of world value, behind the United States at 26.0%. As a result of their low moisture content and small size, wood pellets are easily transported over long distances, making them an ideal commodity for global trade. The primary provinces that made up these exports were British Columbia at 78.0%, Quebec at 13.0%, and New Brunswick at 6.1%. The largest importing country from these three provinces in 2017 was the United Kingdom, resulting in a wood pellet total export value exceeding \$263 million (Natural Resources Canada, 2020).



CANADA'S BIOENERGY SUPPLY

82.2% solid biofuels

11.3% liquid biofuels

6.5% other

(IEA Bioenergy, September 2018)

IEA Bioenergy found that Canada ranked fifth internationally for liquid biofuel production on a volume basis in 2016. Of the 526 petajoules of energy produced by bioenergy sources in Canada in 2016, liquid biofuels accounted for 13.7% of the total output (11.3% fuel ethanol and 2.4% biodiesel). Of the 3.4% of renewable energy consumed for transport energy in 2016, 2.9% was sourced from bioenergy, more specifically, liquid biofuels (IEA Bioenergy, September 2018).

Canadian Investment Trends and Initiatives

Twenty-five countries—including Canada—are members of IEA Bioenergy, an organization created by the IEA with the aim of improving the international exchange of bioenergy research, development, and deployment. Canada is currently involved in nine of the eleven ongoing IEA Bioenergy tasks for the triennium of 2019-2021. Canada and other member countries directly benefit from access to global research and scientific results regarding the advancement of bioenergy technologies (Natural Resources Canada, July 20, 2020). IEA modelling shows that bioenergy is necessary to meet global climate change commitments; these nations' collaborative efforts increase the likelihood of advancing the sector and creating feasible solutions to meet the agreed-to targets (IEA Bioenergy, June 2019).

In Canada, various funding programs are available in the bioenergy market to help stimulate and promote the growth of the bioenergy sector. These include the *EcoEnergy for Biofuels Program*, *Pulp and Paper Green Transformation Program*, B.C.'s *Northern Rural and Remote Communities Green Heat Initiative*, and Sustainable Development Technology Canada's *NextGen Biofuels Fund*, the latter organization also being a factor in Canada's position as a leader in pyrolysis oil technology and development (Canadian Biomass, May 16, 2014).

Canada has an enviable supply of natural resources that can be converted to biomass and used for bioenergy at home and abroad. We also have the human resources required to innovate, manufacture, and commercialize the products associated with the bioenergy sector. Moreover, the Government of Canada views its investments in energy innovation as an important part of building a cleaner economy. NRCan has continued to invest in the bioenergy sector, contributing more than \$33 million since 2011 (Natural Resources Canada, October 13, 2020). However, many renewable energy technologies in this sector are still in the development phase, meaning they are not yet at a level of energy production or economic feasibility to warrant mass adoption.



Canada has an enviable supply of natural resources that can be converted to biomass and used for bioenergy at home and abroad. We also have the human resources required to innovate, manufacture, and commercialize the products associated with the bioenergy sector.

Natural Resources Canada has also been investing in various waste biomass facilities. One investment of \$1.9 million, funded by Natural Resources Canada's *Investments in Forest Industry Transformation* program, will allow Ontario's Woodland Biofuels to develop a technology to produce ethanol from wood and agricultural waste. This technology is expected to cut greenhouse gas emissions and create and maintain jobs for Canadian workers (Renewable Energy Magazine, August 28, 2019).

Another investment of more than \$2.8 million, funded by Natural Resources Canada's *Clean Growth* program, will increase the efficiency of Woodland Biofuels' cellulosic ethanol demonstration plant and support detailed engineering activities, enabling Woodland's first commercial-scale ethanol facility. This production plant utilizes a mixture of forestry waste and construction and demolition wood waste to produce ethanol. The project aims to serve as a model in the creation of a permanent, new revenue-generating industry (Renewable Energy Magazine, August 28, 2019).

Canadian provincial governments have made investments in the bioenergy sector as well. The province of Quebec is adding \$1.57 million to federal funding under the *Technoclimat Program* for CRB Innovations, based out of Sherbrooke, Quebec. CRB Innovations is developing a pilot project to convert forestry residuals and other biomass sources into intermediate products that will be converted into biofuels and bioplastics, among other products. (Natural Resources Canada, September 8, 2020).

In Saskatchewan, Turboden, a company operating under the Mitsubishi Heavy Industries Group, has been contracted to provide the Meadow Lake Tribal Council (MLTC) with a 6.6 megawatt power generation system that will use sawmill biomass as fuel. The Government of Canada is contributing \$52.5 million to build the MLTC Bioenergy Centre (Ganovicheff, May 22, 2019).

The use of renewable energy in public transportation makes the aspirational list of many municipalities. British Columbia began using a hydrogen bus fleet as part of B.C. Transit operations in 2010 and continued through to 2014. Hydrogen-fueled fleet operations were eventually halted, citing higher operating costs of \$1.34/km compared to the diesel fleet counterpart of \$0.65/km (CBC News, December 5, 2014).



