Canada's

VENTURES TO VALUE CHAINS

FOREST BIOECONOMY

NOVEMBER 2023

FORESIGHT
CANADA

ACKNOWLEDGEMENTS

Foresight acknowledges that the lands on which we conducted this work are the traditional, ancestral, and unceded territories of the xwməθkwəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations.

This report was prepared by Foresight Canada. It was written by Colton Martinez Rubio with support from Alyssa Kelly. Additional support was contributed by Khushi Nilani, Jacob Atherton, Sandy Ferguson, Tyler Maksymiw, Carlos Espejo, David Sanguinetti, Samantha Lego, Morgan Scott, Kaitie Unwin, and Tyler Klinkhammer. Design by Steffi Lai.

We'd like to acknowledge and thank the contributions of Natural Resources Canada and bioNEXT, an initiative of Foresight with partners CMPC, Genome BC, and the Government of Canada, in compiling the forest bioeconomy ecosystem data.

bioNEXT

Thank you to Foresight's Net Zero Innovation Network in British Columbia (BCNZIN) team for their contributions. Foresight's Net Zero Innovation Network (BC) is made possible by financial support from PacifiCan and the Province of British Columbia through the Ministry of Energy, Mines and Low Carbon Innovation.

BC NET ZERO INNOVATION NETWORK

Foresight is Canada's cleantech accelerator.

We bring together innovators, industry, investors, government, and academia to address today's most urgent climate issues and support a global transition to a green economy.

ABOUT

TABLE OF CONTENTS

INTRODUCTION 6
RATIONALE 7
FOREST BIOECONOMY TECH: THE VALUE CHAIN 8
METHODOLOGY 9
CANADA'S FOREST BIOECONOMY COMPANIES 11
DEEP DIVE: PROVINCIAL TRENDS 15
- BRITISH COLUMBIA 18
- PRAIRIES (ALBERTA, MANITOBA, AND SASKATCHEWAN) 20
- ONTARIO 23
- QUÉBEC 25
- ATLANTIC PROVINCES 27

FOREST BIOECONOMY TECH: STRENGTHS + OPPORTUNITIES 29
- UPGRADING FOREST BIOMESS TO MITIGATE GHGs 31
- BIOFUELS IN CANADA 34
- BIOPROCESSING 35

RECOMMENDATIONS 37
CONCLUSION 40
REFERENCES 41
- APPENDICES FOUND IN ACCOMPANYING DOCUMENT

INTRODUCTION

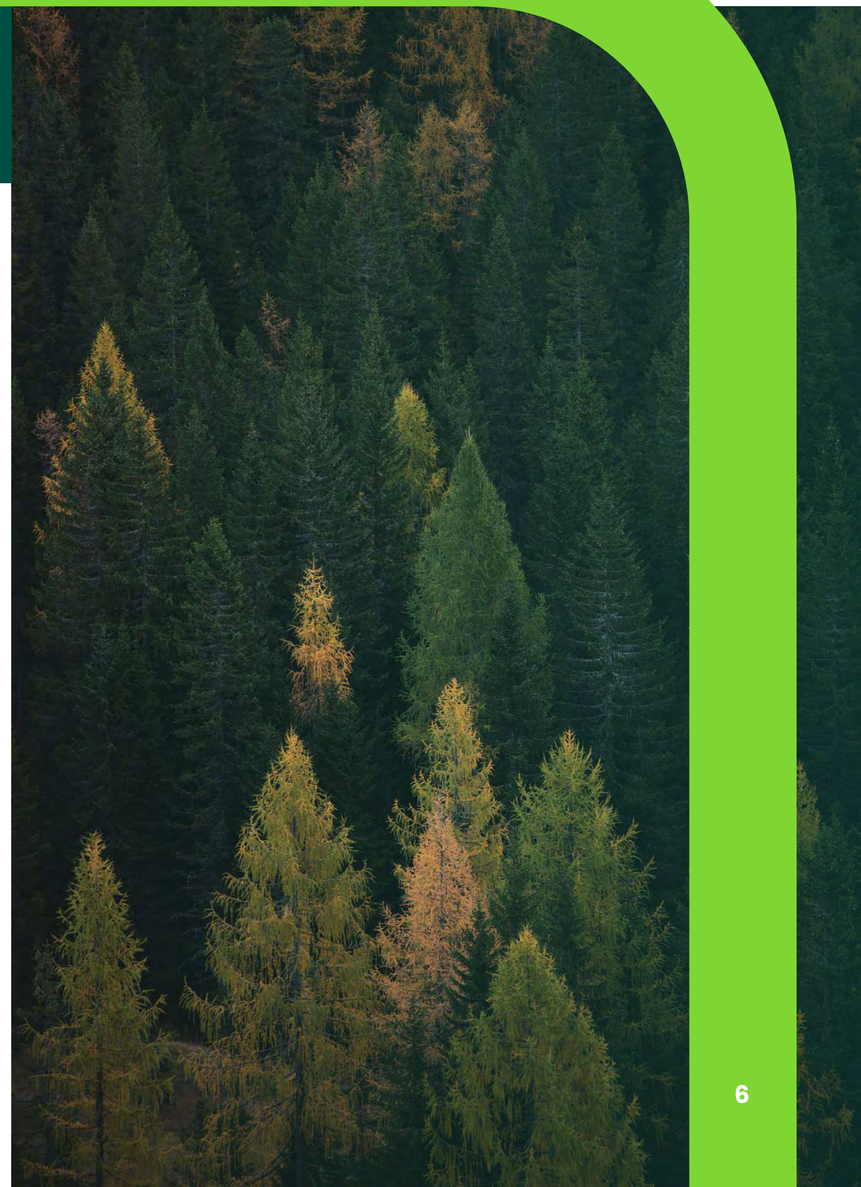
CANADA IS THE WORLD'S SECOND-LARGEST FOREST PRODUCTS EXPORTER. [1]

In 2021, the forestry sector contributed $19.5 billion towards Canada's real GDP, accounted for 345,825 direct and indirect jobs, and exported approximately $44.9 billion in wood, pulp and paper, and fabricated products. [2] Between 2011 and 2021, operating profits and return on capital employed rose. [3]

The forestry industry has historically been an economic lifeline for many regions across Canada, particularly rural communities where local forest product companies stood as one of the few sources of economic growth. However, as demand for traditional forest products such as lumber, panels, pulp, print, and paper has changed, [4] so too has Canada's forest product industry. Mill closures and industry consolidation have affected several forestry hubs across the country and driven industry to move up the value chain to find ways to capture additional value from forest biomass. In pursuit of new economic opportunities, stakeholders in the forestry sector have been exploring how low-quality/low-value fibre can be utilized to create value-added products. [5]

The majority of the forest bioeconomy finds novel ways to utilize the residues of traditional forestry companies such as lumber, pulp, and paper mills, for the purpose of creating value-added products. Cleantech innovation in this sector represents a renewed opportunity for economic growth through the proliferation of engineered wood products, biofuels, biochemicals, biomaterials, and more. From cellulose nanocrystals to mass timber, biochar, renewable fuels, and drone technology, there are a wide range of products being commercialized by Canadian innovators.

The global forest bioproducts market is expected to grow to $670 billion by 2030 and Canada's forest bioeconomy has a strong foundation to capture this market opportunity in the coming years. [6] Further evidence-based research will help both the private and public sector to grow its understanding of the role Canada's forest bioeconomy can play in the net-zero transition. To guide the sector, the Canadian Council of Forest Ministers released the "Renewed Forest Bioeconomy Framework" in 2021 and Bioindustrial Innovation Canada developed the Canadian Bioeconomy Strategy in 2019. [1] This edition of Foresight's Ventures to Value Chains initiative aims to contribute to the evolving dialogue in the forestry industry and provide insights on perceived areas of strength for Canada as well as opportunities for growth.



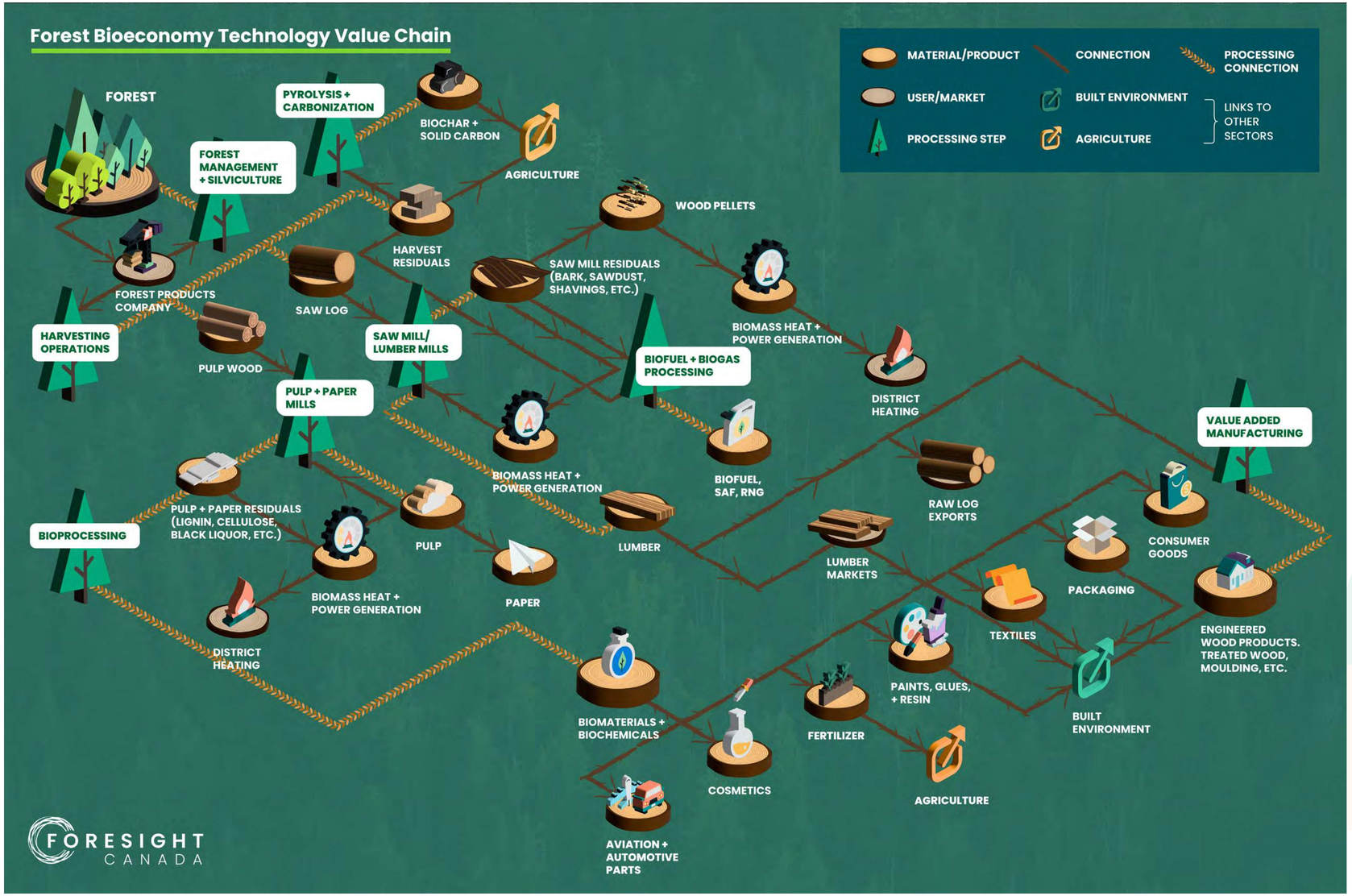
RATIONALE

VENTURES TO VALUE CHAINS

is a Foresight initiative that leverages data from technology companies and other key stakeholders to map and categorize strategically important industry value chains for Canada in the clean economy.

