



CICE

B.C. CENTRE
FOR INNOVATION
& CLEAN ENERGY

Bioenergy Resource Library

B.C. Centre for Innovation & Clean Energy

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Low-Carbon Bio and Synthetic Fuels Resource Library

Purpose

Copious research has been undertaken to understand low-carbon bio and synthetic fuels in B.C., and beyond. In the B.C. Centre for Innovation and Clean Energy (CICE)'s efforts to contribute to the success of low-carbon fuels in the province, these resources have played a key role in understanding the current landscape of economics, technology, and policy, uncovering gaps and potential areas of focus for CICE's investment.

Resources by Region

- B.C.
- Canada
- United States

Library Framework

This resource library provides a summary of key studies, reports, and publications from B.C., Canada, and the United States (US). Each resource is organized by challenges, aspirations, focus areas, guiding principles, activities, and outcomes, organized by date of publication. CICE has included resource links and will update this resource library as needed.

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B.C. Resources

Wood Pellets in BC (2022)

Published by: Wood Pellet Association of Canada (WPAC)

Challenges	BC's wood pellet industry has gained a relatively negative reputation in the media and has led to confusion regarding the sector's future in the province.
Aspirations	The Wood Pellet Association of Canada aims to review the wood pellet industry and the rest of the forest sector
Focus Areas	Solid biofuels, bioproducts
Guiding Principles	Assess relevant data and information to conduct an independent assessment of the use of fibre by the sector.
Activities	Provide a brief history of the BC forest industry, describe the main wood products produced by the forest industry, describe wood fibre feedstocks used by the pellet industry, and present and address questions relating to the impact on issues related to the sourcing and consumption of forest-derived feedstocks by the BC pellet industry and related counterfactuals.
Outcomes	Demonstrating that despite its small size, the wood-pellet industry in BC plays a critical role in the long-term success of the forest sector.
Resource Link	Here

B.C. Low Carbon Fuel Standard (LCFS) (2022)

Published by: BC Provincial Government

Challenges	Production, transport, and use of fossil fuels in BC have led to increasingly high carbon intensity (CI) values in transportation fuels and other sectors of the province. The LCFS aims to address these challenges and reduce emissions.
Aspirations	This leading regulation aims to reduce the consumption and carbon intensity of fossil fuels in BC, supporting fuel suppliers to comply with stringent targets by providing credits for compliance.
Focus Areas	Liquid Biofuels
Guiding Principles	The Greenhouse Gas Reduction (Renewable & Low Carbon Fuel Requirements) Act and the Renewable & Low Carbon Fuel Requirements Regulation, known collectively as British Columbia's low carbon fuel standard (LCFS), was introduced to reduce the carbon intensity (CI) of fuels used in the province.
Activities	<ul style="list-style-type: none"> • The LCFS sets CI targets that decline each year. • Fuel suppliers generate credits for supplying fuels with a CI below the targets and receive debits for supplying fuels with a CI above the targets. • The debits and credits are proportional to the emissions a fuel generates over its full life cycle. • Credits can be traded between fuel suppliers or banked for future use. • At the end of each compliance period, suppliers must have a balance of zero or more credits to avoid non-compliance penalties.
Outcomes	Recently amended to increase the carbon intensity reduction requirement from 20% to 30% by 2030 in the gasoline and diesel fuel pools. The proposed carbon intensity reduction schedule will linearly increase the target each year from 2023 to reach 30% by 2030. The second major change effective in 2022 was the increase of the penalty rate for non-compliance with the carbon intensity requirements of the Act from \$200 per tonne to \$600 per tonne.
Resource Link	Here

Climate Preparedness and Adaptation Strategy (2022-2025)