A Clean Energy Fuels article discussed the move towards Compressed Natural Gas (CNG) transit vehicles to replace the diesel-powered buses, the latter polluting more and having higher operating costs. Clean Energy Fuels states that a CNG bus costs \$50,000 more than a diesel alternative; however, over its 16-year lifespan, the CNG vehicle would achieve \$250,000 less in fuel costs, and costs associated with maintenance are less than its diesel counterpart. Where B.C. Transit was not able to make a go of its hydrogen bus fleet, it was operating approximately 125 CNG buses in the urban regions outside of Metro Vancouver in 2018 (Clean Energy Fuels, 2018).

In Calgary, a CNG bus facility was opened in 2019, allowing for an intended phasing out of diesel buses in favour of CNG vehicles over time. Calgary mayor Naheed Nenshi cited as reasons the price volatility of diesel versus the possibility of long-term natural gas contracts, which can ensure a fixed rate for fuel in the years to come. The City has stated that it hopes to ultimately save more than \$4 million in fuel costs every year with the adoption of the CNG fleet (Potkins, 2019).

The City of Hamilton transitioned to CNG buses in 2014, addressing the same concern as the City of Calgary regarding the volatility of diesel. The Ontario city also estimated that the project would reduce greenhouse gas emissions by 25% during regular operations (NGV Global News, 2015). In 2019, Hamilton's fleet included 94 CNG buses. Since then, the City has opted to increase the number of CNG units over available alternatives, in addition to building a CNG station and using clean energy to maintain the facility (Clean Energy Fuels, 2018).

Financing from federal and provincial governments is proving essential to the development of a healthy bioenergy sector. However, the sector does not receive the same support from private investment, mostly due to the bioenergy sector's perceived risk compared to other available renewable energy investments. The IEA Bioenergy report *Technology Roadmap: Delivering Sustainable Energy* discusses the role governments can play in influencing the perception of private investors. More specifically, the report states that governments can offset perceived risks by agreeing to long-term purchase agreements with companies, which acts as a government guarantee of income (IEA Bioenergy, 2017).





Canadian Bio-Economy Employer Survey

In 2020, BioTalent Canada surveyed organizations that operate in the bio-economy sector in different capacities. The survey was conducted via telephone and online, in English and in French.

A total of 573 bio-economy enterprises responded to the survey. Of those organizations, **63 identified bioenergy as either a primary (19) or secondary activity (44). Key findings of the survey are detailed below.**

Survey Scope and Methodology

The BioTalent Canada survey was conducted from January to March 2020, using both phone interviews and an online survey. The survey goals were to identify the number of organizations and employees operating in the bio-economy, assess issues in employment practices, forecast potential growth, and determine future human resource needs. A random sample of companies falling under NAICS codes 2111 (Oil and Gas Extraction) and 3251 (Basic Chemical Manufacturing) were surveyed by telephone. The online survey was promoted to BioTalent Canada's contact database.

Results from the online and telephone samples were merged and analyzed, detailing the major trends in the bio-economy observed in their initial findings.

For the purpose of this study, bioenergy organizations are defined as those that identified bioenergy as a primary or secondary activity. Where relevant, the broader survey data provided by BioTalent Canada was analyzed further to find significant trends regarding the bioenergy sector.

Profile of Bioenergy Respondents

The following is the breakdown of what the bioenergy respondents indicated as their main activities:

