Fuels Energy Market Study

A report prepared for Thunder Bay Community Economic Development Commission

FEBRUARY 2026

THUNDER BAY CEDC COMMUNITY ECONOMIC DEVELOPMENT COMMISSION

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KEY TERMS USED IN REPORT

Glossary

1G	1st generation
2G	Second generation
ASTM	American Society for Testing and Materials
BECCS	BioEnergy with Carbon Capture and Storage
BtL	Biomass to Liquid
CAPEX	Capital expenditures
CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CFR	Clean Fuel Regulations
CI	Carbon Intensity
CMPF	Critical Minerals Processing Fund
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSM	Climate-Smart Mining Initiative
e-SAF	Electro-Sustainable Aviation Fuel
EU ETS	EU Emissions Trading System
FAME	Fatty Acid Methyl Ester
FSG	Forest Solutions Group
FT	Fischer Tropsch
GHG	Greenhouse Gas
H_20	Water
ICMM	International Council on Mining and Metals
ICSV	Innovation for Cleaner, Safer Vehicles
IEA	International Energy Agency
IMO	International Maritime Organization
IRA	Inflation Reduction Act
LCFS	Low Carbon Fuel Standard
LFO	Light Fuel Oil
LULUCF	Land Use, Land-Use Change and Forestry
MtJ	methanol-to-jet
NDC	Nationally Determined Contributions
NGO	Non-Governmental Organization
OPS	onshore power supply
PGM	Platinum grade metals
RED III	Renewable Energy Directive III
RNG	Renewable Natural Gas
SABA	Sustainable aviation buyers' alliance
SAF	Sustainable aviation fuels
SEZA	Special Economic Zones Act
WBCSD	The World Business Council for Sustainable Development
ZEMBA	Zero emission maritime buyers' alliance

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A global need to cut emission brings attention to biofuels; biofuels could help heavy industry decarbonize in Northwest Ontario

POTENTIAL BIOFUELS CONSUMERS IN NW ONTARIO

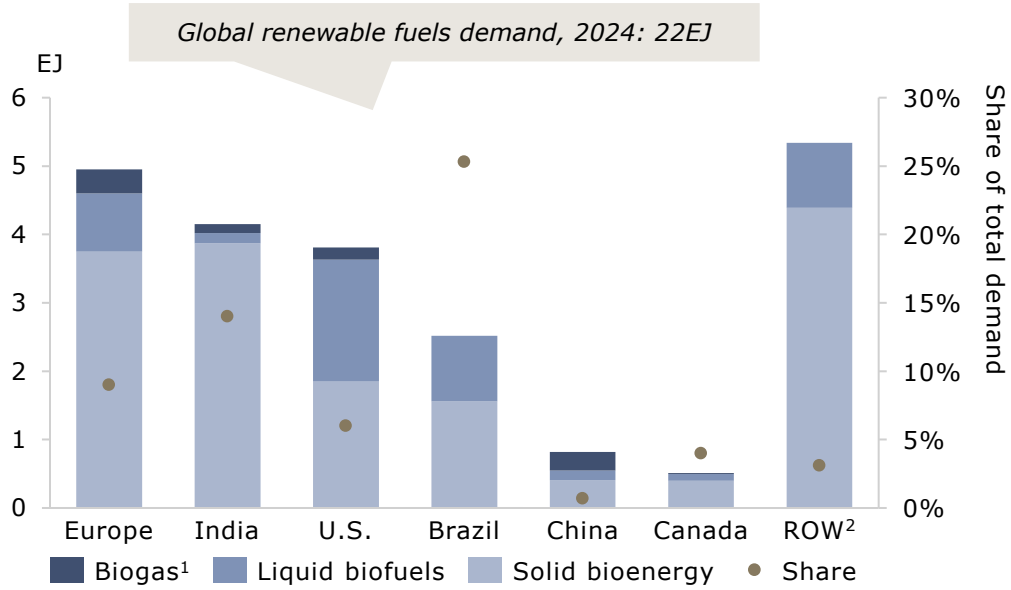
Mining, forestry, and transportation are large industries in NW Ontario contributing to exports, employment and economic wealth, but also to carbon emissions.

Thunder Bay is a key regional hub in Canada's mining sector, with 10 active mines and over 18 major exploration projects.

Thunder Bay's is home to Ontario's largest sawmill, a major pulp and paper mill, and to pilot plants and research centers within the forest bioeconomy sector.

Thunder Bay is a key transportation hub in Canada, with the largest outbound port on the Great Lakes, one of the busiest airports in Ontario and highways/railways, supporting trade with the U.S. and across Canada.