Published by: BC Provincial Government

Challenges	Climate-driven changes are already having impacts on our communities, economy, infrastructure, and ecosystems. After a year impacted by severe heatwaves, wildfires, and unprecedented flooding, the need to take urgent action to prepare for and adapt to the impacts of climate change has never been clearer.
Aspirations	The Climate Preparedness and Adaptation Strategy strengthens our capacity to anticipate, reduce and manage climate risks. It involves actions to respond to sudden events like wildfires, floods, and heatwaves, while also helping us to prepare for changes that happen more slowly like sea level rise, habitat loss, receding glaciers, and water shortages.
Focus Areas	Bioenergy
Guiding Principles	The Greenhouse Gas Reduction (Renewable & Low Carbon Fuel Requirements) Act and the Renewable & Low Carbon Fuel Requirements Regulation, known collectively as British Columbia’s low carbon fuel standard (LCFS), was introduced to reduce the carbon intensity (CI) of fuels used in the province.
Activities	<p>The strategy groups actions into four key pathways:</p> <ol style="list-style-type: none"> 1. Foundations for success 2. Safe and healthy communities 3. Resilient species and ecosystems 4. Climate-ready economy and infrastructure.
Outcomes	The strategy aims to better prepare B.C. communities for extreme climate events through such actions as a consistent approach to floodplain mapping, wildfire prevention, and an extreme heat preparedness framework.
Resource Link	Here

B.C. Renewable and Low Carbon Gas Supply Potential Study (2022)

Published by: BC Bioenergy Network, FortisBC, and the BC Provincial Government

Challenges	B.C. is a major producer and supplier of natural gas, and the Government of B.C. is trying to decarbonize natural gas use and enable the clean energy transition
Aspirations	The potential of renewable and low carbon gases could be as high as 440 petajoules per year by 2050 (double what is currently used by Fortis' gas infrastructure in B.C.)
Focus Areas	Renewable and Low Carbon Gas
Guiding Principles	Aligning with CleanBC and other provincial targets, the report examines the potential production of renewable and low-carbon gases using solely B.C. resources by 2030 and 2050
Activities	The potential of renewable and low-carbon gases could be as high as 440 petajoules per year by 2050
Outcomes	By 2050, the province's gas system could be completely supplied by made-in-B.C. renewable and low-carbon sources
Resource Link	Here

CleanBC Roadmap to 2030 (2020)

Published by: The BC Provincial Government

Challenges	Addressing the challenges in BC in reaching Net-Zero according to the International Energy Agency (IEA)
Aspirations	Achieve Net-Zero targets as set out by the IEA
Focus Areas	Low Carbon Energy, Transport, Buildings, Communities, Industry, Forest, Agriculture, Technology
Guiding Principles	Reducing the impact of climate change around the world
Activities	Price on carbon, targets for fuels and low-carbon technologies, negative outcomes for not curbing GHG emissions
Outcomes	Drive deeper emissions reductions at a faster pace to build up the BC low-carbon economy
Resource Link	Here

Refining Margins in British Columbia (2018)

Published by: Advanced Biofuels Canada and Navius Research

Challenges	The Federal Government is enacting an overarching regulation that dictates CI requirements for liquid fuels in each Canadian province.
Aspirations	Examining transportation fuel prices and refinery net revenues in the context of supply costs and provincial liquid fuel policy
Focus Areas	Liquid biofuels and transportation fuels
Guiding Principles	This report provides an analysis of the high wholesale gasoline and diesel prices in the Vancouver area of British Columbia in recent years.
Activities	The analysis covers the Lower Mainland of B.C., east to Hope, north to Pemberton, and Vancouver Island. These regions account for 78% of the provincial population. The report analyzes fuel prices in these areas as a function of fuel supply costs including crude oil costs, transportation costs of crude oil and finished fuel, and refinery margins.
Outcomes	Federal regulations mandate the decarbonization of liquid fuels in Canada with a corresponding fuel LCA model to verify CI and support the establishment of a credit market.
Resource Link	Here

BC Climate Leadership Plan (2016)

Published by: The BC Provincial Government

Challenges	Reaching our 2050 climate goals of a reduction in emissions 80% below 2007 levels
Aspirations	Helping meet 2050 GHG emission reduction goals of 80% below 2007 levels, while building a cleaner economy
Focus Areas	Natural gas, transportation, forestry, agriculture, industry, utilities, communities, public sector
Guiding Principles	BC's efforts to already implement a successful carbon tax and limit fuels building from the 2008 Climate Action Plan
Activities	Restrict GHG emissions, increase low-carbon fuel requirements, recover wood fibre, efficiency standards, build infrastructure, mandate public sector low-carbon use
Outcomes	Reducing GHG emissions by 25 million tons below current forecasts by 2050 and adding 66,000 jobs over the next 10 years
Resource Link	Here