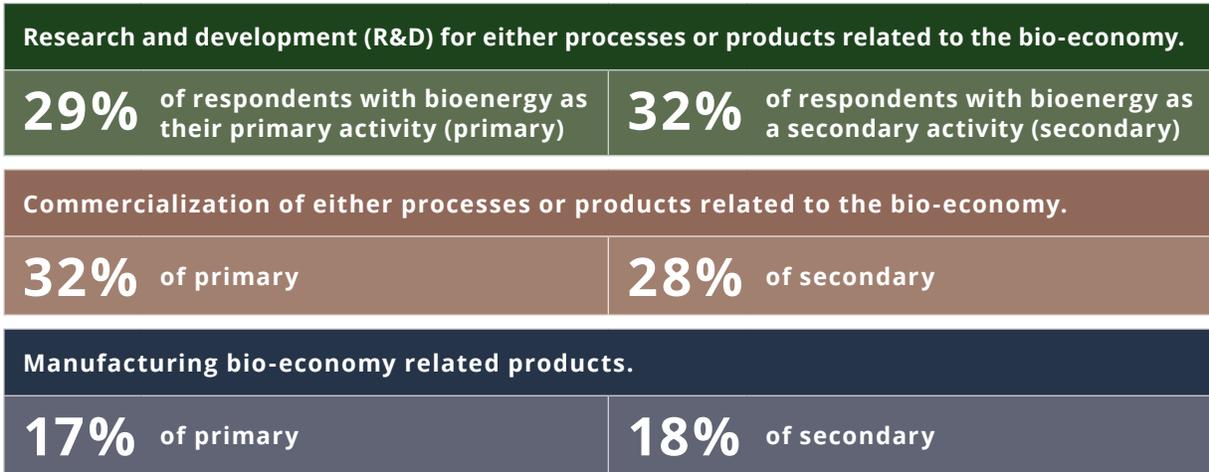
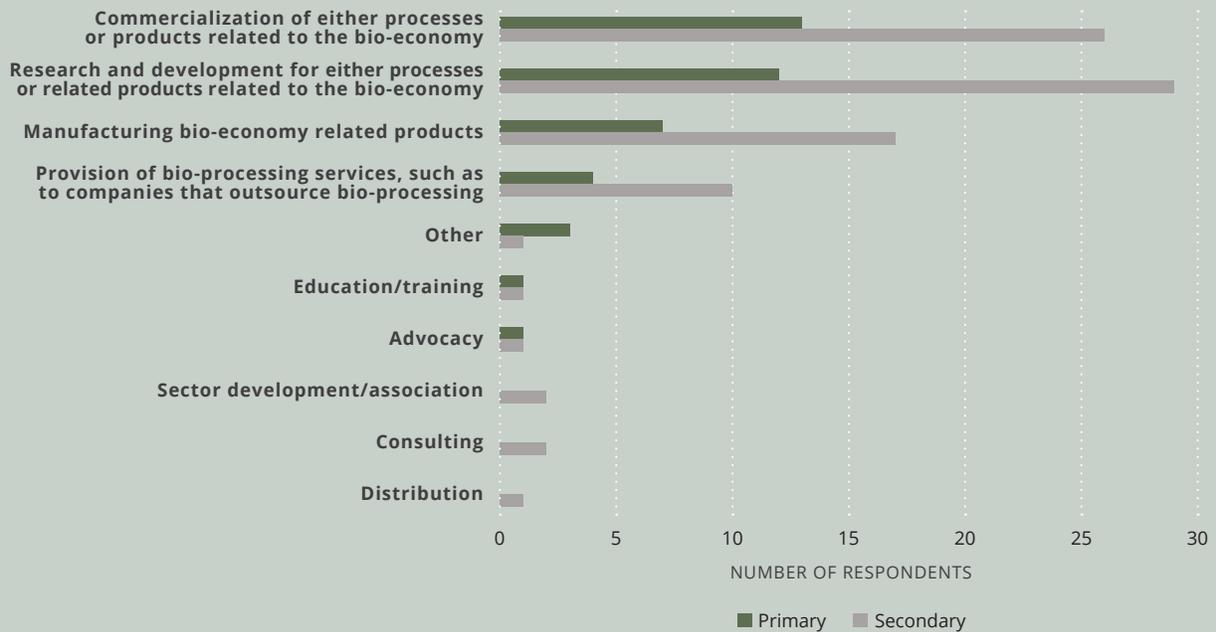


Figure 1

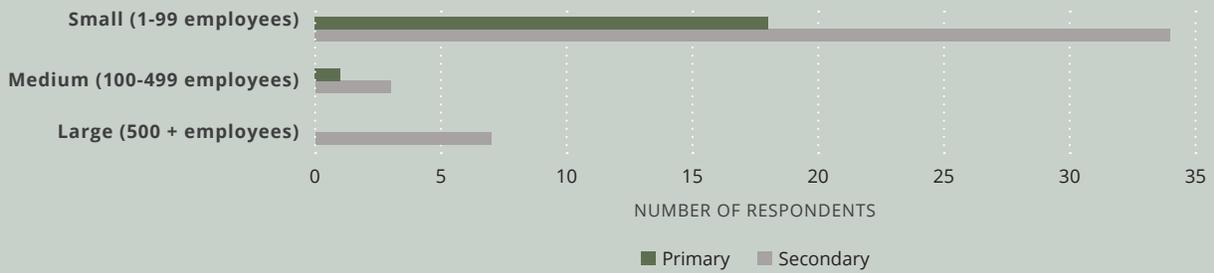
Activities of Bioenergy Respondents



Most bioenergy respondents have fewer than 100 employees (83%). In contrast, in December 2018, 97.9% of all Canadian businesses were considered small enterprises with fewer than 100 employees (Government of Canada, December 12, 2019).

Figure 2

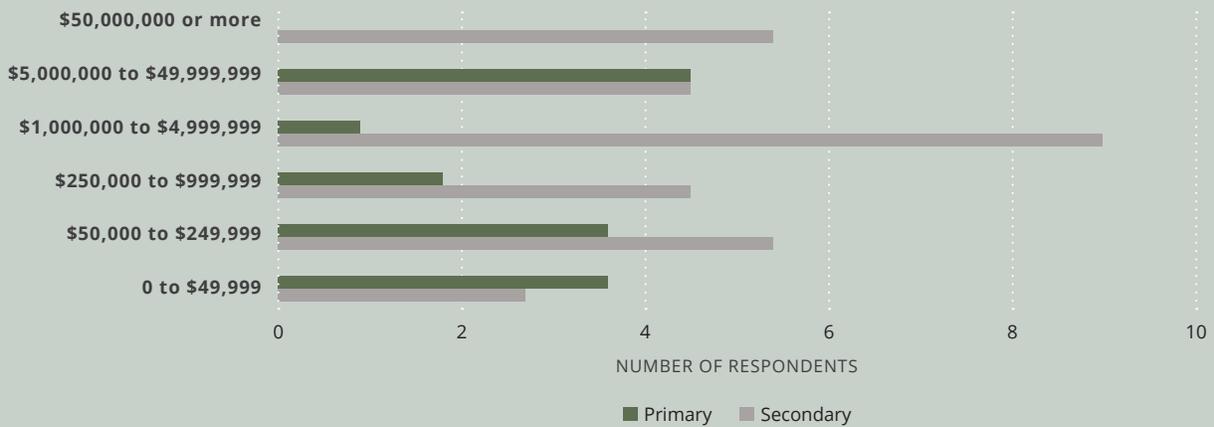
Size of Bioenergy Respondents' Organizations