MORE BIOFUELS ARE NEEDED TO MEET NET ZERO STANDARDS



– In order to meet the IEA Net Zero Emissions by 2050 Scenario, renewable fuel use will need to increase by more than double by 2030 from 2023 levels and then double again by 2050.

Increased usage of biofuels by heavy industry players can help with decarbonization efforts.

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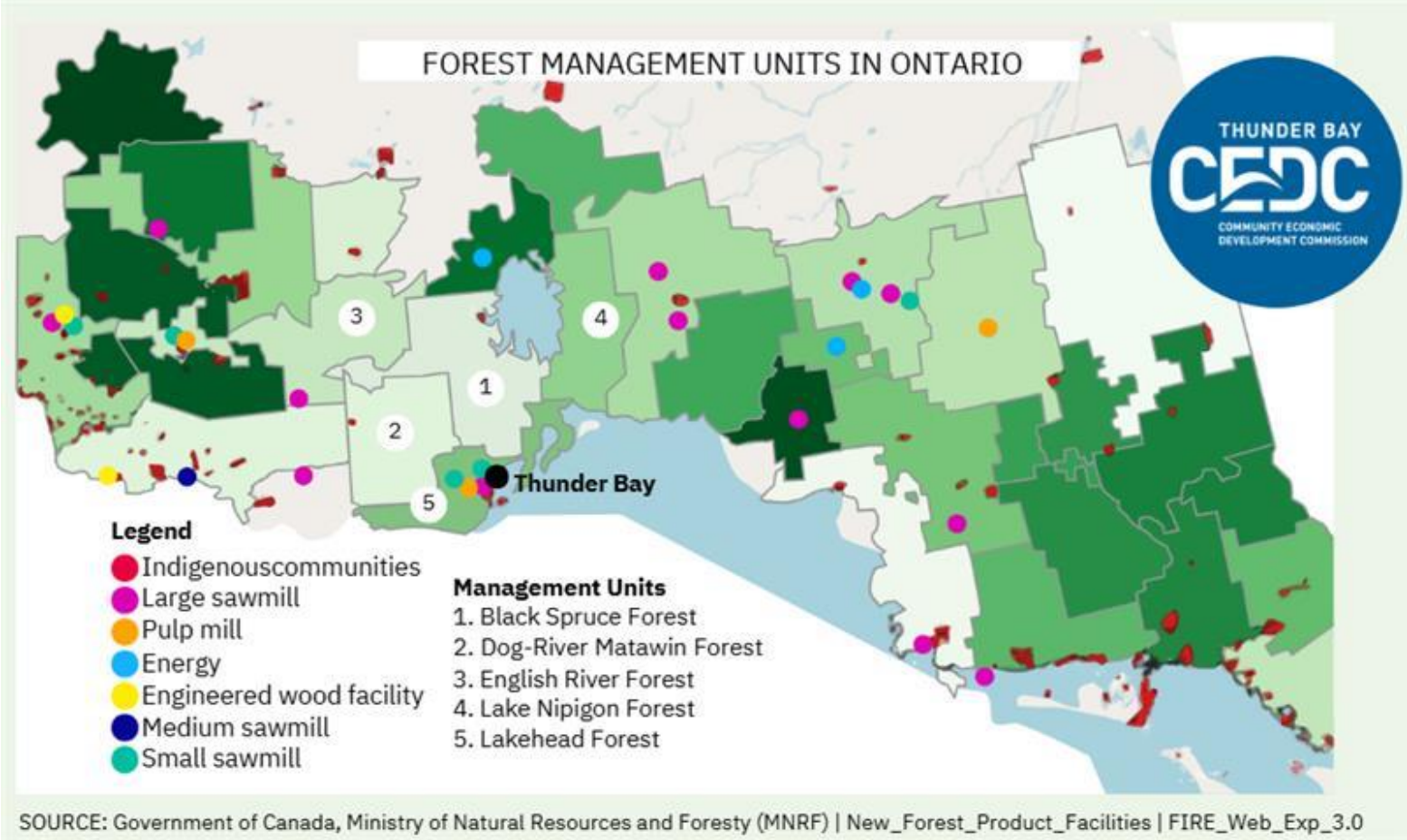
With ~3 million GMT of available biomass in Ontario, a strong case for biofuels production within the region emerges

WOODY RESIDUAL AVAILABILITY

- Approximately **3 million GMT of unmarketable residuals** are available in the Northwest Ontario region, most of which comes from sawmill residuals and fully utilized slash.
- Nevertheless, challenges remain with transport infrastructure and legislated eligibility pathways.

Unmarketable wood—trees or tree parts that are not economically feasible to harvest—constitutes an **untapped resource within Northwest Ontario** which could be used for biofuels production.