This initiative will result in a searchable database, which can be used as a tool to inform stakeholders on Canada's competitive strengths, ecosystem gaps, and areas of opportunity and growth. These insights can identify where targeted programming, research and development, or funding will bolster Canada's leadership and economic development as we transition to a clean economy and net zero emissions.

FOREST BIOECONOMY TECH: THE VALUE CHAIN



The value chain (Figure 1) describes the journey of raw forest biomass inputs through a number of processing steps and the ways in which they connect to inputs, outputs, and end points such as users, markets, or the environment.[1]

Because forest products are used in several industries, this value chain also identifies areas where there are overlaps with other sectors Foresight is mapping. These are not intended to be an exhaustive list of sectors that may overlap.

Figure 1 Value Chain

[1] While these are labelled as processing steps, they include both processing (e.g., treatment) and other types of actions within the value chain (e.g., use). For definitions of each of the processing steps, see Appendix A.

METHODOLOGY

This research was conducted by mapping Canada's forest bioeconomy ecosystem, categorizing companies in up to two value chain steps (VC steps), and subsequently analyzing the distribution of companies. [2]

The forest bioeconomy database comprises companies, enablers, and knowledge generators within the ecosystem. The value chain mapping and analysis focused on companies that fit within the following criteria:

- Are involved in technology innovation, research, or development in some capacity. In most cases, this is their primary focus, while for others, this is a component of a larger portfolio of services.
- Excluded, based on the first set of criteria, are suppliers, distributors, service providers, consulting firms, and forest product companies (harvesting, saw mills, paper mills, etc.).
- Also excluded are "end-users"; larger companies in the forest bioeconomy ecosystem that play an important role, but are the consumers/acquirers of novel technologies, rather than the developers.
- "Bioeconomy" refers to the forest bioeconomy. Companies that process/use both agricultural and forestry inputs have been included in the database, while bioeconomy companies that exclusively use agriculture feedstocks have been omitted.
- Bioprocessing encompasses a broad set of companies that may be creating a variety of intermediary products related to "biomaterials" or "biochemicals", but do not sell finished products.
- Companies marked as "biomaterials" or "biochemicals" are producing final products to deliver to consumers.
- Companies must either be headquartered in Canada or have a strong Canadian presence that includes research and innovation.

[2] To better distinguish within categories, all companies were also classified based on the climate adaptation technology (CAT) framing and taxonomy, which is the intellectual property of Mazarine Ventures LLC, available to all under the Creative Commons (CC) license.

METHODOLOGY

Secondary research was used to provide additional context to the trends. Because the data can only indicate clustering and concentrations, and not why trends exist, observations are communicated as:

- **Areas of strength:** Areas where the data and supporting research suggests that the forest bioeconomy sector is doing well.
- **Opportunities:** Areas where the data and/or supporting research suggests that there is an opportunity to leverage the forest bioeconomy to meet the growing need for climate solutions.

For more detail on the methodology, see Appendix B.

CANADA'S FOREST BIOECONOMY COMPANIES

141 COMPANIES WERE ASSIGNED TO CANADA'S FOREST BIOECONOMY VALUE CHAIN

This is equal to approximately **seven per cent** of the over **2000** Canadian cleantech companies identified by Natural Resources Canada in 2022. [7] Forest bioeconomy companies found in this exercise are highly concentrated in Canada's four largest provinces and among a few value chain steps.

- Quebec: **27 companies**
- Ontario: **28 companies**
- Alberta: **33 companies**
- British Columbia: **41 companies**

For companies with "processing" technology, the leaders were: 1) biofuels/biogas and 2) bioprocessing (for the purpose of developing biomaterials/bioproducts and/or biochemicals). For companies delivering products to the market, the leader was biochar/solid carbon, followed by biochemicals, engineered wood products and biomaterials.

Processing

- Biofuel processing: **35 companies**
- Bioprocessing: **38 companies**

Material/Product

- Biochar/solid carbon: **15 companies**
- Biochemicals: **13 companies**
- Engineered wood products: **15 companies**
- Biomaterials: **11 companies**

The forestry bioeconomy is unique compared to other value chains Foresight has mapped, in that a relatively higher proportion of companies are at the material/product level rather than processing. Most companies we mapped leverage forestry by-products and mill residues to create new value added products (e.g., bioprocessing, biofuels, biochar/solid carbon).

Natural Resources Canada's 2022 Cleantech Industry Survey found that the majority of firms in the bioeconomy have a high level of technological maturity: 51 per cent of firms are in the commercialization and scale-up (TRL 9+) or exporting stages of development, while 41 per cent are in pre-commercial research and development or testing stages. [7]

The forest bioeconomy value chain is also unique in that 92 per cent of companies are marked as "Address" in the Mazarine classification system, meaning that fewer technologies are focused on monitoring or analyzing operations than other sectors.

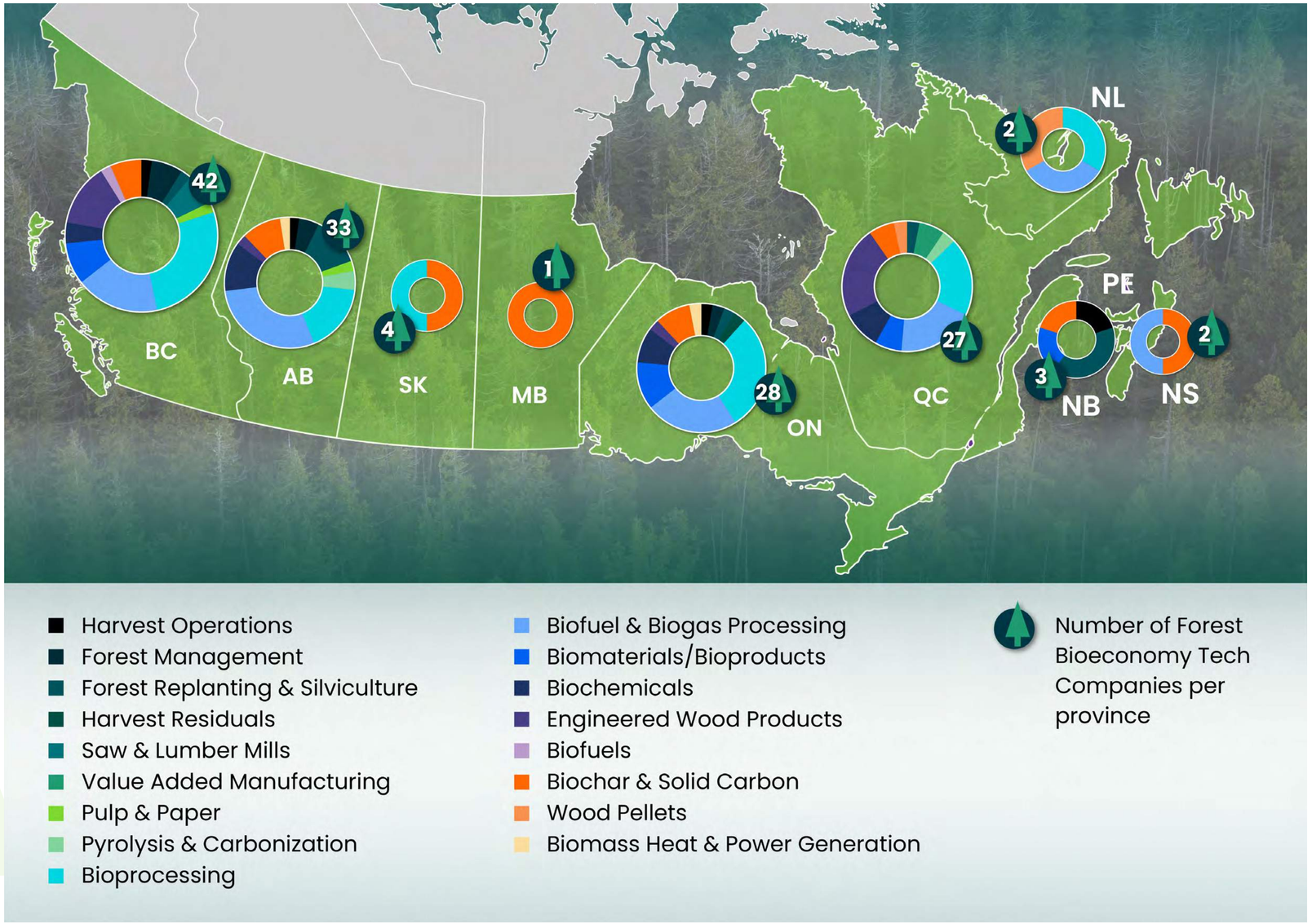


Figure 2

Distribution of carbon tech companies across the value chain processing steps.