Among primary activity bioenergy respondents, 63% reported revenues of less than one million dollars.

Figure 3

Reported Total Annual Revenue of Bioenergy Respondents

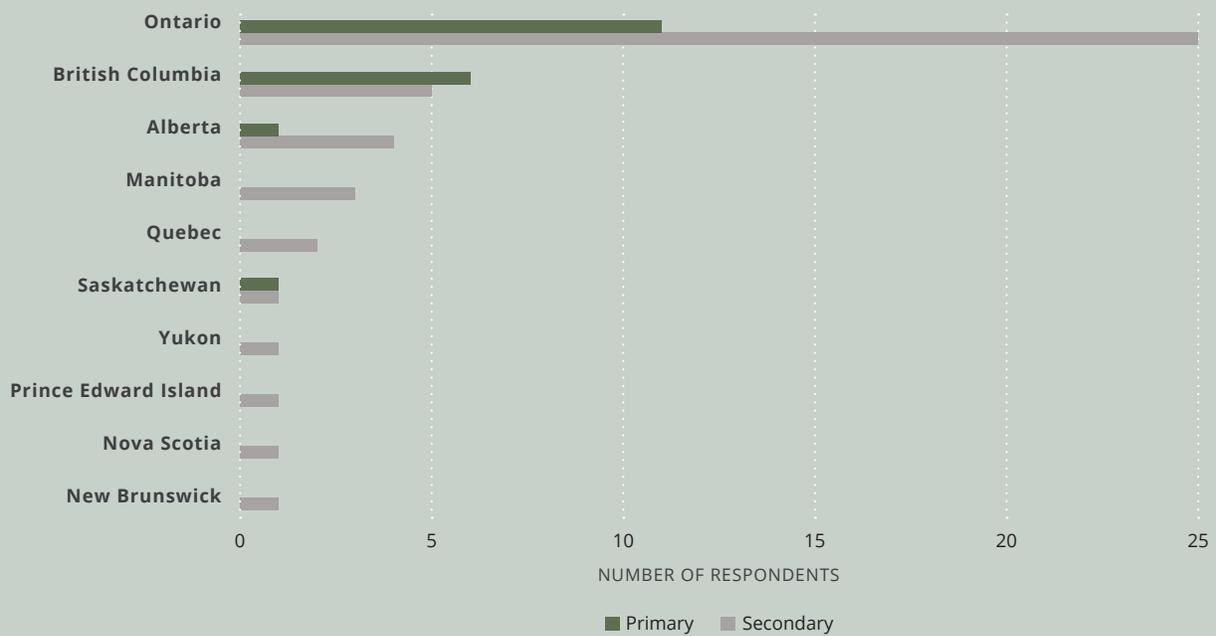


Most bioenergy respondents are located in:

- Ontario (57%)
- British Columbia (17%)
- Alberta (8%)