SOURCE: Government of Canada, Ministry of Natural Resources and Foresty (MNRF) | New_Forest_Product_Facilities | FIRE_Web_Exp_3.0

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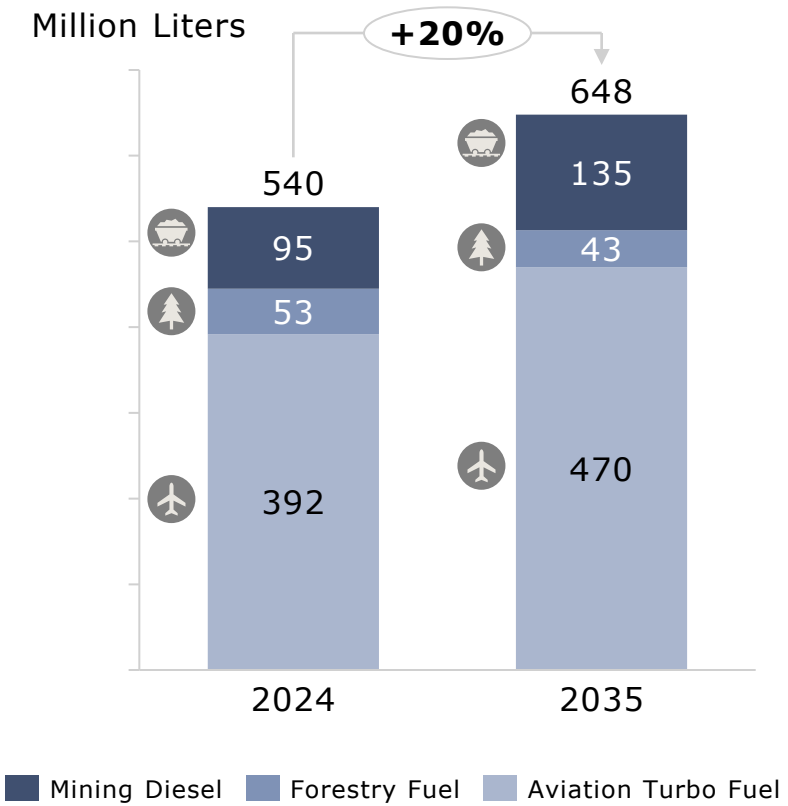
Increasing regional future fuel needs and underutilized woody biomass in Northwest Ontario creates an opportunity for a biofuels production facility

AFRY assessed fuel demand across heavy industries, considering:

- Stakeholder input
- Regulations
- Market dynamics, and
- Resource availability.

FUEL CONSUMPTION GROWTH OVER THE NEXT DECADE



Increasing heavy industry fuel needs, paired with availability of unused woody biomass in the region, offers an **opportunity for a biofuels production facility** in the region.

Incorporation of additional biofuels allows for further **decarbonization in carbon-intensive sectors while supporting domestic industries**.

Note: Forestry Fuel refers to a mixture of diesel, light fuel oil, and kerosene

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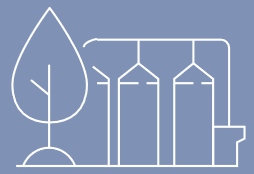
Future expected demand for biofuels is supportive of a business case for a biofuels production facility in Northwest Ontario

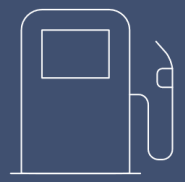
There are **~3 million GMT** of woody biomass available in Northwest Ontario.



There are opportunities to **reduce facility build CAPEX costs by up to 40–50%** with certain production pathways.

Existing assets and infrastructure in the regions allow for more affordable project costs.

The development of bankable offtake agreements can be supported by clear CI pathways and continued regulatory support to achieve an **affordable and competitive price point** for biofuels.



There is **strong, clear demand for fuel**, especially from heavy industry players, extending into the next decade.

Based on surveys conducted by AFRY, all industry participants are **open and ready to collaborate** with indigenous and local communities.