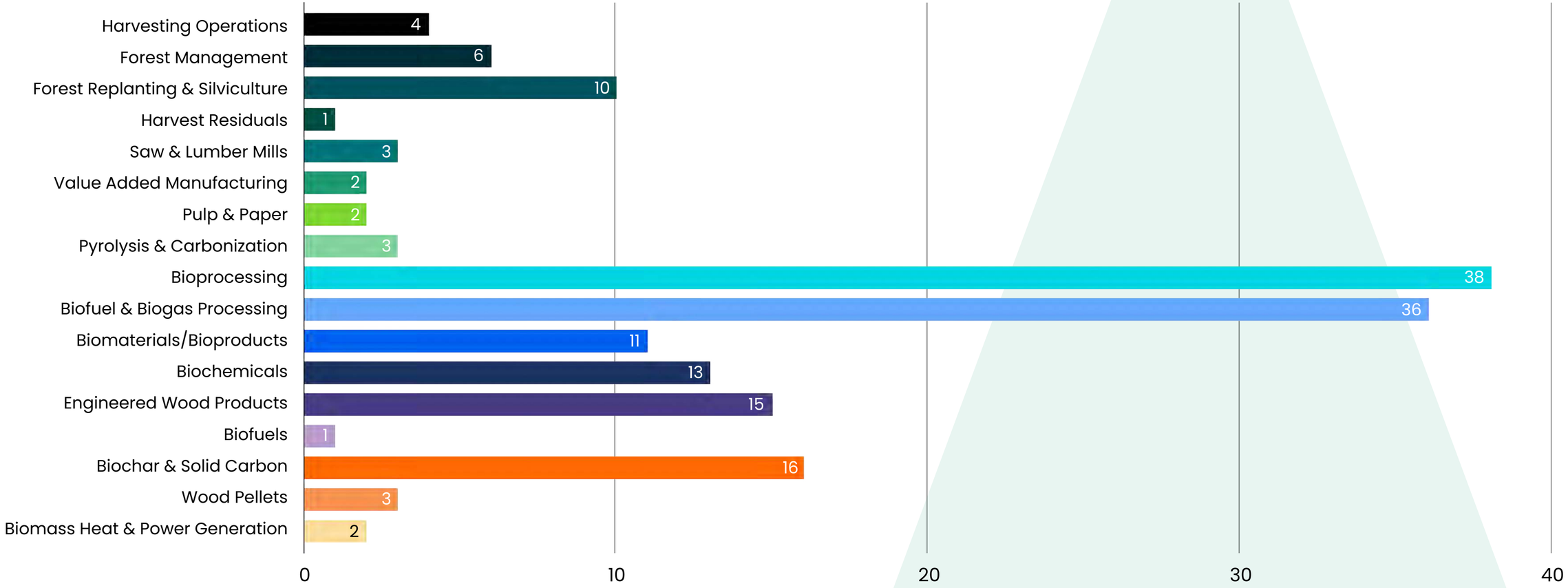


Figure 3

Distribution of forest bioeconomy technology across the Value Chain.

DEEP DIVE:
PROVINCIAL TRENDS

THIS SECTION COVERS KEY TAKEAWAYS BASED ON AREAS OF STRENGTH AND CLUSTERING ACROSS THE PROVINCES.

While companies are assigned to the province in which their public headquarters is located, it is important to note that companies likely serve other provinces and territories. Not every value chain step is covered in every province, which is to be expected and some value chain steps represent emerging areas or areas that have a higher concentration of “end-users” of new technology and thereby fall outside the scope of this exercise.

KEY INSIGHTS

- Biofuel processing is an area of strength for Alberta and British Columbia.
- Bioprocessing is an area of strength for British Columbia and Ontario.
- Engineered wood products companies are concentrated in British Columbia and Québec.

FOREST BIOECONOMY TECHNOLOGY VALUE CHAIN BY PROVINCE

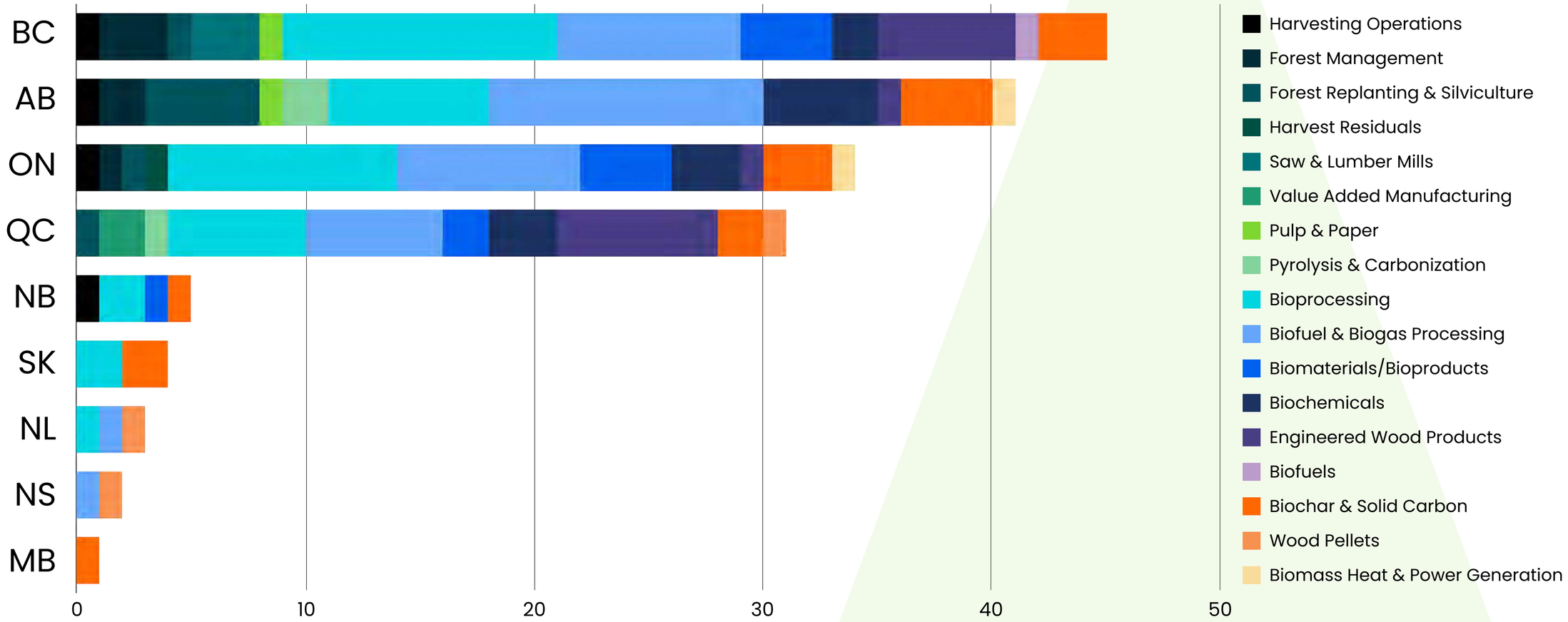
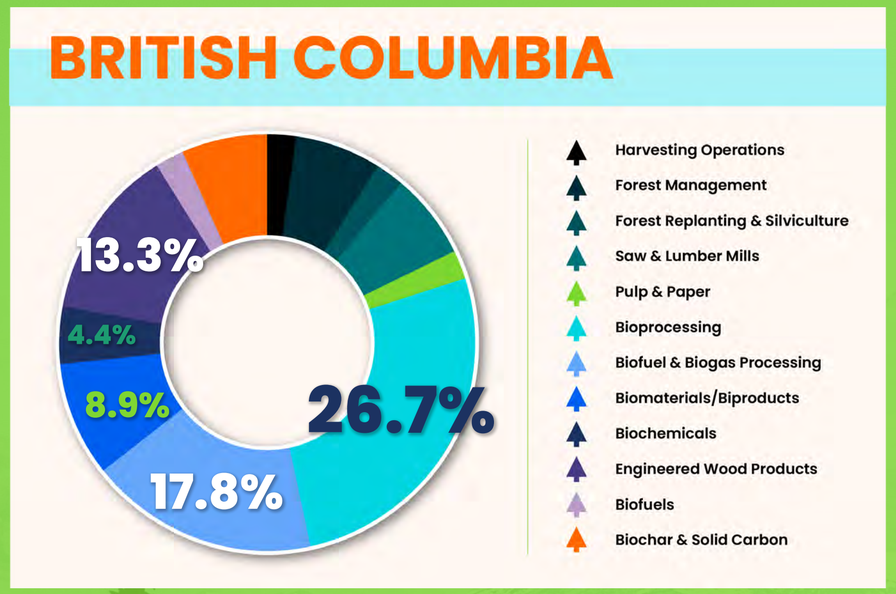


Figure 4

Forest bioeconomy technology value chain by province.

BRITISH COLUMBIA



British Columbia has a wide range of funding, research and demonstration programs that have helped drive innovation in the forest bioeconomy, such as the Wood First Initiative, First Nation Clean Energy Business Fund, Forestry Innovation Investment, Indigenous Forestry Initiative, Investments in Forest Industry Transformation, and the Mass Timber Demonstration Program.[35] To guide the sector, the province commissioned an eight-year cleantech innovation strategy for the sector in 2016, however there have yet to be any updates.[36] The province's report, "Modernizing Forest Policy in British Columbia", briefly discusses bioproducts but not in depth.[37]

BRITISH COLUMBIA

OBSERVATIONS

BC HAS THE LARGEST CONCENTRATION OF COMPANIES

BC IS THE MOST WELL-DISTRIBUTED PROVINCE ACROSS THE VALUE CHAIN

BIOFUELS ARE AN AREA OF STRENGTH FOR BC

SUPPORTING DATA

- **41** companies

- Companies in **13** of **18** VC steps
- **Eight** VC steps with more than 1 company

- **Eight** of **35** biofuel + biogas processing companies are based in BC

DISCUSSION

BC forestry contributed $4.98 billion to Canadian real GDP in 2021. BC has a vast ecosystem of actors growing the province's forest bioeconomy, including: FPInnovations, the B.C. Bio-Alliance, the BC Bioenergy Network, BCWood, BioComposites Research Network (BioCRN), and Woodworks BC. [35] The BC Ministry of Forests also hosted the 2023 Forest Innovation & Bioeconomy Conference, in collaboration with FPInnovations, UBC BioProducts Institute (UBC BPI), and Foresight. [6]

Knowledge generators and enablers developing the forest bioeconomy in BC include:

- UBC BioProducts Institute (UBC BPI)
- Clean Energy Research Centre
- Pacific Forestry Centre
- BC Bioenergy Network
- BC First Nations Forestry Council
- BC Pulp & Paper Bioproducts Alliance (BioAlliance)
- BC Wood Specialties Group
- bioNEXT
- BC Council of Forest Industries (COFI)
- GenomeBC

BC leads most of the prominent VC steps and has the most bioprocessing and biomaterials companies.

BC also has the second-most companies in biofuel + biogas processing, engineered wood products, and biochar/solid carbon.