Figure 4

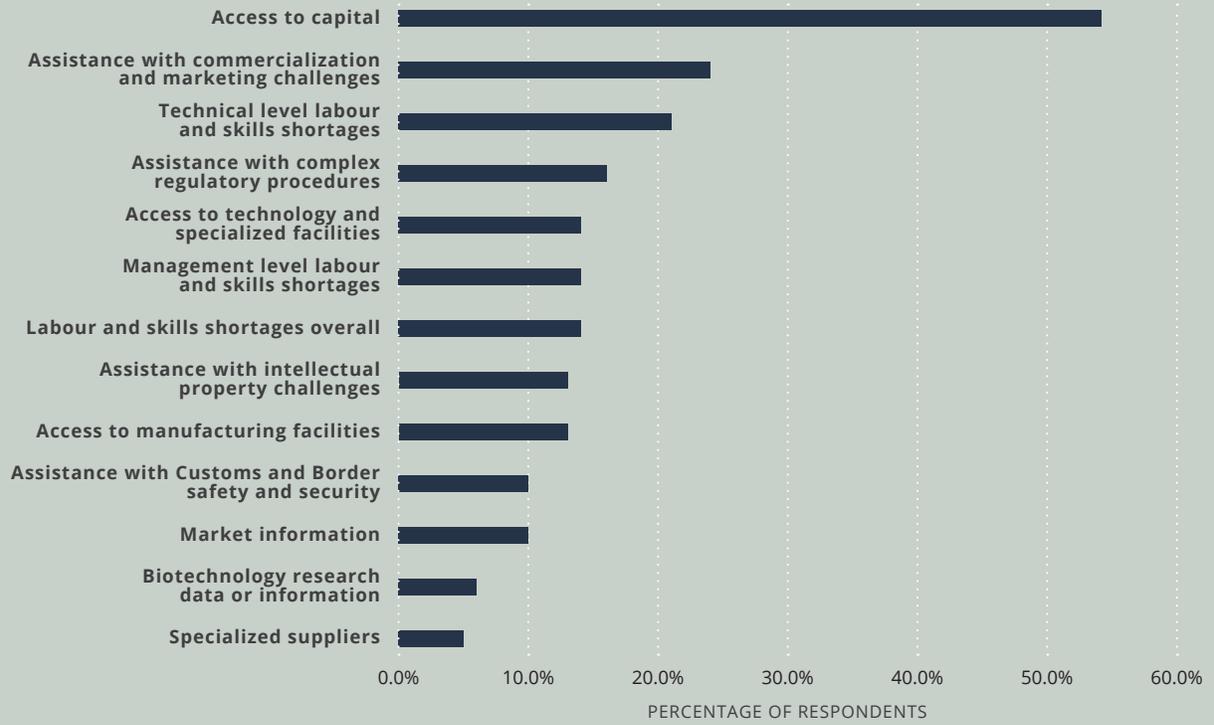
Regional Distribution of Bioenergy Respondents



Most bioenergy respondents identified access to capital as the greatest barrier to service development (54%).

Figure 5

Greatest Barriers to Service Development Identified by Bioenergy Respondents



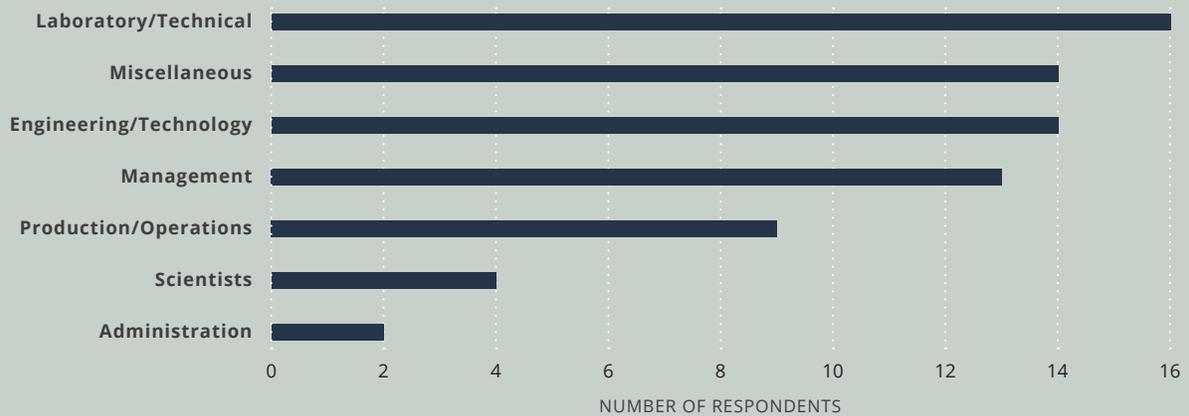
Recruitment Statistics and Challenges

Bioenergy respondents identified these roles as the most difficult to recruit:

- Laboratory/Technical
- Engineering/Technology
- Management
- Production/Operations

Figure 6

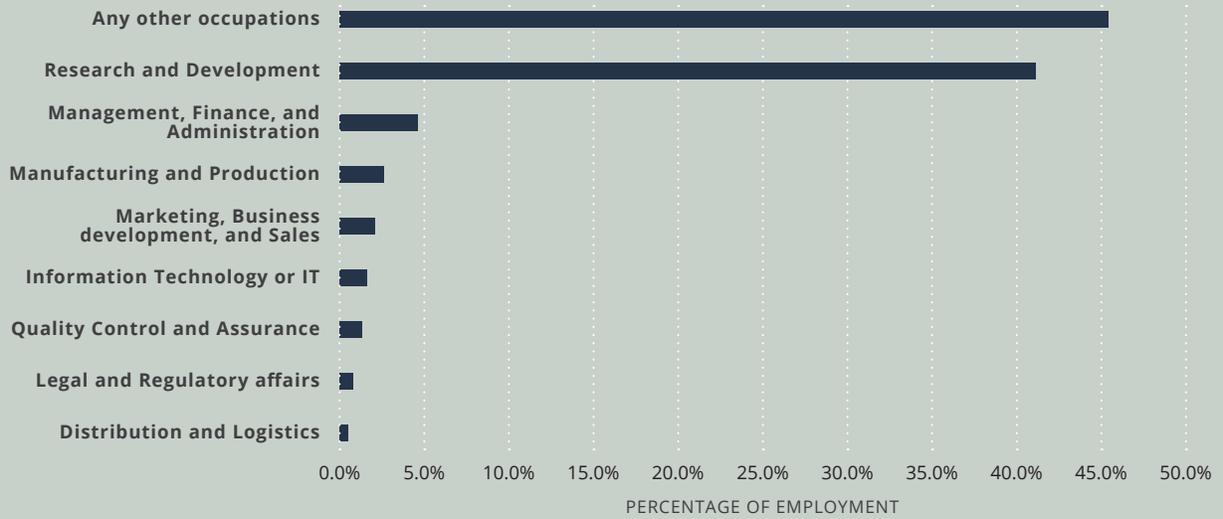
Positions Identified as Most Difficult to Fill by Bioenergy Respondents



Among bioenergy respondents, the job function that had the highest rate of employment for new workers was Research and Development (41%).