Bioenergy Strategy (2008)

Published by: The BC Provincial Government

Challenges	Addressing the need for a diversified domestic bioenergy economy leverages existing biomass industries in BC
Aspirations	Help reduce GHG emissions and strengthen energy independence in the BC grid
Focus Areas	Forestry & Agriculture
Guiding Principles	Building a commercialization roadmap for the export success of bioenergy products from BC
Activities	Establishing funding, creating incentives, and setting minimum targets for bioenergy production in the BC grid
Outcomes	Establish BC as a hub for biomass for ultimate waste-to-energy usage
Resource Link	Here

Canadian Resources

Biofuels in Canada (2022)

Published by: Advanced Biofuels Canada and Navius Research

Challenges	While there are many policies designed to increase the consumption of renewable and low-carbon fuels in Canada, there is no detailed and comprehensive data source characterizing the impact of these policies.
Aspirations	Tracking biofuel consumption, feedstocks, and avoided greenhouse gas emissions from 2010 to 2022
Focus Areas	Biofuels – Liquid Fuels
Guiding Principles	Navius Research uses public data to catalog the volume of transportation biofuels consumed in each Canadian province while estimating the impact of biofuel consumption on greenhouse gas emissions and transportation energy costs.
Activities	Evaluate and communicate the impact of renewable and low-carbon fuel policies in Canada by quantifying the volumes of renewable transportation fuels consumed in each province, estimating their impact on GHG emissions, and estimating how biofuel consumption may impact energy costs, including analysis of the role of fuel taxation within this cost impact.
Outcomes	Advanced Biofuels Canada engaged Navius Research to release this 'Biofuels in Canada' report, annually released since 2016.
Resource Link	Here

Canada's Aviation Climate Plan (2022-2030)

Published by: Government of Canada

Challenges	While air travel supports Canada's economy, trade, and tourism, and connects Canadians separated by great distances and rugged terrain, it also generates greenhouse gas emissions, which contribute to an increased rate of climate change.
Aspirations	Recognizing the need for coordinated action, this voluntary initiative sets a vision for net-zero aircraft emissions by 2050 and identifies how the parties intend to collaborate to reduce greenhouse gas emissions from aviation activities over the course of this plan.
Focus Areas	Biofuels – Liquid Fuels
Guiding Principles	Canada's Aviation Climate Action Plan (the Action Plan) sets out a vision for net-zero greenhouse gas (GHG) emissions –both domestic and international – by 2050 for Canada's aviation sector and identifies the key measures to get there. The Action Plan is the result of the collaborative efforts between the Government of Canada and the aviation industry and meets Canada's international commitments to submit an updated action plan to the International Civil Aviation Organization (ICAO).
Activities	The Aviation Climate Action Plan examines various pathways to achieve Net Zero by 2050, including the development and adoption of green aerospace technologies, improvements in ground and air operations, out-of-sector reductions, and the widespread availability and use of SAF.
Outcomes	<ul style="list-style-type: none"> • The Action Plan sets an aspirational target of 10% SAF use by the year 2030. • The plan commits to exploring putting a price on carbon emissions from inter-provincial flights. • Transport Canada will collaborate with airport authorities to map their GHG emissions. • Over the next 3 years ECCC will develop an experimental meteorological tool for the identification and prediction of contrail forming zones in the atmosphere for Canadian airspace to enable alternate flight paths.
Resource Link	Here

Clean Fuels Report Card (2022)