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Political, economic, social and technological drivers incentivize the decarbonization transition

1. POLITICAL & REGULATORY DRIVERS

- Regional and country-specific (incl. Canada) reduction targets to reduce emissions and/or achieve climate neutrality by 2050, lead to stringent environmental regulations and reporting obligations
- Increased focus on legal enforcement of environmental obligations
- Canada has a robust framework to support fuel decarbonization, incl. in mining and heavy industry, with a net zero target for 2050. They have e.g., proposed Clean Fuel Regulations that will reduce the carbon intensity of liquid fossil fuels

4. SOCIAL DRIVERS

- Conscious consumerism
- Pressure from NGOs and public on the industry due to its impact on the environment
- Inclination of scarce talent towards preferring working for environmentally conscious firms

2. ECONOMIC DRIVERS

- Volatile gas, electricity & raw material prices
- Declining costs of sustainable technologies paired with changes in subsidies and tax incentives favor clean energy technologies
- Promoting energy security by increasing domestic production, limiting dependence on imports or expanding trading partners
- Canada's programs like the Strategic Innovation Fund and tax cuts for zero-emission tech manufacturing support these efforts

3. TECHNOLOGICAL DRIVERS

- Advancement in competitive sustainable technologies
- Scaling of renewable energy sources and power storage systems
- Rapid electrification of mobility and heating (heat pump) systems
- Development and deployment of large-scale clean green fuel solutions
- Canada has launched the Energy Innovation Program to accelerate development, validation and deployment of e.g., clean technologies

NGO: Non-Governmental Organization

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Biofuels are often categorized based on the feedstock type, or by physical form of the fuel

GENERAL

BIOFUEL

Liquid and gaseous fuel for transport or industry produced from biomass. Term commonly used in Europe.

RENEWABLE FUEL

Fuel with energy derived from non-fossil sources. All biofuels and biomass energy is included, as well as hydrogen produced with non-fossil electricity. Term commonly used in North America.

CATEGORISATION BY FEEDSTOCK TYPE AND FUEL FORM

1G BIOFUEL

1st generation (1G) refers to fuels produced from feedstocks that compete with food or feed production, such as corn or vegetable oils.

2G BIOFUEL

2G feedstocks are not in competition with the food chain but are commonly different residual feedstocks, such as corn stover, wheat straw or sawdust.

ADVANCED BIOFUEL

Produced from a list of waste and residue-based feedstocks specified by regional regulations.

In the EU, this is RED III Annex IX Part A[1]. In the U.S., advanced biofuel refers to biofuels with GHG reduction above 50% and not made from corn.

LOW CARBON FUELS

In the EU, low carbon fuels are fuels such as recycled carbon fuels, low-carbon hydrogen, and synthetic fuels that achieve at least 70% lifecycle GHG savings compared to fossil fuels. In Canada, low carbon fuels are fuels whose lifecycle carbon intensity is below 90% of the fossil fuel baseline, as defined in the Clean Fuel Regulations.

GASEOUS BIOFUEL

Biomass-based fuel in gaseous form, such as biogas from anaerobic digestion, or renewable natural gas Applied both in the industry and transportation sectors.

LIQUID BIOFUEL

Biomass-based fuel in liquid form, such as conventional biodiesel, renewable diesel, ethanol or sustainable aviation fuel. Typically applied in the transportation sector.

SOLID BIOFUEL

Biomass-based fuel in solid form, such as wood pellets or biochar. Typically applied in the industry, e.g., the power and heat sector.

1. RED III Annex IX Part A lists feedstocks eligible for advanced biofuels under the EU's Renewable Energy Directive (RED III).

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Liquid biofuels are pooled both in drop-in and low blend fuels, and by vehicle engine. Here, the key focus is on drop-in diesel, aviation and maritime fuels

GENERAL TERMINOLOGY

Drop-in fuels

Fuels can replace up to 100% of the fossil fuel without alterations in the vehicle engine.

Low blend fuels

Fuels that can only be mixed with conventional fossil fuels up to a limited percentage, known as blend wall, due to technical compatibility with existing vehicle engines.

For example, FAME biodiesel 5-7%[1] in volume.

E-fuels / synthetic fuels

Fuels produced using electrolytic hydrogen and captured CO_2, with the hydrogen generated from renewable electricity (e.g., solar, wind).

HVO vs. Biomass-to-Liquid (BtL) fuels

HVO fuels are produced from liquid/oily feedstocks (e.g., vegetable oils), and BtL fuels from solid feedstocks (e.g., forestry residues).

	DIESEL AND KEROSENE POOL	GASOLINE POOL
DROP-IN FUELS	**HVO** Hydrogenated Vegetable Oil *HVO is also known as RENEWABLE DIESEL* Other drop-in diesel, e.g., – Biomass-to-Liquid – Power-to-Liquid (e-diesel, synthetic diesel) Sustainable aviation fuel (SAF)	Renewable naphtha Other drop-in gasoline, e.g., – Biomass-to-Liquid – Power-to-Liquid (e-gasoline, synthetic gasoline) Methanol (in maritime transport)
LOW BLEND FUELS	**FAME** Fatty Acid Methyl Ester = methyl esters from e.g., rapeseed oil, soybean oil or used cooking oil *FAME is also known as BIODIESEL*	Ethanol Methanol (in road transport)

Fuels in the scope of this work

Note: non-exhaustive list | 1. In Europe, max. 7% FAME is allowed in diesel fuel and 5% in U.S.