Figure 7

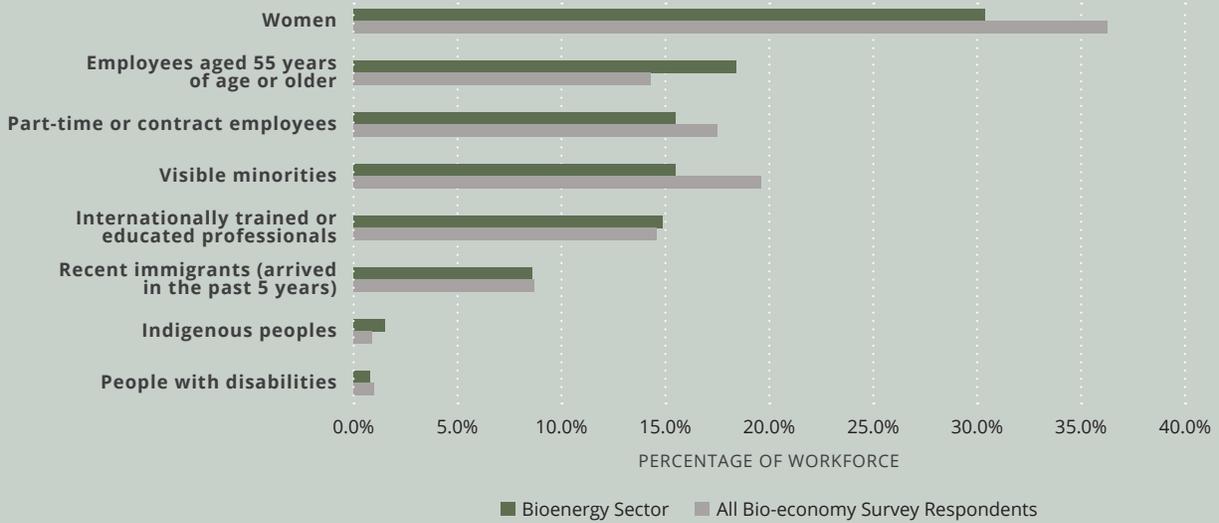
Job Function of New Employees of Bioenergy Respondents



The companies surveyed that conducted bioenergy operations as their primary or secondary activities employed a greater percentage of employees aged 55 or older (+4.1%), but a lower percentage of women and visible minorities (-5.9% and -4.1%, respectively) than all firms surveyed.

Figure 8

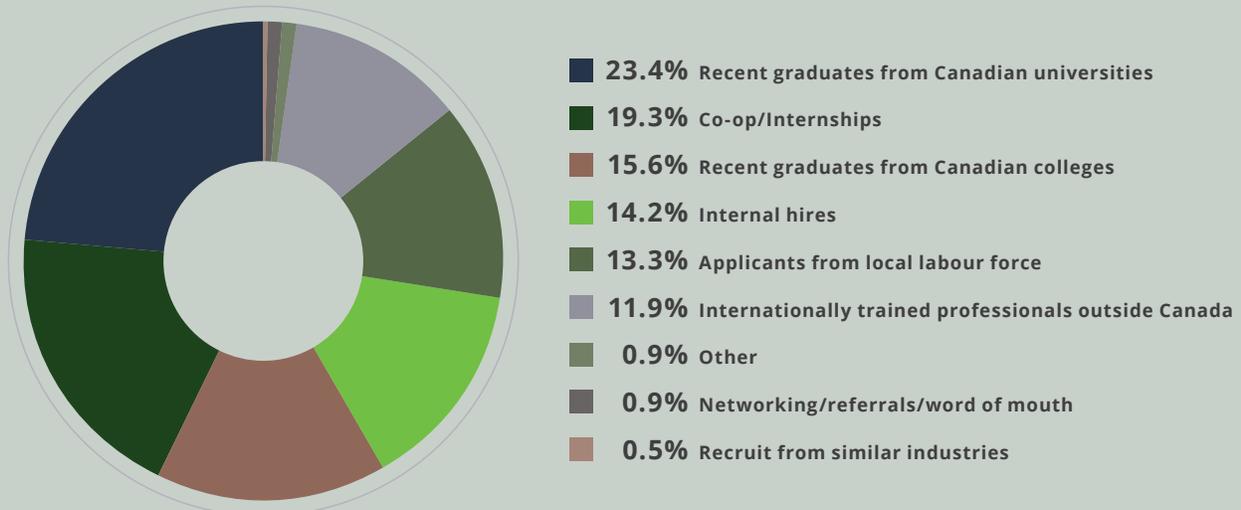
Workforce Demographic Comparison - Bioenergy Respondents and All Bio-Economy Respondents



Of the bioenergy businesses surveyed, the primary source of employment was recent graduates from Canadian universities (23%), followed by co-ops/internships (19%).