Published by: Advanced Biofuels Canada

Challenges	With the increased development and use of biofuels in Canada, there is currently no way to synthesize this information into meaningful change for the sector. Based on data from the Biofuels In Canada 2022 Databook by Advanced Biofuels Canada and Navius Research, this Clean Fuels Report Card intends to provide this meaningful synthesis.
Aspirations	The report card aims to create a complete picture of biofuels' use impacts in Canada.
Focus Areas	Solid biofuels, bioproducts
Guiding Principles	The report's interactive data convey key results to visualize comparative greenhouse gas reductions (absolute and per vehicle), biofuel blending levels, fuel costs and savings, biofuel capacity (existing, under development), and the impact of carbon and fuel taxes on clean fuel use.
Activities	This interactive report contains several new analyses of biofuels' use impacts in Canada, including the impact of fuel taxation (excise, carbon) on fuel buyers' costs. The report card identifies provincial leaders (ON, BC, AB) on GHG reductions (absolute & per vehicle), costs and savings from biofuel use, and provincial biofuel production capacity.
Outcomes	As a direct result of increased biofuel use, BC realized 82% more GHG emissions than it did in 2015. On the other hand, heavy-duty trucking has seen fuel cost increases. BC would have saved \$208 million over 2016-2020 if carbon and fuel taxes were applied properly.
Resource Link	Here

Clean Fuel Regulations (2022)

Published by: Government of Canada, Environment and Climate Change Canada, Low Carbon Fuels Division

Challenges	The Federal Government is enacting an overarching regulation that dictates CI requirements for liquid fuels in each Canadian province.
Aspirations	These regulations will result in substantial CI reductions in liquid fuels in both the short and long term in Canada.
Focus Areas	Liquid biofuels
Guiding Principles	The Clean Fuel Regulations will require gasoline and diesel primary suppliers (i.e., producers and importers) to reduce the carbon intensity (CI) of the gasoline and diesel they produce in and import into, Canada from 2016 CI levels by 3.5 grams of carbon dioxide equivalent per megajoule (gCO _{2e} /MJ) in 2023, increasing to 14 gCO _{2e} /MJ in 2030. The regulations will also establish a credit market whereby the annual CI reduction requirement could be met via three main categories of credit-creating actions: (1) actions that reduce the CI of the fossil fuel throughout its lifecycle, (2) supplying low-carbon fuels, and (3) supplying fuel and energy in advanced vehicle technologies.
Activities	The draft Clean Fuel Regulations were published in 2019 in the Canada Gazette and were amended in 2022.
Outcomes	Federal regulations mandate the decarbonization of liquid fuels in Canada with a corresponding fuel LCA model to verify CI and support the establishment of a credit market.
Resource Link	Here

Hitting Canada's Climate Targets with Biogas and RNG (2022)

Published by: The Canadian Biogas Association and Navius Research

Challenges	Current policies, including the proposed federal Clean Fuel Standard, only capture a small fraction of biogas & RNG's potential climate contributions in Canada.
Aspirations	The report seeks to identify the role of biogas and RNG in Canada's 2030 and 2050 targets.
Focus Areas	Biogas and RNG
Guiding Principles	To determine the role of biogas and RNG in supporting Canada's 2030 and 2050 climate goals, the Canadian Biogas Association commissioned Navius Research to model the impact of several potential government policies on the GHG reductions happening through biogas & RNG. This report presents and interprets the key findings of that modeling
Activities	The report examines methane and GHG abatement, clean energy production and clean economic growth to determine the potential for hitting Canada's climate targets using biogas and RNG. The study also highlights policies to unlock biogas and RNG.
Outcomes	
Resource Link	Here

Reaching Cruising Altitude – A Plan for Scaling Sustainable Aviation Fuel (2022)

Published by: Deloitte

Challenges	Aviation is an industry that is hard to decarbonize and will need other industries to help it decarbonize directly and indirectly
Aspirations	Sustainable aviation fuel (SAF) will be used primarily to decarbonize the aviation industry in Canada
Focus Areas	Aviation and aviation fuel
Guiding Principles	Canada is not expected to reach 2050 GHG emission reduction goals unless the aviation industry can reduce its emissions
Activities	The production of SAF and aligning the value chain to accelerate adoption in Canada
Outcomes	To develop a sustainable and abundant SAF market in Canada to help decarbonize the aviation industry and meet 2050 GHG emission reduction goals
Resource Link	Here

Fuelling 2050: The Road Forward (2022)