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Using excess forest biomass for biofuels can create jobs, enhance forest health, and reduce Thunder Bay's carbon footprint

DRIVERS FOR RENEWABLE FUELS

FUEL DECARBONIZATION MEASURES

WOOD-BASED PATHWAYS

OPPORTUNITIES FOR THUNDER BAY

KEY FINDINGS

- Regulatory frameworks in European Union and North America are the main drivers for transportation fuel decarbonization globally. In mining and forestry, regulations support fuel decarbonization, but they do not explicitly mandate fuel switching.[1]
- Fuel decarbonization is also supported through investment support, R&D projects, action plans and roadmaps (i.e., Canada's Clean Fuel Regulation) , and voluntary commitments.

- Various fuel decarbonization measures are being pursued e.g., increased use of biomass and renewable fuels, electrification, carbon capture, operational efficiency and new technologies, etc.
- Transportation fuel decarbonization also contributes to decarbonization of mining and forest industries.

- There are both existing and developing wood-based pathways that can contribute to fuel decarbonization of transport, mining and forest products industries, e.g., pyrolysis oil.
- Wood-based pathways compete with other fuel decarbonization strategies and may not be the main focus area.

- Mining, forestry, and transportation are major industries in Thunder Bay, driving exports and jobs but also contributing to carbon emissions.
- Excess woody biomass in the region could be converted into low-carbon biofuels to cut emissions from these sectors.
- Building a local biofuels industry would create jobs, improve forest health, and generate lasting regional value.

1. In 2024 in Canada, mining accounted for 5334 kt CO_2e, agriculture and forestry for 3342 kt CO_2e, and transportation for 195 548 kt CO_2e.

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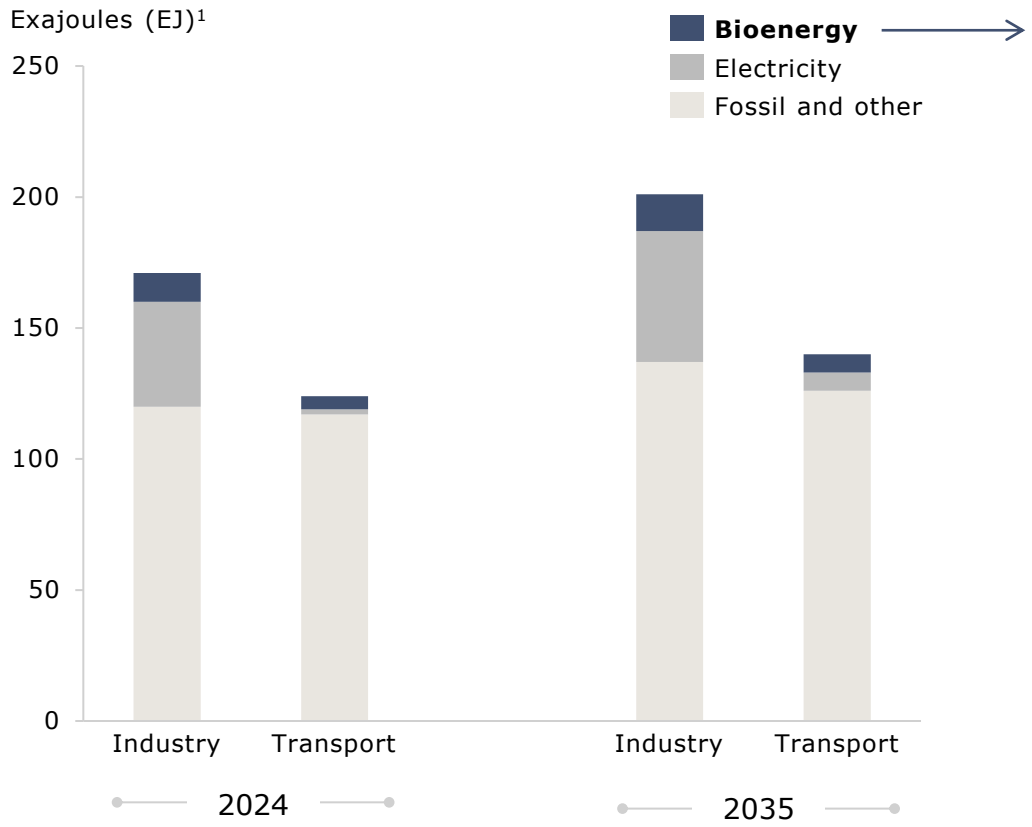
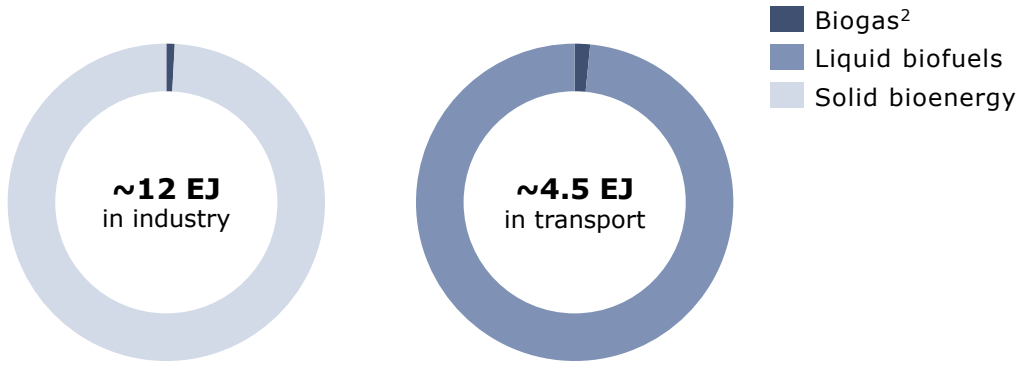
Bioenergy meets 4–6% of global energy demand in industry and transport – solid bioenergy dominates industry, while liquid biofuels power transport