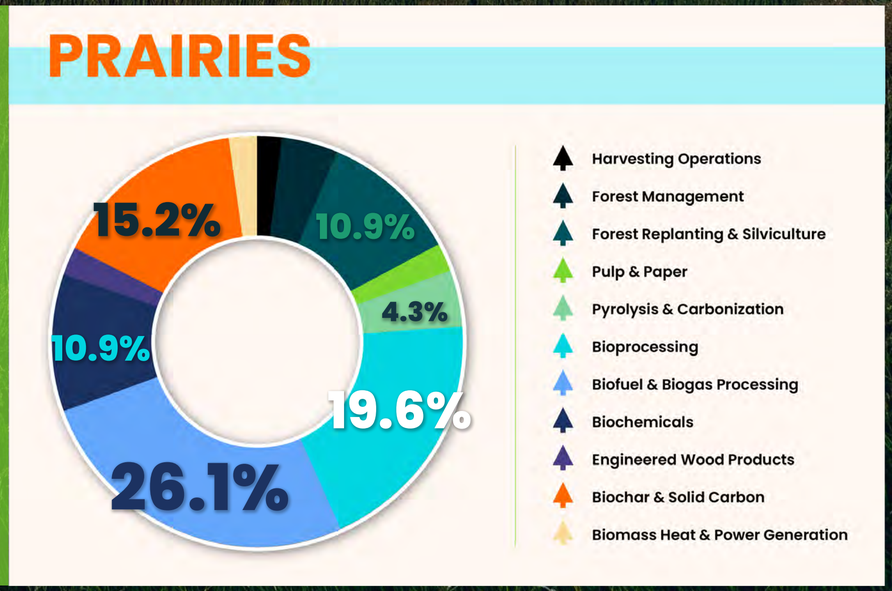
BC's Renewable and Low Carbon Fuel Requirements Regulation is one of the province's long-standing and most effective climate policies. It requires a carbon intensity reduction of 30 per cent by 2030, and biofuel blending requirements of five per cent for gasoline and four per cent for diesel. The supportive regulatory environment in BC has encouraged growth in the biofuel sector.

Recent examples of industry activity include:

- REN Energy is developing innovative plants in BC that will use wood waste to create biomethane. They are expected to be operational by 2025. [38]
- G45 insights is commercializing PyroCatalytic Hydrogenation technology to create renewable gases from forestry waste. [39]
- Arbios Biotech, a joint venture of Canfor and Royal Dutch Shell, is developing Catalytic Hydrothermal Reactor technology adjacent to Canfor's Pulp Mill in Prince George, to produce commercial biocrude. [40,41]

PRAIRIES
(ALBERTA, MANITOBA, AND SASKATCHEWAN)

The Government of Alberta has few explicit initiatives for the forest bioeconomy, these include its support for Wood WORKS! Alberta and the “Forest Jobs Action Plan”.[24] Outside of Alberta, very few companies were identified and neither Saskatchewan nor Manitoba have dedicated programs or long term strategies for the forest bioeconomy.



PRAIRIES

OBSERVATIONS

ALBERTA HAS THE SECOND MOST TOTAL COMPANIES AND IS WELL DISTRIBUTED ACROSS THE VALUE CHAIN

BIOFUEL + BIOGAS PROCESSING IS AN AREA OF STRENGTH FOR ALBERTA

SUPPORTING DATA

- **34** companies identified
- **11** VC steps covered
- **Seven** VC steps with more than one company
- **12** companies in biofuel + biogas processing

DISCUSSION

Alberta has the most companies assigned to biofuel + biogas processing, biochemicals, replanting and silviculture, and biochar; as well as the third-most bioprocessing companies. Alberta's forest industry contributed $2.4 billion to Canadian real GDP in 2021.

Knowledge generators and enablers developing the forest bioeconomy in Alberta include:

- Alberta Forest Products Association (AFPA)
- GenomeAlberta
- GenomePrairie (serves AB, SK, and MB)

The plurality of Alberta's companies were assigned to biofuel + biogas bioprocessing. Alberta's expertise as a global leader in the oil and gas industry positions the province well for the clean fuel boom on the horizon. Alberta has had a Renewable Fuels Standard with blending requirements of five per cent for gasoline and two per cent for diesel, and is subject to the federal clean fuel regulations.

Recent examples of industry activity include:

- Calgary-based Expander Energy is building a biodiesel plant with annual capacity of 8 million litres, using wood waste feedstock. [25]
- Steeper Energy has been supported by the province to commercialize proprietary Hydrothermal Liquefaction technology in Alberta, which will create biocrude from forestry waste. [26]
- Forge Hydrocarbons announced an MOU with Edmonton International Airport to scale their Lipid to Hydrocarbon technology, which creates biofuels from a variety of feedstocks including wood waste. [27]

PRAIRIES

OBSERVATIONS

SASKATCHEWAN'S REPRESENTATION IS LIMITED TO TWO VC STEPS

MANITOBA HAS VERY LITTLE INNOVATION ACTIVITY IN THE FOREST BIOECONOMY

SUPPORTING DATA

- **Four** companies across bioprocessing, biofuels and biochar/solid carbon

- **One** company found

DISCUSSION

Saskatchewan's representation in our forest bioeconomy database is limited to two companies producing solid carbon products, one company producing cellulose nanocrystals and another developing biofuels.

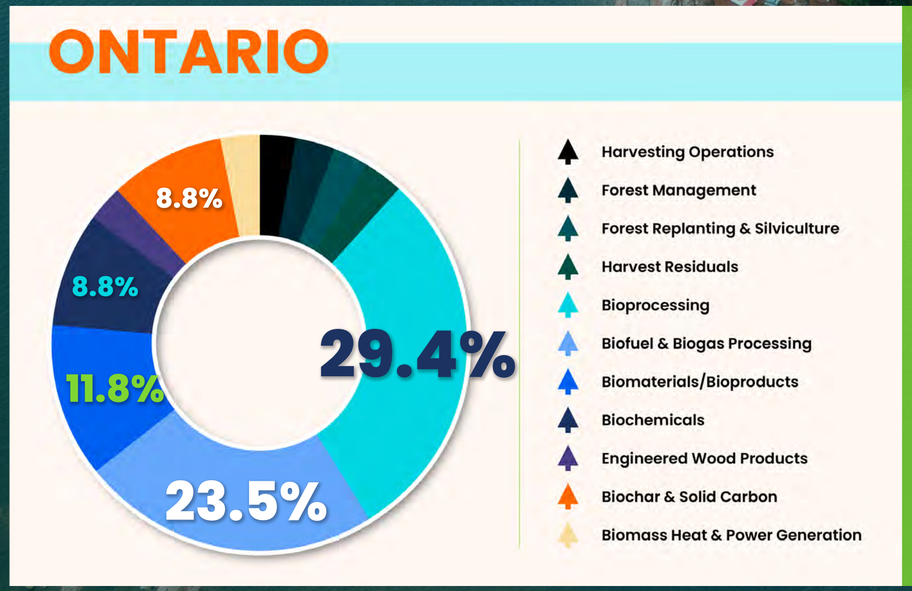
Other prominent industry activity in Saskatchewan's forest bioeconomy includes:

- The Meadow Lake Tribal Council developed an 6.6MW biomass energy plant using local sawmill residuals as a feedstock, the first of its kind in the province. [28]

- In partnership with leading forest product company Dunkley Lumber, BC Biocarbon is building a new biochar refinery in Saskatchewan that will expand its feedstock capacity by eight tonnes per hour and sequester 44,000 tonnes of CO_2e. [29,30]

Carbon Lock Tech, a company developing biochar technology, was the only Manitoba company mapped on the forest bioeconomy value chain.

ONTARIO



Ontario developed an overarching strategy for the forest sector in 2020 and followed up with a targeted five-year "Forest Biomass Action Plan" in 2022, the latter of which focuses on supporting companies developing new commercial uses for biomass including biochemicals, biomaterials and bioenergy. [19,20] More recently, the province created a $20 million "Forest Biomass Program" that complements this action plan by investing in projects creating value-added products from low-value wood and mill by-products. [21]

ONTARIO

OBSERVATIONS

ONTARIO IS HOME TO THE THIRD-MOST COMPANIES

BIOPROCESSING AND BIOFUELS ARE AREAS OF STRENGTH FOR ONTARIO

SUPPORTING DATA

- **28** companies
- **11** VC steps covered
- **10** companies for bioprocessing
- **Eight** companies for biofuel + biogas processing

DISCUSSION

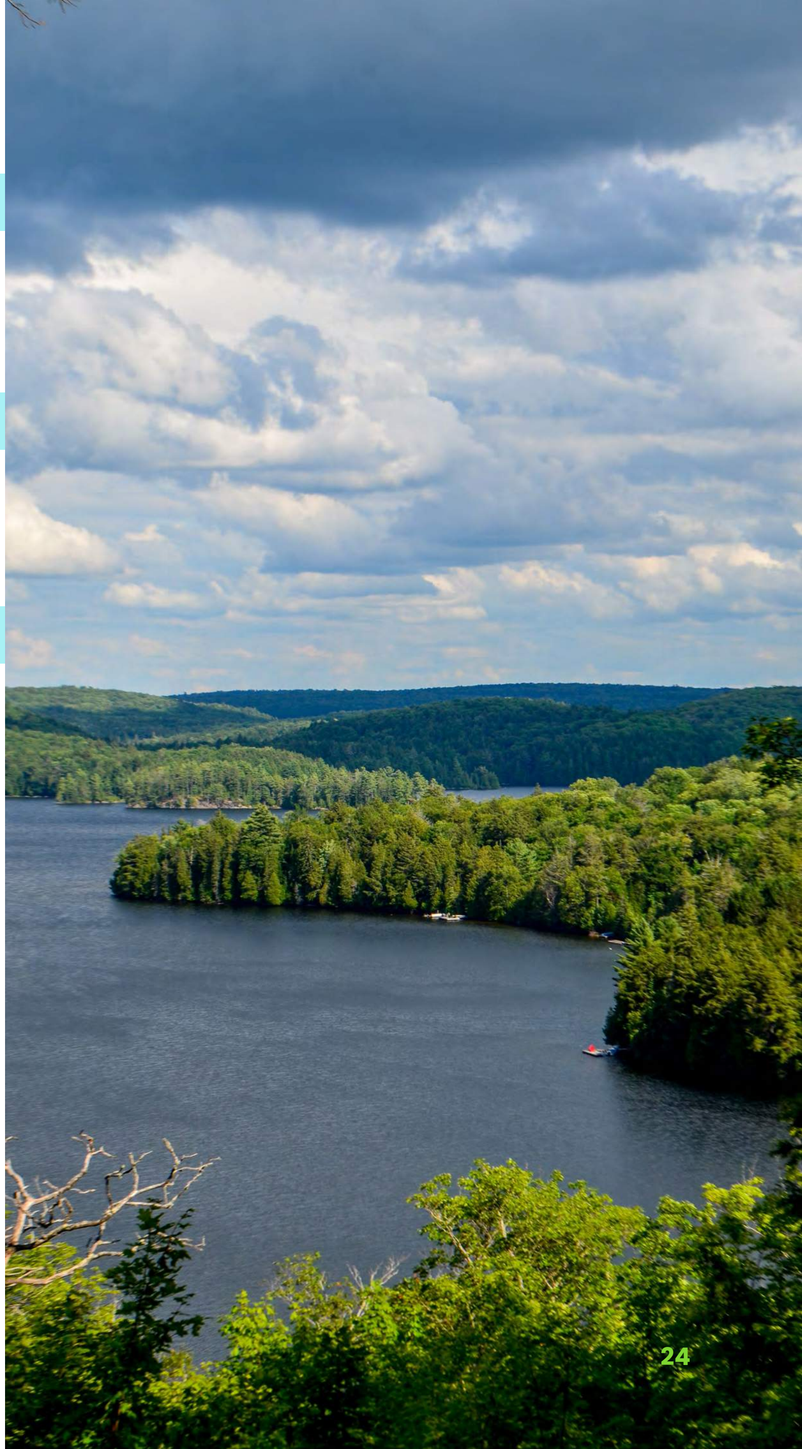
Ontario is tied with BC for the most biomaterial companies and has the second-most bioprocessing companies. Ontario's forestry sector contributed $4.1 billion to Canadian real GDP in 2021.