Published by: The Conference Board of Canada

Challenges	The transportation sector in Canada accounts for about 29% of GHG emissions.
Aspirations	Examining transportation fuel prices and refinery net revenues in the context of supply costs and provincial liquid fuel policy
Focus Areas	Liquid biofuels and transportation fuels
Guiding Principles	This report provides an analysis of the high wholesale gasoline and diesel prices in the Vancouver area of British Columbia in recent years.
Activities	The analysis covers the Lower Mainland of B.C., east to Hope, north to Pemberton, and Vancouver Island. These regions account for 78% of the provincial population. The report analyzes fuel prices in these areas as a function of fuel supply costs including crude oil costs, transportation costs of crude oil and finished fuel, and refinery margins.
Outcomes	Federal regulations mandate the decarbonization of liquid fuels in Canada with a corresponding fuel LCA model to verify CI and support the establishment of a credit market.
Resource Link	Here

Biofuels in Canada (2021)

Published by: Advanced Biofuels Canada and Navius Research

Challenges	Canada can't meet 2030 or 2050 transportation GHG goals without significantly increasing low-carbon biofuel content in gasoline and diesel
Aspirations	An open source that provides full access to Canadian renewable and low-carbon fuel market data
Focus Areas	Renewable fuels for transportation and advanced biofuels
Guiding Principles	The report is 5 th in a series commissioned annually by Advanced Biofuels Canada
Activities	The annual report calculates the volumes of renewable and petroleum transportation fuels consumed in each Canadian province, and characterizes these calculations by fuel type, feedstock, and carbon intensity.
Outcomes	It provides an evaluation of Canadian renewable and low carbon fuel policies and their impact on fuel consumption, greenhouse gas (GHG) emissions reduction, and consumer costs.
Resource Link	Here

Economic Impact of Current and 10-Year Projections of Biofuels Production in Canada (2021)

Published by: Bureau of Business and Economic Research and Advanced Biofuels Canada

Challenges	B.C. is a major producer and supplier of natural gas, and the Government of B.C. is trying to decarbonize natural gas use and enable the clean energy transition
Aspirations	Increased production of low-carbon fuels will have a significant impact on Canada's economy.
Focus Areas	Liquid biofuels and advanced biofuel technologies
Guiding Principles	The study includes the estimated economic impact of 2020 (baseline) biofuels production along with the projected (2030) economic impacts of additional biofuels production capacity.
Activities	Advanced Biofuels Canada contracted with the Bureau of Business and Economic Research to identify and study the economic impact of increased biofuel production on six provinces in Canada pursuant to increased demand from federal and provincial fuel regulations.
Outcomes	According to 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.
Resource Link	Here

Driving to 2050 (2020)

Published by: Canadian Fuels Association

Challenges	Identify opportunities to supply low-carbon energy from domestic supply and processing
Aspirations	Production and distribution hub for low-carbon energy products and feedstock
Focus Areas	Refining & Petroleum Products
Guiding Principles	Canada can source its own low-carbon fuels through existing infrastructure and partners in the energy sector
Activities	Resulting in process improvements, biofuels, carbon capture and storage, and synthetic fuels
Outcomes	Leadership role in the Clean Resources Innovation Network (CRIN) committed to developing clean hydrocarbon energy and a strong energy economy
Resource Link	Here

Sustainable Aviation Fuels: A Canadian Perspective (2019)

Published by: Green Aviation Research and Development Network (GARDN)

Challenges	Canada, as an early adopter, set environmental targets for reducing the carbon footprint of commercial aviation and researching sustainable aviation fuels (SAF) around 15 years ago. Decarbonizing the aerospace sector requires significant efforts through various pathways.
Aspirations	Since 2009, the Green Aviation Research and Development Network (GARDN) has played a pioneering role in the development of SAF through collaborative research projects where cross-sectoral industrial and academic partners have co-created less-environmentally-impactful ways to travel by air.
Focus Areas	Biofuels (SAF)
Guiding Principles	These strategic areas form the basis of GARDN's vision of a Pan-Canadian Sustainable Aviation Fuels Initiative (SAFI Canada), a commercialization roadmap that builds on the principles of the circular economy, strategic eco-design, and industrial symbiosis to advance the decarbonization of the Canadian air transport sector using domestically produced SAF.
Activities	<p>Future efforts demand addressing current gaps and opportunities from a collaborative and integrated perspective throughout the following strategic areas:</p> <ol style="list-style-type: none"> 1. research, development, and demonstration (RD&D) and innovation, 2. financing and strategic partnerships, 3. policy and regulations, 4. technical and sustainability certifications, 5. outreach and knowledge transfer, and 6. consortia building and regional initiatives.
Outcomes	The report provides recommendations for each of the 6 listed activities. For RD&D, the facilitation of cross-sectoral research for advanced and non-conventional feedstocks and conversion technologies. For Financing, encourage federal
Resource Link	Here