GLOBAL ENERGY DEMAND BY SECTOR AND FUEL TYPE



GLOBAL BIOENERGY DEMAND BY FUEL TYPE IN 2024

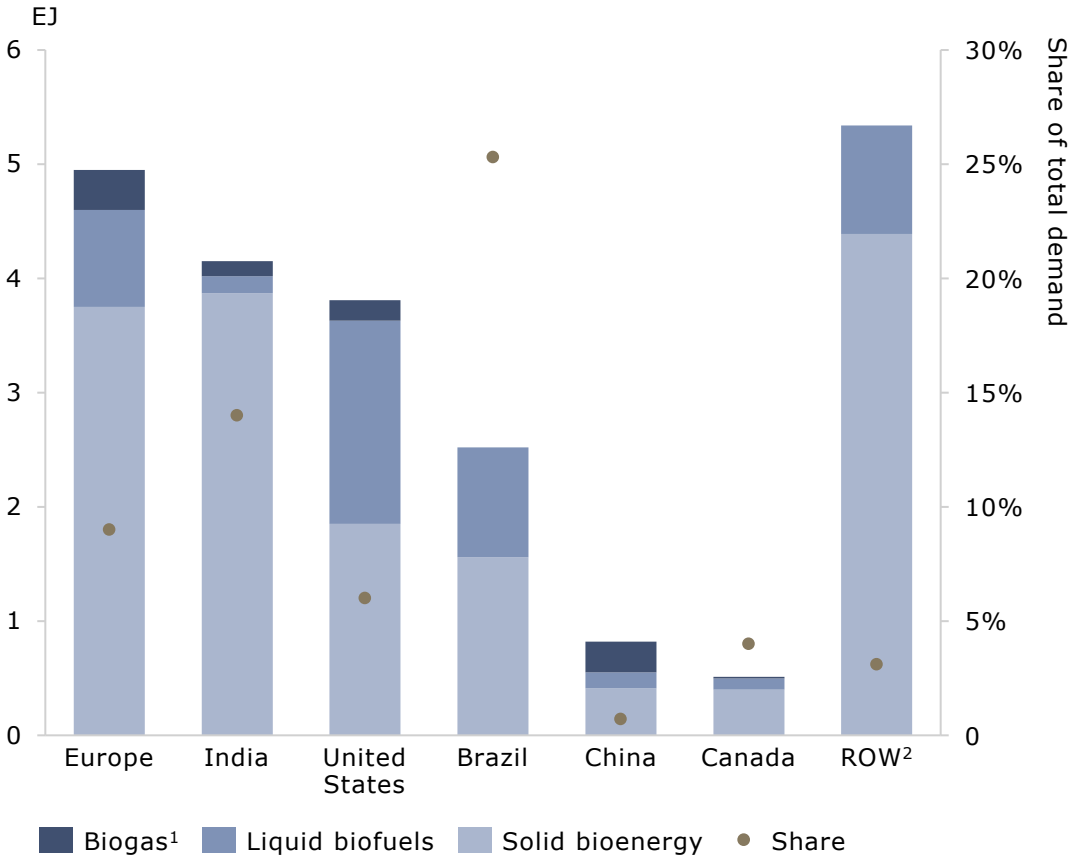


- Currently, bioenergy meets over 6% of the energy demand in the industry sector, but only 4% of the transport sector demand
  - By 2035, the shares are expected to have grown a little to 5% in transport and 7% in industry
- Industry sector relies on solid bioenergy, such as fuel wood, wood pellets, sawdust and bark
- Transport sector relies on liquid biofuels, with FAME biodiesel and 1G ethanol dominating the market
- Both sectors apply only very small shares of biogas (incl. RNG) as energy source