Figure 9

Source of Employment for Bioenergy Respondents





A World of Opportunity Ahead

Canada is gifted with an abundance of natural resources that can be used in the generation of bioenergy—so much so that we could become leaders in the development and export of biomass and bioenergy to countries around the globe looking to reduce their environmental impacts.

This study provides a brief insight into the expanding bioenergy sector and related trends identified within Canada and around the world. Understanding these market and investment trends is critical for advancing the bioenergy sector, not only to the benefit of the environment, but also employees, employers, investors, and governments. **As the need for renewable energy becomes more pressing, this report suggests that the bioenergy industry will grow faster with the development and adoption of new technologies and increased investment into the sector.**

The study also identifies that bioenergy companies are constrained by shortfalls in accessing capital to support growth, as well as assistance with marketing and commercializing their products. Survey respondents acknowledged difficulty with recruiting technical labour and filling management positions and reported hiring mostly from the ranks of co-op students and recent graduates. The survey sample has shown us where some of the challenges and opportunities lie, but more research needs to be done to identify where Canada currently fits into the global bioenergy sector, how each province and territory ranks by contribution to the sector, how we can identify and support the companies most likely to succeed, and whether the work being done is viable for the long term.

The Paris Agreement climate treaty adopted in 2015 addresses the urgency of climate change with signatories agreeing to respective targets for carbon reduction. The 2030 Paris Agreement deadline is fast approaching, and countries are exploring cleaner energy sources such as bioenergy. As global economies move towards cleaner energy alternatives, Canada has an opportunity to establish a strong bioenergy presence on the global stage. By leveraging readily available bioenergy inputs, such as products and by-products of the agriculture and forestry industries, intensifying the bioenergy research conducted by Canadian institutions, and increasing government support, bioenergy can become a solid foundation for affordable and environmentally sustainable solutions.

Appendix A: Acronyms

CNG	Compressed Natural Gas
FPAC	Forest Products Association of Canada
GHG	Greenhouse Gas
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
NAICS	North American Industry Classification System
NRCan	Natural Resources Canada
RNG	Renewable Natural Gas
UN	United Nations

Appendix B: Sectors of Bioenergy

Solid Biofuels (Biomass)

Solid biofuels are biomass-derived fuels with a solid structure, such as firewood, wood pellets, wood chips, and briquettes. The Canada Energy Regulator identified organic materials such as wood, organic residues, aquatic plants, and animal wastes as inputs for biomass power generation (Canada Energy Regulator, June 24, 2020). Biomass is generally considered a carbon-neutral process because the carbon dioxide (CO₂) released from burning the biomass is roughly equal to the amount of CO₂ those plants take in from the atmosphere in their lifetime. Biomass plants are economically and environmentally feasible when built close to fuel supplies, such as sawmills and plant farms, to avoid transporting organic matter over long distances.

Liquid Biofuels

Liquid biofuels are biomass-derived fuels with a liquid form, such as fuel ethanol and biodiesel. These biofuels are blended with their petroleum counterparts to reduce the environmental impact of the combustion processes. Natural Resources Canada approves of a low blend fuel (5-10%) for most gasoline vehicles and a B5 blend (5% biodiesel and 95% diesel) for diesel vehicles (Natural Resources Canada, May 15, 2020). These blends are deemed viable mixes for widespread public use in that they do not sacrifice a noticeable amount of energy output. Higher percentage blends of these biofuels have the potential to be used for vehicles but, due to the lower energy output, require vehicle modifications to make it a viable option for consumers. For example, a larger fuel tank will store more fuel to offset the lower energy output.

Biogas

Biogas is derived from biomass that is converted to a synthetic gas through a process of gasification or anaerobic digestion. Once captured, biogas can be used to produce heat and power engines, microturbines, and fuel cells (Environmental and Energy Study Institute, October 3, 2017).

Biogas can also be converted to biomethane for use as a renewable natural gas as the properties are nearly identical to that of natural gas extracted through drilling. The City of Toronto has made use of this technology, in collaboration with Enbridge, to install biogas upgrading equipment in the Dufferin Waste Management Facility and inject the renewable natural gas (RNG) into the existing natural gas grid (read more about the process below) (City of Toronto, 2020).

Biomethane (Renewable Natural Gas)

Renewable natural gas is a product of the purification of biogas. Through multiple iterations, biogas must be filtered for contaminant gases such as carbon dioxide. Once biogas has been cleaned and contains only methane and small amounts of nitrogen, it is referred to as biomethane or renewable natural gas. Biomethane has properties similar to conventional natural gas and can be injected into existing pipeline systems to be delivered to customers (FortisBC, 2020).