Roadmap to 2030 – Clean Fuels Investment in Canada (2019)

Published by: Advanced Biofuels Canada

Challenges	Canada's clean liquid fuel sector targets growth in production capacity from 3 billion litres per year to 8.5 billion litres by 2030.
Aspirations	To meet our emissions reduction commitments and improve the competitiveness of the Canadian economy, Canada must implement a Clean Fuel Strategy to establish competitive conditions to attract private sector investment in the production and use of clean fuels in Canada.
Focus Areas	Advanced biofuels and synthetic liquid fuels
Guiding Principles	Canada's clean liquid fuels sector targets growth in production capacity from 3 million litres per year to 8.5 billion litres by 2030 to reduce incremental greenhouse gas emission reductions by at least 15 million tonnes and contribute over \$15 billion per year in new economic activity.
Activities	Advanced Biofuels Canada contracted with the Bureau of Business and Economic Research to identify and study the economic impact of increased biofuel production on six provinces in Canada pursuant to increased demand from federal and provincial fuel regulations.
Outcomes	The report identifies private sector investment potential of over \$6 billion to build production capacity and infrastructure to transition to expanded non-fossil, low-carbon fuel use by 2030.
Resource Link	Here

A Healthy Environment and a Healthy Economy (2021)

Published by: Environment and Climate Change Canada (ECCC)

Challenges	The COVID-19 pandemic caused significant loss and uncertainty in Canada and around the world.
Aspirations	The report seeks to identify the role of biogas and RNG in Canada's 2030 and 2050 targets.
Focus Areas	Biogas and RNG
Guiding Principles	This report summarizes the modeling findings commissioned by the Canadian Biogas Association, conducted by Navius Research. It examines the role of biogas and RNG in achieving Canada's 2030 and 2050 climate goals, highlighting the impact of various government policies on GHG reductions.
Activities	The report examines methane and GHG abatement, clean energy production, and clean economic growth to determine the potential for hitting Canada's climate targets using biogas and RNG. The study also highlights policies to unlock biogas and RNG.
Outcomes	Among other actions, the Government of Canada is committing \$15.4 million over three years, starting in 2020-21 to create and support the Net-Zero Advisory Body. It will consult with Canadians and provide independent advice to the Minister of Environment and Climate Change on pathways to achieve net-zero emissions by 2050.
Resource Link	Here

United States Resources

A Life-Cycle Analysis of the Greenhouse Gas Emissions from Corn-Based Ethanol (2018)

Published by: ICF for the U.S. Department of Agriculture

Challenges	Since 2010, EPA’s estimated GHG mitigation value for corn ethanol (i.e., 21 percent lower emissions than an energy equivalent quantity of gasoline) has dominated academic, industry, and policy discussions of GHG issues related to renewable transportation fuels, as well as the design of federal renewable fuels policy.
Aspirations	For these reasons, the structure for the LCA developed for this report is designed so that comparisons of its results with those in the RIA are relatively straightforward
Focus Areas	LCA, Liquid biofuels and transportation fuels
Guiding Principles	The report draws on existing data and models to develop a Life Cycle Analysis of GHG emissions for Corn-Based Ethanol.
Activities	This report has analyzed the current GHG profile of U.S. corn ethanol and two projected emissions profiles for 2022.
Outcomes	Projections that in 2022, the life cycle emissions associated with ethanol would be 21 percent lower than those of an energy equivalent quantity of gasoline.
Resource Link	Here