1. Exajoule = 1 * 10^{18} joule | 2. Includes renewable natural gas (RNG) | Source: IEA World Energy Outlook 2025, Stated Policies Scenario; IEA Renewables 2024, AFRY analysis.
FAME = fatty acid methyl ester

Current demand share for renewable fuels is only 0-25% depending on the region. Countries are pushing to increase the share to lower carbon emissions

RENEWABLE FUEL DEMAND BY COUNTRY, 2024



1. Includes renewable natural gas (RNG) | 2. Rest of the World | Source: IEA Renewables 2024

- Global renewable fuels demand was 22EJ in 2024. To be in line with the IEA Net Zero Emissions by 2050 Scenario, renewable fuel use would need to more than double by 2030 from 2023 levels, and then double again by 2050
- None of the renewable fuels are on track with the Net Zero by 2050 Scenario; however, countries and regions are pushing to increase renewable fuel use, via legislations, incentives, investment support etc.
  - India provides investment and production incentives for liquid biofuels, biogases, solid biomass and hydrogen, as well as blending targets for biofuels and biogases
  - Brazil plans to increase biofuel blending targets and has announced a 3.2 BUSD green hydrogen incentive program
  - In Europe, the Renewable Energy Directive III, ReFuelEU Aviation and ReFuelEU Maritime drive demand for liquid biofuel, biogas and hydrogen
  - In the United States policies (incl. Inflation Reduction Act incentives, a national Renewable Fuel Standard and state level low-carbon fuel standards) support liquid biofuel and biomethane use in the transport sector, and some hydrogen uptake in transport and industry
  - In Canada, Clean Fuel Regulations require fuel suppliers to reduce the carbon intensity of liquid fuels. Compliance can be achieved using renewable fuels or low-carbon fuels or purchasing credits. The country also has a renewable fuel requirement of min 5% renewable content in gasoline and 2% in diesel/heating oil

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FUEL DECARBONIZATION

Mining

Regulations support fuel decarbonization, but they do not explicitly mandate fuel switching

- The mining sector currently generates 1.9-5.1 Gt of CO_2 equivalent (CO_2e) emissions annually, representing 4-7% of global GHG emissions.[1]
- The global transition to clean energy will require unprecedented quantities of minerals, with the World Bank estimating a potential increase in selected minerals production of nearly 500% by 2050 to meet clean technology demands.
  - This presents an opportunity for the mining industry but also a challenge for the sector's decarbonization efforts.
- Regarding Paris Agreement targets & Nationally Determined Contributions (NDCs)[2], many countries include mining in their climate strategies, which indirectly push fuel decarbonization through emissions targets.
- Today, most regulations do not explicitly mandate fuel switching in mining but create strong financial and compliance incentives to do so.

EXAMPLES OF REGULATORY DRIVERS FOR FUEL DECARBONIZATION IN MINING INDUSTRY

REGION	DRIVER
EUROPEAN UNION	EU Emissions Trading System (ETS) Renewable Energy Directive (RED III) Industrial Emissions Directive (IED)
CANADA	Clean Fuel Regulations (CFR) Federal and province-level carbon pollution pricing systems for industry Mining Decarbonization Demonstration Call (support mechanism)
AUSTRALIA	Safeguard Mechanism Reform
U.S.	Clean Air Act Inflation Reduction Act (IRA) modified by OBBBA[3]
SOUTH AFRICA	Carbon Tax Act

1. Source: Welink Grup | 2. Countries' self-defined climate action plans submitted under the Paris Agreement to reduce greenhouse gas emissions and adapt to climate change impacts. | 3. The One Big Beautiful Bill Act (OBBBA) is a new law that modifies or replaces some provisions of the IRA, particularly the clean energy tax credits and restrictions on foreign entities of concern

Industry organizations support mining industry fuel decarbonization through voluntary action plans, research, roadmaps, and emission reduction targets