Knowledge generators and enablers developing the forest bioeconomy in Ontario include:

- Centre for Research and Innovation in the Bio-Economy (CRIBE)
- Ontario Forest Industries Association (OFIA)
- Ontario Genomics
- Whitesand Bioeconomy Centre
- Lakehead Biorefining Research Institute

Ontario's "Forest Biomass Action Plan" names bioenergy and bioproducts as critical value-added products for low-value forest biomass.[20] The province also published its "Low-Carbon Hydrogen Strategy" in 2022, which outlines multiple technology pathways for forest biomass to be used as a feedstock in the production of renewable gases.[22]

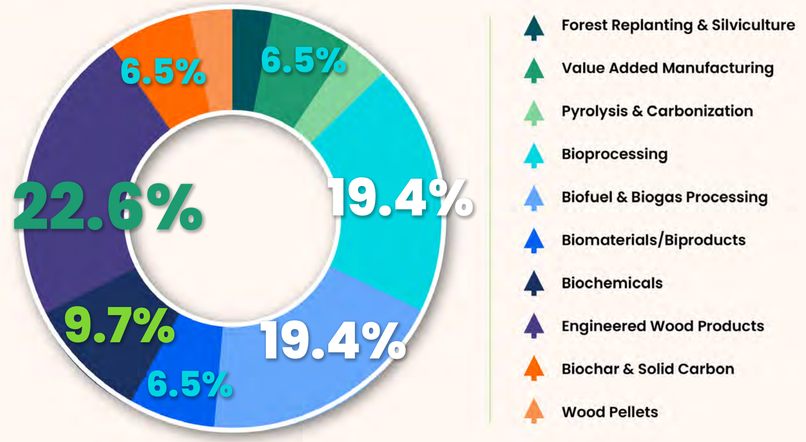
Ontario-based companies developing bioprocessing technologies were focusing on a wide range of sectors, from sustainable packaging, biopolymers, and more. This was complemented by a few Ontario companies found at the "material/product" stage who sell biomaterials, bioplastics, and bio-packaging. These findings align with the known strengths of Ontario's petrochemicals sector: Ontario is responsible for nearly 50 per cent of the production in Canada's chemical manufacturing industry.[23]



QUEBEC

Québec developed a five-year strategy for the forest product sector in 2018, known as the Forest Products Industry Development Strategy. [8] Complementary programs and plans for the forest bioeconomy include the Policy for the Integration of Wood in Construction and the Wood Construction Innovation Program. [9,10]

QUÉBEC



QUÉBEC

OBSERVATION

QUÉBEC IS ONE OF THE MOST WELL DISTRIBUTED PROVINCES ACROSS THE VALUE CHAIN FOR PROCESSING STEPS

ENGINEERED WOOD PRODUCTS IS AN AREA OF STRENGTH

BIOFUEL + BIOGAS PROCESSING IS AN AREA OF STRENGTH

SUPPORTING DATA

- **27** companies
- **11** VC steps covered
- **Six** each for bioprocessing, engineered wood products and biofuel processing
- **Seven** out of **17** companies based in Québec; only one other province (BC) has more than one
- **Six** of **35** biofuel + biogas processing companies are based in Québec

DISCUSSION

Québec ranks fourth in bioprocessing and biofuel processing, and leads the country in engineered wood product companies. Of the 11 different steps in the value chain Québec has companies in, six were found to have more than one company. Québec's forestry industry has a sizable impact on real GDP: $5.3 billion in 2021. Québec has two 'A' rated Bioeconomy Development Opportunity Zone (BDO Zone) designations.

Knowledge generators and enablers developing the forest bioeconomy in Québec include:

- BioFuel Net
- CRIBIQ
- Laurentian Forestry Centre
- McGill Network for Innovation in Biofuels and Bioproducts (McNIBB)
- Ecotech Québec
- Genome Québec
- Innofib

BP Canada and MSL, the only two woodfibre insulation manufacturers in Canada, are both headquartered in Québec. Five other companies developing sustainable building materials were found in Québec.

Québec's Policy for the Integration of Wood in Construction and the Wood Construction Innovation Program are examples of the local supportive policy environment.

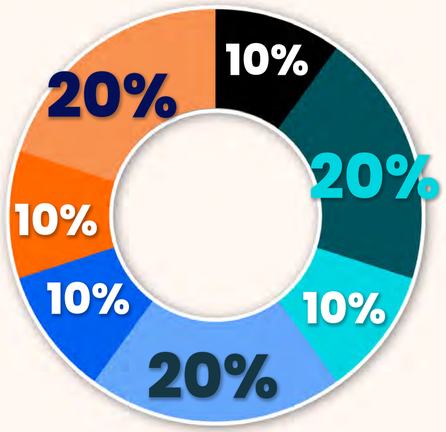
Québec's "green hydrogen and bioenergy strategy" was developed to fulfill, among others, the promise to increase bioenergy production by 50 per cent by 2030. [11] The provincial government commissioned a technical study in 2021 to review the feedstock availability for bioenergy production. [12] Québec's current low-carbon fuel regulation requires a 15 per cent biofuel blend for gasoline and a 10 per cent blend for diesel, by 2030. [13] The province also began requiring a minimum share of biomethane in the gas grid in 2020, which will rise to 10 per cent by 2030. [14]

Recent examples of industry activity include:

- "CADAQ-100", a $19 million Québec government-supported initiative was launched to produce next generation sustainable aviation fuels. [15]
- $1.2 billion is being invested in Enerkem's Varennes Carbon Recycling facility, which will produce biofuels and biochemicals from waste, including woody biomass. [16]
- The provincial government invested over $8 million in 2020 to build wood waste-to-biofuel demonstration and pilot facilities in La Tuque and Sherbrooke. [17,18]

ATLANTIC PROVINCES

ATLANTIC CANADA



- Harvesting Operations
- Forest Replanting & Silviculture
- Bioprocessing
- Biofuel & Biogas Processing
- Biomaterials/Bioproducts
- Biochar & Solid Carbon
- Wood Pellets

Atlantic Canada is home to a robust forestry industry, however no province has an official, completed strategy for the forest bioeconomy. Nonetheless, several complementary organizations and initiatives exist. Nova Scotia is the most well developed province with initiatives such as the Nova Scotia Forestry Economic Task Force and the Nova Scotia Forestry Innovation Transition Trust, as well as the Nova Scotia Innovation Hub. [31] PEI appointed a forestry commission in 2023 and released an analysis of biomass energy utilization in the province.[32] Newfoundland and Labrador's 2014-2024 Forest Management Strategy mentions opportunities in the bioeconomy, and the NL Forest Industry Association led a recent three-year research project to examine provincial opportunities for the bioeconomy. [33,34] New Brunswick is developing "a shared vision, roadmap, and operational model" for the bioeconomy. [1]