Biomethane can also be used for transportation in compressed natural gas (CNG) vehicles. However, CNG vehicles must be fitted with pressurized fuel tanks to store the fuel and require specialized fueling stations. The lack of readily available fueling stations and higher costs associated with the vehicles are reasons that they have not been widely adopted by the consumer market (Consumer Reports, April 2014). Overall, natural gas emits a lower amount of carbon dioxide during the combustion process, making CNG vehicles a cleaner alternative to standard gasoline vehicles.

Hydrogen

Hydrogen is a by-product of the gasification process for biogas. Through the interaction of carbon monoxide and water, carbon dioxide and hydrogen gases are created. The hydrogen produced is then separated and undergoes a purification process for use (Office of Energy Efficiency and Renewable Energy, 2020). Hydrogen is one of two fuel sources required to operate hydrogen fuel cells, the other being oxygen. Hydrogen fuel cell vehicles are emerging as a potential alternative to combustion vehicles as the chemical reaction of hydrogen and oxygen only emits water.

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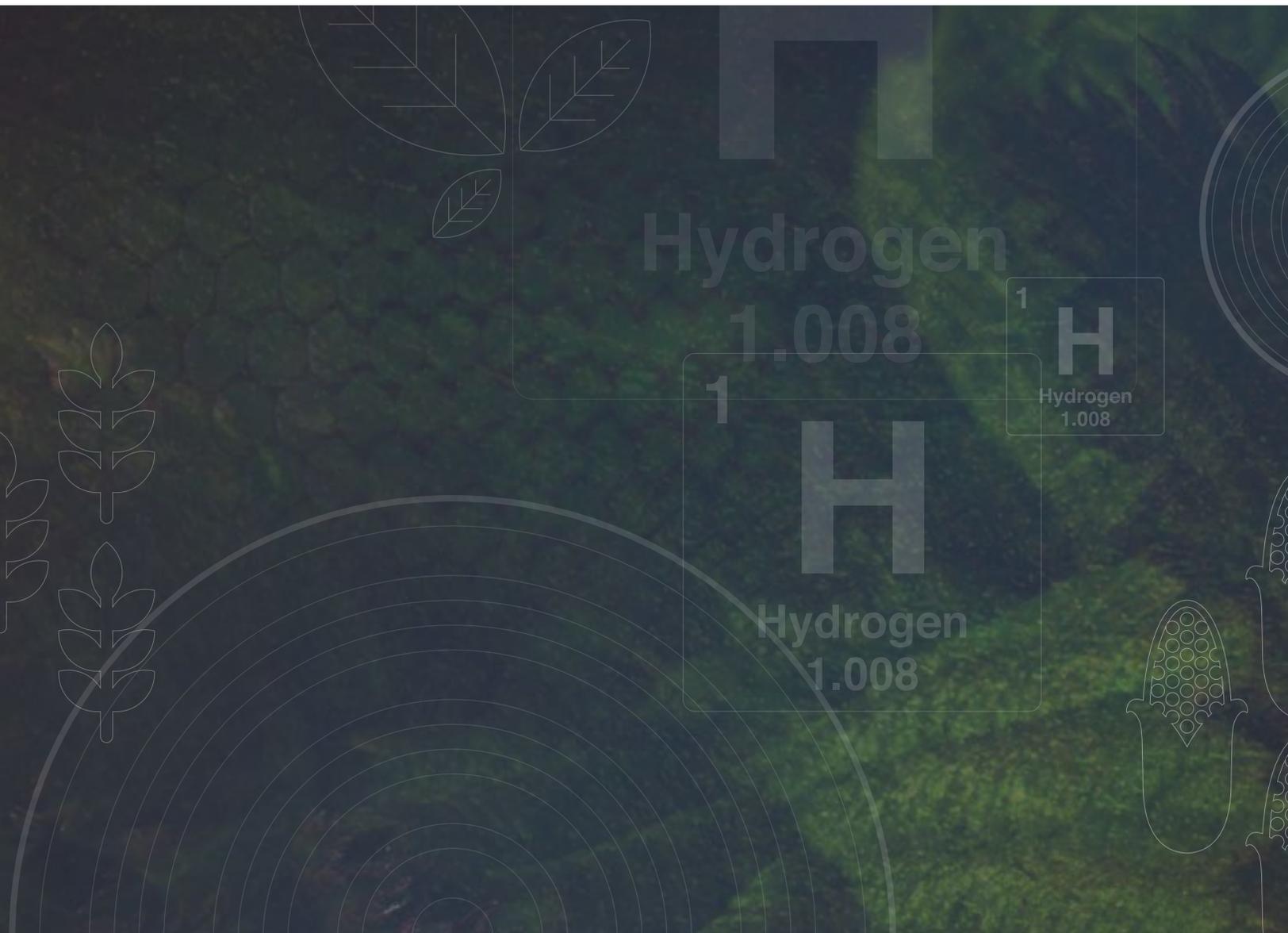
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CONTACT US

...

ECO Canada
Suite 400, 105 12 Avenue SE
Calgary, Alberta T2G 1A1

P : 1-800-890-1924

E : research@eco.ca

W : eco.ca

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