ATLANTIC PROVINCES

OBSERVATION

ATLANTIC CANADA HAS OPPORTUNITY TO GROW ITS SHARE OF THE FOREST BIOECONOMY

SUPPORTING DATA

- **Seven** companies
- **Seven** VC steps covered

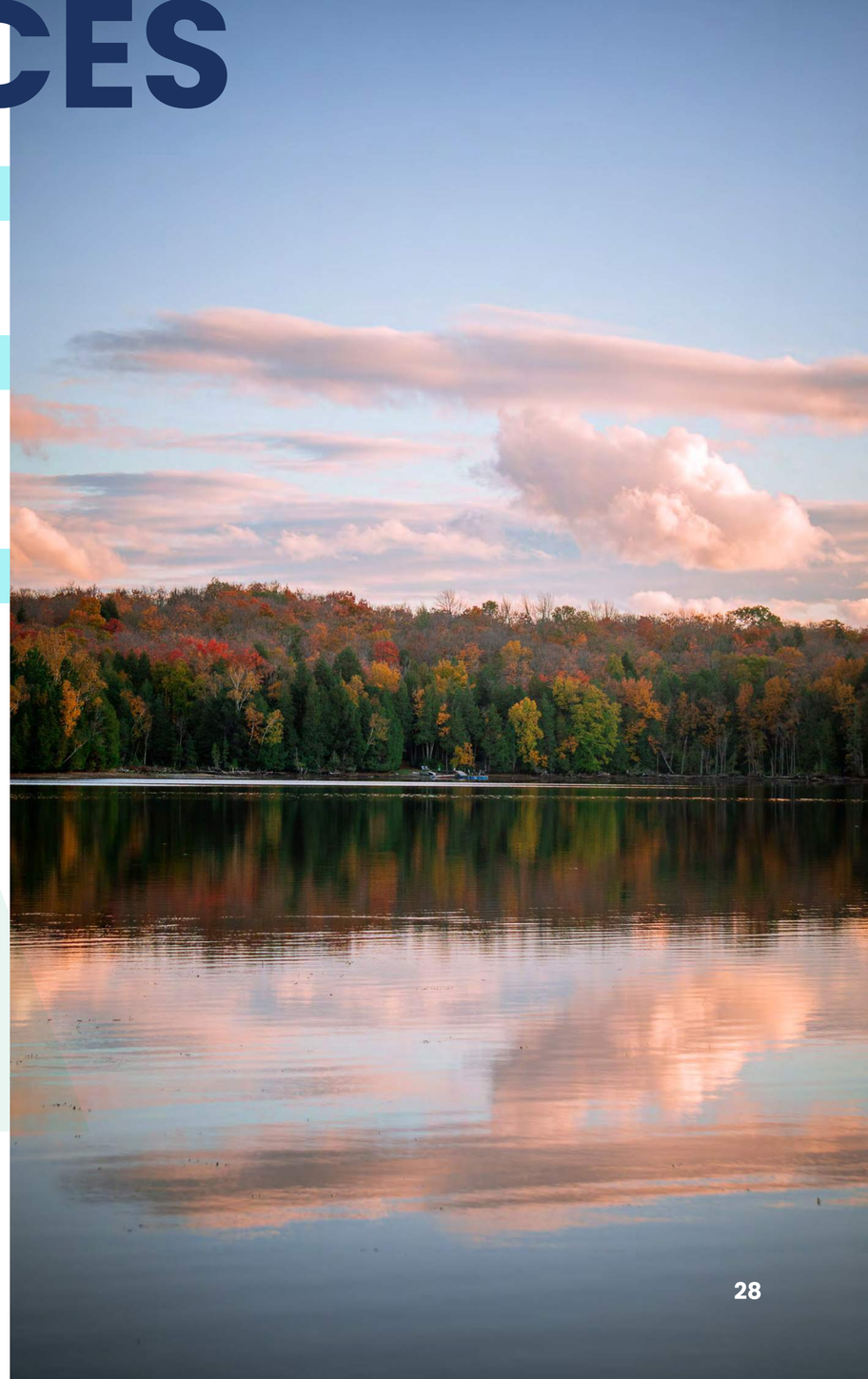
DISCUSSION

Atlantic Canada has robust activity in the forestry sector despite the low number of companies in our database. The distribution is broad, with no more than two companies in any single VC step. No companies were identified on Prince Edward Island, despite the provincial sector's nearly $31 million contribution to real GDP in 2021. [2]

While there were not many companies identified in this mapping exercise, it does discount the size of the sector's economic activity in the region. Traditional Atlantic forest product companies exported nearly $3.3B of wood, pulp and paper, and fabricated products in 2021. These companies can be considered "end-users"; pulp and paper mills, lumber mills, and other companies who are investing in innovative technologies and exploring new product opportunities, but are excluded based on the criteria of this database.

Knowledge generators and enablers developing the forest bioeconomy in Atlantic Canada include:

- Nova Scotia Innovation Hub
- Forest Nova Scotia
- Maritime Lumber Bureau
- Forestry Sector Council
- Atlantic Forestry Centre
- Research Nova Scotia
- Canadian BioEnergy Centre
- PEI BioAlliance
- ResearchNB
- Forest NB - Forêt NB
- New Brunswick Forest Products Commission
- Wood Science and Technology Centre
- Nova Scotia Forest Innovation Centre

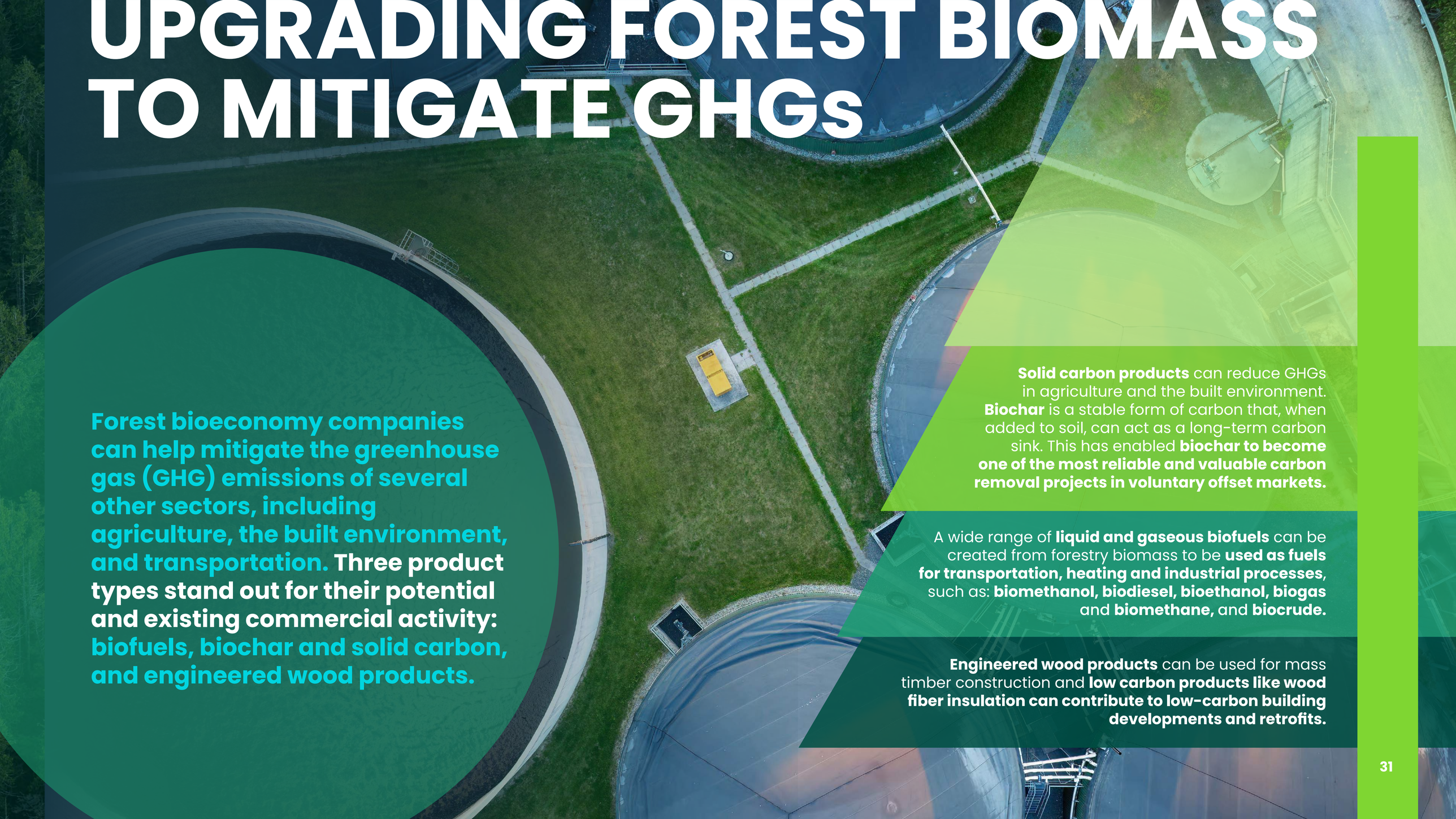


FOREST BIOECONOMY TECH: STRENGTHS + OPPORTUNITIES

THIS SECTION IDENTIFIES AREAS OF STRENGTH WITHIN THE FOREST BIOECONOMY VALUE CHAIN.

CANADA'S LONG-STANDING EXPERIENCE IN THE NATURAL RESOURCE SECTOR AND ABUNDANT AGRICULTURAL AND FORESTRY FEEDSTOCKS, POSITION THE COUNTRY TO BE A LEADER IN THE LOW-CARBON ECONOMY.

UPGRADING FOREST BIOMASS TO MITIGATE GHGs



Forest bioeconomy companies can help mitigate the greenhouse gas (GHG) emissions of several other sectors, including agriculture, the built environment, and transportation. Three product types stand out for their potential and existing commercial activity: biofuels, biochar and solid carbon, and engineered wood products.

Solid carbon products can reduce GHGs in agriculture and the built environment. **Biochar** is a stable form of carbon that, when added to soil, can act as a long-term carbon sink. This has enabled **biochar to become one of the most reliable and valuable carbon removal projects in voluntary offset markets.**

A wide range of **liquid and gaseous biofuels** can be created from forestry biomass to be **used as fuels for transportation, heating and industrial processes,** such as: **biomethanol, biodiesel, bioethanol, biogas** and **biomethane,** and **biocrude.**

Engineered wood products can be used for mass timber construction and **low carbon products like wood fiber insulation can contribute to low-carbon building developments and retrofits.**

UPGRADING FOREST BIOMASS TO MITIGATE GHGs

OBSERVATIONS

BIOCHAR AND SOLID CARBON ARE AREAS OF OPPORTUNITY

SUPPORTING DATA

- **15** of **141** companies sell solid carbon products and/or develop biochar processing technology (e.g., pyrolysis equipment)

DISCUSSION

Biochar can be used as a soil amendment to potentially enhance soil structure, nutrient availability, and microbial activity. Its long-term carbon storage capabilities have also made it a valuable source of voluntary carbon removal offsets. [42] Wood waste can be transformed to biochar and other by-products using pyrolysis technology. Further research and investigation is merited to validate the market opportunities for Canada's biochar producers. Recent publicly-available estimates for the global biochar market expect it to reach between USD $3 billion to USD $3.6 billion in the next two to three years. [43,44] The addition of biochar to concrete, asphalt, and other construction materials is an emerging opportunity that also has the potential to improve the life cycle footprint of the built environment.

Recent industry activity in Canada includes:

- Airex Energy is building a new plant that will increase their annual biochar production capacity by 30,000 tonnes by 2026. By 2035, the plant expects annual production to increase to 350,000 tonnes. [45,46]
- CHAR Technologies announced a $6 million investment by ArcelorMittal to expand its production of "biocoal", which will be used as a substitute for coal use at ArcelorMittal's steel plants. [47]
- BC Biocarbon's new Saskatchewan biorefinery (see Prairies section). [29]
- Haliburton Forest Biochar announced a $10 million expansion in 2022 to expand its production facility. [48]

OBSERVATIONS

BIOGASES AND BIOFUELS ARE AN OPPORTUNITY TO EXPAND ON AS THEY CAN DECARBONIZE TRANSPORTATION AND HEATING

WOOD PRODUCTS ARE AN OPPORTUNITY TO EXPAND ON AS THEY CAN REDUCE THE LIFE CYCLE GHGS OF OUR BUILT ENVIRONMENT

SUPPORTING DATA

- **35** of **141** forest bioeconomy companies develop technologies and/or processes for biofuels.

- **17** of **141** companies develop engineered wood products.

DISCUSSION

Refineries, biofuel producers, and synthetic fuel producers all have an interest in accessing biomass waste, including forestry by-products, for the purpose of complying with low carbon and renewable fuel regulations. The rising demand for biofuels should strengthen the market value of their feedstocks. Canada's new Clean Fuel Regulations will also create new revenue streams for low-carbon fuel suppliers, through the compliance credits system. [49]

Modelling commissioned by the Canadian Biogas Association and Clean Prosperity indicated that, if prioritized, liquid and gaseous biofuels could be significant contributors to Canada's GHG reductions over the next three decades. [50,51] In 2022, approximately 500 million litres of renewable diesel were consumed, and national biomethane capacity was roughly 9 PJ. By 2027, annual biomethane and renewable diesel supply are expected to rise to over 18 PJ and 3.7 billion litres respectively, with new and expanding facilities across Alberta, BC, Saskatchewan, Ontario, Québec, and Newfoundland and Labrador. [52,53,54] Canada's first roadmap for sustainable aviation fuels was released in 2023, also indicating opportunity for further biofuel investment for the airline industry. [55]

Canada has a foundation of companies and organizations dedicated to advancing mass timber construction and proliferating the use of forestry products in substitute of high carbon building materials such as steel and concrete. The introduction of net zero building codes in Canada will generate further demand for mass timber, as developers seek to align with low-carbon and energy efficiency requirements. Forestry by-products and other low-value biomass could be used for value-added, low-carbon products in the construction sector, such as composite materials and low-emission concrete.

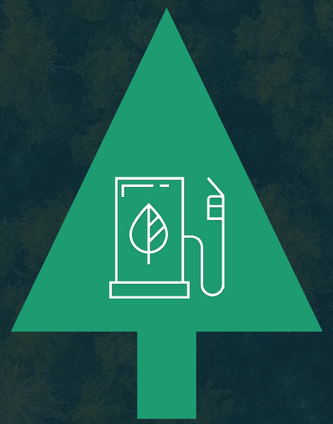
Organizations such as the Canadian Wood Council and FPInnovations have led research and development to grow the use of engineered wood products in construction.

BIOFUELS IN CANADA

Several types of biofuels can be created from forestry biomass, such as:

Biomethanol: Biomethanol can be produced by the fermentation of forestry waste, such as sawdust, to produce a bioalcohol that can be used as a fuel for transportation and heating.

Biodiesel: Biodiesel can be produced from the oils in forestry waste using a process called transesterification, which involves the conversion of the oils into a diesel-like fuel that can be blended with diesel and used in diesel engines.



Bioethanol: Bioethanol can be produced from the sugars and starches in forestry waste, such as sawdust and bark, through a process of fermentation and distillation. Bioethanol can be used as a gasoline additive or as a standalone fuel for flexible-fuel vehicles.

Biomethane: Biomethane can be created from forestry residuals through the process of anaerobic digestion. The process produces methane and carbon dioxide, along with other by-product gases. Gasification technology is being commercialized to create biomethane from non-traditional feedstocks such as wood waste. Biomethane can be used as a drop-in substitute for gas-powered vehicles, building heating systems, industrial processes and electricity generation.

Biocrude: is a biomass-derived replacement for crude oil, produced through pyrolysis or hydrothermal liquefaction. It can be co-processed in refineries with crude oil to produce low-carbon fuels such as renewable gasoline and diesel.

Canadian renewable and low-carbon fuel regulations:

- Canada Clean Fuel Regulations (CFR)
- B.C. Renewable & Low Carbon Fuel Requirements Regulation (BC-LCFS)
- Quebec low-carbon fuel regulation
- Ontario Cleaner Transportation Fuels regulation
- Alberta Renewable Fuels Standard
- Saskatchewan Renewable Diesel Act
- Manitoba Ethanol & Biodiesel Mandate

BIOPROCESSING

Outside of the well known applications of forest biomass such as biofuels and wood products, there are a wide variety of technologies and products that have many other applications. Bioprocessing in the context of the forest bioeconomy "can be defined as the chemical, biological, or mechanical processing of forest biomass into value added products". [56] In the forest bioeconomy value chain, the two large sub-categories of bioprocessing are biomaterials and biochemicals, "a growing and diverse class of forest biomass-based products that are not typical pulp and paper or wood products". [57] Outside of biofuels and wood products, these steps in the value chain encompass the rest of the companies finding innovative ways to utilize forest biomass. Biomaterials and biochemicals are expected to account for 13 per cent and 28 per cent, respectively, of the bioeconomy's global market value by 2030, with further growth expected towards mid-century. [58] Bio-based products (from both forestry and agriculture feedstocks) are expected to make up 50 per cent of consumer products by 2050. [59]

According to Canada's Renewed Forest Bioeconomy Framework, we lag behind our national competitors in value added per cubic meter of wood harvested. [1] Seeking greater diversity in the types of bioproducts we are producing can help address this gap.

BIOPROCESSING

OBSERVATIONS

BIOPROCESSING IS AN AREA OF OPPORTUNITY

SUPPORTING DATA

- **38** of **141** companies were assigned to bioprocessing
- **11** companies were assigned to biomaterials
- **13** companies were assigned to biochemicals

DISCUSSION

Due to the diverse nature of the bioprocessing step of the value chain, there are a wide range of companies assigned. Bioprocessing involves technologies and processes that produce bioproducts “intended for markets such as energy, transportation, chemicals, plastics, foods, pharmaceuticals, and nutraceuticals”. [57]

Companies identified in our database are developing technologies and processes for products including but not limited to cellulose nanocrystals, bioplastics, biopolymers, biomaterials, and biochemicals. Biomaterials and biochemicals, the prominent sub-steps of bioprocessing, can be used as direct substitutes to ubiquitous non-renewable and fossil-based counterparts.

Examples of industry activity include:

- Origin Materials has built a commercial plant in Sarnia, ON, making chloromethyl furfural and hydrothermal carbon from woody biomass. [60]
- Calgary-based SixRing Inc. received $1.4 million in federal funding in 2022 to scale its processing technology that creates a liquid Lignin-Hemicellulose-Depolymerization-Organics (LHDOTM) effluent and solid cellulose from agricultural and woody feedstocks. [61,62]
- CKF Inc. expanded its manufacturing to BC, to grow its product line of pulp-based fruit and vegetable packaging. [63]
- Resolute Forest Products built a commercial cellulose filaments plant in Québec, which can be used in a variety of applications, including bioplastics, adhesives and pulp and paper products. [64]
- West Fraser’s pulp mill in Hinton, Alberta launched Canada’s first commercial lignin recovery plant in 2016 using a patented technology developed by FPInnovations and NORAM Engineering. [65] Further research and testing is underway to identify applications for lignin in the low-carbon economy, such as a binder in asphalt. [66] West Fraser sold this mill in 2023.

RECOMMENDATIONS

VENTURES, INVESTORS, GOVERNMENT, AND INDUSTRY CAN ALL BENEFIT FROM THIS DATA AND THE INSIGHTS IT PROVIDES ABOUT THE SECTOR AS WE TRANSITION TO A NET ZERO ECONOMY.

VENTURES ARE RECOMMENDED TO USE THIS DATABASE TO GLEAN VALUABLE INSIGHTS ON GAPS AND OPPORTUNITIES WITHIN THE ECOSYSTEM TO:

- Identify innovation opportunities, potential partnerships, and competitors segmented both by geography and position in the value chain.
- Apply a broader understanding of where technologies fit on the value chain, and take stock of what other companies fit around them to better promote their existing strengths and make informed business decisions.

INVESTORS AND INDUSTRY WILL ALSO FIND THIS DATA TO BE AN INVALUABLE TOOL TO USE WHEN EVALUATING INVESTMENT AND/OR ACQUISITION OPPORTUNITIES IN ORDER TO:

- Understand the value-add prospective ventures provide by identifying their role in the value chain.
- Determine what competitors might exist for any given company.
- Identify strengths, opportunities, and trends in the Canadian market to inform business decisions.

ADDITIONALLY, GOVERNMENTS CAN CONSIDER THE KEY INSIGHTS DERIVED FROM THIS DATA TO IDENTIFY TARGETED AREAS FOR SUPPORT IN A MORE COORDINATED AND INTENTIONAL WAY. KEY RECOMMENDATIONS FOR GOVERNMENT INCLUDE:

- Leverage and build on regional strengths and clusters to support a thriving innovation landscape. These strengths and clusters include biofuels in Alberta, BC, and Québec, bioproducts in Ontario, and engineered wood products in BC and Québec.
- Strengthen cross-jurisdictional collaboration to leverage the technology and expertise of certain regions with the biomass feedstock in others.
- Develop national, provincial and territorial industry-informed strategies and plans for the forest bioeconomy that specifically analyze how to capture value added opportunities from forest biomass.
- Commission additional studies to evaluate fibre supply and feedstock availability for specific high value products (e.g., renewable gases).
- Continue funding research and development of pre-commercial technology pathways critical to the growth of the forest bioeconomy.

CONCLUSION

THE BREADTH AND DEPTH OF THE **CANADIAN FOREST BIOECONOMY VALUE CHAIN** DEMONSTRATES THE SECTOR'S TRACK RECORD OF **INNOVATION AND ITS BRIGHT FUTURE.** THERE ARE MANY OPPORTUNITIES FOR CANADA TO GROW AND BE **A GLOBAL LEADER IN THE NEW ERA OF VALUE-ADDED FORESTRY PRODUCTS.**

Interested in learning more about Canada's forest bioeconomy value chain?

FORESIGHT CANADA

Please contact Alyssa Kelly, Director of Research at Foresight Canada: akelly@foresightcac.com

REFERENCES

1. Canadian Council of Forest Ministers. Renewed Forest Bioeconomy Framework. https://www.ccfm.org/wp-content/uploads/2022/11/40829.pdf (2022).

2. Natural Resources Canada. Canadian Forest Service Statistical data. https://cfs.nrcan.gc.ca/statsprofile/economicimpact/ca.

3. Natural Resources Canada. The State of Canada's Forests: Annual Report 2022. https://natural-resources.canada.ca/sites/nrcan/files/forest/sof2022/SoF_Annual2022_EN_access_(4).pdf (2022).

4. Natural Resources Canada. How does the forest sector contribute to Canada's economy? https://natural-resources.canada.ca/our-natural-resources/forests/state-canadas-forests-report/forest-industry-contribute/16517 (2023).

5. Genome Canada. The Forest Value Chain: Stakeholder Engagement and Strategy Session. https://www.ontariogenomics.ca/wp-content/uploads/2020/04/2020-LSARP_WorkshopReport_The-Forest-Value-Chain-1.pdf (2019).

6. Ministry of Forests. Forest bioeconomy conference cultivates jobs, opportunities. Government of British Columbia https://news.gov.bc.ca/releases/2023FOR0037-000968 (2023).

7. Natural Resources Canada. 2022 Cleantech Industry Survey Results. https://ised-isde.canada.ca/site/clean-growth-hub/sites/default/files/attachments/2023/2022-cleantech-industry-survey-results-e.pdf (2022).

8. Stratégie de développement des produits forestiers 2018-2023. Gouvernement du Québec https://www.quebec.ca/agriculture-environnement-et-ressources-naturelles/forets/entreprises-industrie/soutien-industrie-forestiere/strategie-developpement-industrie (2018).

9. Programme d'innovation en construction bois. Gouvernement du Québec https://www.quebec.ca/agriculture-environnement-et-ressources-naturelles/forets/entreprises-industrie/aide-financiere/programme-innovation-construction-bois.

10. Politique d'intégration du bois en construction. Gouvernement du Québec https://www.quebec.ca/agriculture-environnement-et-ressources-naturelles/forets/entreprises-industrie/soutien-industrie-forestiere/politique-dintegration-du-bois-en-construction (2020).

11. Québec green hydrogen and bioenergy strategy. Gouvernement du Québec https://www.quebec.ca/en/government/policies-orientations/strategy-green-hydrogen-bioenergy (2022).

12. WSP Canada. Inventaire de la biomasse disponible pour produire de la bioénergie et portrait de la production de la bioénergie sur le territoire québécois. (2021).

13. Ethanol and biodiesel. Gouvernement du Québec https://www.quebec.ca/en/agriculture-environment-and-natural-resources/energy/energy-production-supply-distribution/bioenergy/ethanol-biodiesel.

14. Renewable natural gas. Gouvernement du Québec https://www.quebec.ca/en/agriculture-environment-and-natural-resources/energy/energy-production-supply-distribution/bioenergy/renewable-natural-gas.

15. Quebec initiative to advance next-gen sustainable aviation fuel. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/quebec-initiative-to-advance-next-gen-sustainable-aviation-fuel/ (2023).

16. The Canadian Press. Canada Infrastructure Bank invests $277M in Quebec biofuels facility. Global News https://globalnews.ca/news/9580790/quebec-biofuels-cib-investment/ (2023).

17. Quebec government invests $5.9M in wood-waste-to-biofuel project. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/quebec-government-invests-5-9m-in-wood-waste-to-biofuel-project/ (2020).

18. Cools, E. CRB Innovations receives $8.575M to convert wood waste into biofuels. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/crb-innovations-receives-8-575m-to-convert-wood-waste-into-biofuels/ (2020).

19. Sustainable growth: Ontario's forest sector strategy. Government of Ontario https://www.ontario.ca/page/sustainable-growth-ontarios-forest-sector-strategy (2020).

20. Forest Biomass Action Plan. Government of Ontario https://www.ontario.ca/page/forest-biomass-action-plan (2022).

21. Ontario Creating New Program to Support Forestry Innovation and Job Creation. Government of Ontario https://news.ontario.ca/en/release/1003099/ontario-creating-new-program-to-support-forestry-innovation-and-job-creation (2023).

22. Ontario's low-carbon hydrogen strategy. Government of Ontario https://www.ontario.ca/page/ontarios-low-carbon-hydrogen-strategy (2022).

23. Chemical and biochemical. Invest Ontario https://www.investontario.ca/chemical-and-biochemical.

24. Forest sector strategies. Government of Alberta https://www.alberta.ca/forest-sector-strategies.aspx.

25. Calgary's Expander Energy to build bio-synthetic diesel facility. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/calgarys-expander-energy-to-build-bio-synthetic-diesel-facility/ (2023).

26. Steeper Energy. Steeper Energy, Invest Alberta to bring biocrude plant to Alberta. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/steeper-energy-invest-alberta-to-bring-biomass-conversion-plant-to-alberta/ (2023).

27. Air Company. Edmonton International Airport, FORGE Hydrocarbons ink SAF deal. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/edmonton-international-airport-forge-hydrocarbons-ink-saf-deal/ (2023).

28. MLTC Bioenergy Centre. MLTC Bioenergy Centre https://mltcbioenergy.ca/.

29. Edgewood biorefinery. Puro.earth https://puro.earth/accelerate/edgewood-biorefinery-100072.

30. Goldsworthy, N. Carrot River, Sask., biorefinery to convert wood waste into products. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/carrot-river-sask-biorefinery-to-convert-wood-waste-into-products/ (2023).

31. Apply for funding from the Nova Scotia Forestry Innovation Transition Trust. Government of Nova Scotia https://novascotia.ca/forestry-trust/.

32. Sustainability of Biomass Utilisation - issue analysis by the PEI Forestry Commission. Government of Prince Edward Island https://www.princeedwardisland.ca/en/publication/sustainability-of-biomass-utilisation-issue-analysis-by-the-pei-forestry-commission (2023).

33. Government of Newfoundland and Labrador. Growing our Renewable and Sustainable Forest Economy: Provincial Sustainable Forest Management Strategy 2014-2024. https://www.gov.nl.ca/ffa/files/publications-pdf-psfms-14-24.pdf (2014).

34. Forest-Based Bio Economy in Newfoundland. NL Workforce Innovation Centre https://www.nlwic.ca/forest-based-bio-economy-in-newfoundland/.

REFERENCES

35. Forest Bioeconomy in B.C. Government of British Columbia https://www2.gov.bc.ca/gov/content/industry/forestry/supporting-innovation/bio-economy.

36. FPInnovations. Clean-Tech Innovation Strategy for the B.C. Forest Sector 2016-2024. (2017).

37. Government of British Columbia. Modernizing Forest Policy in British Columbia: Setting The Intention and Leading the Forest Sector Transition. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/competitive-forest-industry/modernizing_forestry_in_bc_report.pdf (2020).

38. REN Energy. REN Energy https://rencorp.ca/home-one/.

39. G4 Insights. G4 Insights http://www.g4insights.com/.

40. Arbios biotech. Arbios Biotech https://arbiosbiotech.com/chuntoh-ghuna-pg.

41. Business in Vancouver. Canfor invests in new biofuel plant in BC. Business in Vancouver https://biv.com/article/2021/10/canfor-invests-new-biofuel-plant-bc (2021).

42. Aggarwal, C. Removing carbon with biochar: how you can get involved in a cutting-edge removal project. South Pole https://www.southpole.com/blog/biochar-help-fight-climate-change (2022).

43. Pokharel, R. & Comer, B. Economics of biochar. Michigan State University https://www.canr.msu.edu/news/economics-of-biochar (2021).

44. Biochar Market Size, Share, Growth Report 2030. Zion Market Research https://www.zionmarketresearch.com/report/biochar-market.

45. SUEZ Group. SUEZ Group and Airex Energy will industrialize an innovative carbon capture solution to restore soil quality and act for the climate. SUEZ Group https://www.suez.com/en/news/press-releases/suez-group-and-airex-energy-will-industrialize-an-innovative-carbon--capture-solution-to-restore-soil-quality-and-act-for-the-climate (2021).

46. Airex Energy. Airex Energy partners to build Canada's first industrial biochar plant in Quebec. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/airex-energy-partners-to-build-canadas-first-industrial-biochar-plant-in-quebec/ (2023).

47. Berkow, J. World's largest steelmaker invests in Canadian cleantech startup CHAR Technologies. The Globe and mail (2023).

48. Collings, V. Haliburton Forest Biochar announces $10 million expansion. Haliburton Echo https://haliburtonecho.ca/haliburton-forest-biochar-announces-10-million-expansion/ (2022).

49. Clean Fuel Regulations. Government of Canada https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations.html.

50. Canadian Biogas Association. Hitting Canada's Climate Targets with Biogas and RNG. https://biogasassociation.ca/images/uploads/documents/2022/resources/Hitting_Targets_with_Biogas_RNG.pdf (2022).

51. Hervas, M. F. A. Achieving net-zero pathways for Canada: Interim paper 1, What progress are we on track to make by 2050? https://cleanprosperity.ca/wp-content/uploads/2023/06/Achieving-net-zero-pathways-June-2023-Clean-Prosperity.pdf (2023).

52. Government of Canada & Canada Energy Regulator. Market Snapshot : Two Decades of Growth in Renewable Natural Gas in Canada. Canada Energy Regulator https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2023/market-snapshot-two-decades-growth-renewable-natural-gas-canada.html (2023).

53. 2022 Biofuels in Canada. Navius Research Inc https://www.naviusresearch.com/publications/2022-biofuels-in-canada/ (2022).

54. Market snapshot: New Renewable Diesel Facilities Will Help Reduce Carbon Intensity of Fuels in Canada. Canada Energy Regulator https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2023/market-snapshot-new-renewable-diesel-facilities-will-help-reduce-carbon-intensity-fuels-canada.html (2023).

55. Roadmap. C-SAF https://c-saf.ca/roadmap/ (2023).

56. Bioprocessing overview. Georgia Tech https://research.gatech.edu/rbi/bioprocessing-overview.

57. Natural Resources Canada. Forestry glossary. Government of Canada https://cfs.nrcan.gc.ca/terms.

58. B. C. Ministry of Forests. Conference to accelerate bioeconomy development for B.C.'s forest sector. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/conference-to-accelerate-bioeconomy-development-for-b-c-s-forest-sector/ (2023).

59. Bioindustrial Innovation Canada. Canada's Bioeconomy Strategy: Leveraging our Strengths for a Sustainable Future. https://www.bincanada.ca/_files/ugd/85c216_271a8ef8a7074537a3d1be554c180fdc.pdf (2019).

60. Morden, P. Origin Materials celebrates opening of Sarnia bio-chemical plant. The Stratford Beacon Herald https://www.stratfordbeaconherald.com/news/local-news/origin-materials-celebrates-opening-of-sarnia-bio-chemical-plant (2023).

61. Aldrich, J. Calgary biofuel company gets $1.4 million in federal funding to scale and research new applications. Calgary Herald https://calgaryherald.com/business/calgary-biofuel-company-gets-1-5-million-in-federal-funding-to-scale-and-research-new-applications (2022).

62. Renewable fuels — Revolutionary Biofuel Technology. SixRing https://www.sixring.com/renewable-fuels.

63. Canadian Manufacturing. CKF Inc. adds production line of bio-based packaging in Langley, B.C. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/ckf-adds-production-line-of-bio-based-packaging-in-langley-b-c/ (2023).

64. Resolute Forest Products. Resolute inaugurates new cellulose filament plant in Quebec. Canadian Biomass Magazine https://www.canadianbiomassmagazine.ca/resolute-inaugurates-new-cellulose-filament-plant-in-quebec/ (2023).

65. LignoForce system. FPInnovations https://web.fpinnovations.ca/lignin-from-black-liquor/.

66. Lignin from Canadian forests: the secret ingredient for greener roads. FPInnovations https://web.fpinnovations.ca/lignin-from-canadian-forests-the-secret-ingredient-for-greener-roads/ (2021).

67. Our Taxonomy for Climate Adaptation Tech ('CAT'). Mazarine Ventures https://www.mazarineventures.com/post/our-taxonomy-for-climate-adaptation-tech-cat (2022).


FORESIGHT
CANADA