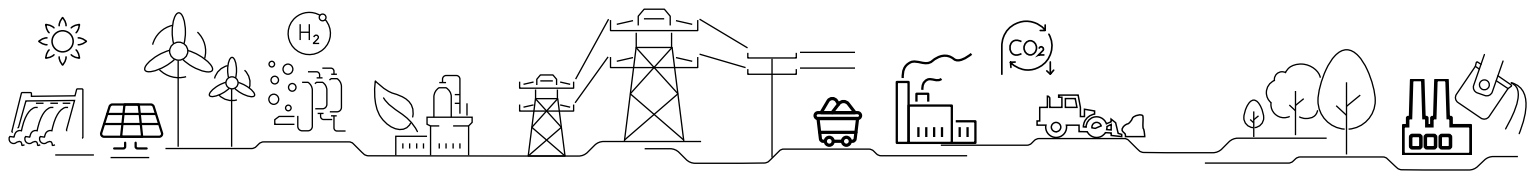
Ontario Mining Association (OMA)	*International Council of Mining and Metals*	*World Bank & International Finance Corporation*	*Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development*	*Euromines*	*Mining Innovation, Rehabilitation and Applied Research Corporation*	*Mining Association of Canada*
– Aims to increase competitiveness of responsible operations and make mining a cornerstone of Ontario's innovation-oriented green economy – The target is to minimize the temporary disruption of the environment and to maximize the restoration of ecosystems at the end of the mine life	– ICMM members have pledged to achieve net-zero Scope 1 and 2 emissions by 2050 – Innovation for Cleaner, Safer Vehicles (ICSV) program – ICMM works with governments and regulators to promote incentives for low-carbon fuel adoption	– Climate-Smart Mining Initiative (CSM) – Net-Zero Roadmap for Copper and Nickel Mining includes fuel-switching strategies – Provides funding and policy guidance for sustainable mining	– Publishes research, provides policy recommendations for governments, and offers technical assistance and capacity building to member countries to support their transition to low-emission mining practices – Decarbonization of the Mining Sector study published	– Represents European mining interests – Released the Mining for Climate Decarbonisation Roadmap, which includes fuel transition strategies	– Canadian research body focused on sustainable mining technologies – Develops hybrid and electric vehicle solutions for underground mining – Partners with universities and industry to pilot low-emission fuel systems	– Addresses fuel decarbonization through its Towards Sustainable Mining initiative, which includes a Climate Change Protocol – Working to reduce carbon footprint by improving energy efficiency, investing in low-emission technologies, and creating climate change adaptation strategies.

Note: non-exhaustive list

The main measures to decarbonize fuel use in the mining industry are electrification and the use of renewable energy

DECARBONIZATION MEASURES

- Deployment of solar and wind power projects at mine sites
- Electrification of mining equipment and vehicle fleets, reducing diesel consumption
- Adoption of Low-Carbon and Alternative Fuels, e.g., hydrogen, bio- and renewable diesel
- Implementation of energy efficiency measures
- Carbon capture technologies



Main focus of fuel decarbonization of mining industry is currently on other solutions than solid biofuels.

However, woody biomass can still help decarbonize fuel use by serving as a renewable substitute for coal and diesel in thermal processes (e.g., in boilers, kilns, and smelters) and off-grid power generation.

FUEL DECARBONIZATION

Forestry

Forest industry already uses a fair share of renewable fuels and energy; regulations support to further reduce dependency on fossil fuels

- The forest industry is both a source and a sink of carbon emissions. While sustainably managed forests and wood products can store carbon, deforestation, land degradation, and fossil fuel use in operations are causing some forest regions to emit more CO_2 than they absorb
- The forest industry (incl. logging, transport, sawmilling, and pulp and paper production) generates emissions from fuel use primarily through
  - Use of diesel-powered machinery and vehicles
  - Fossil-fuel-based heat and power in processing facilities
- In some cases, pulp and sawmill emissions can be quite small if a large share of the used energy comes from burning of process by-products such as bark and black liquor

EXAMPLES OF REGULATORY DRIVERS FOR FUEL DECARBONIZATION IN FOREST INDUSTRY

REGION	DRIVER
EUROPEAN UNION	EU Emissions Trading System (EU ETS) Renewable Energy Directive (RED III) LULUCF (Land Use, Land-Use Change and Forestry) Regulation
CANADA	Clean Fuel Regulations (CFR) Federal and province-level carbon pollution pricing systems for industry
U.S.	Inflation Reduction Act (IRA) modified by OBBBA[1] Clean Air Act State-level programs, e.g., California's Low Carbon Fuel Standard (LCFS)

1. The One Big Beautiful Bill Act (OBBBA) is a new law that modifies or replaces some provisions of the IRA, particularly the clean energy tax credits and restrictions on foreign entities of concern

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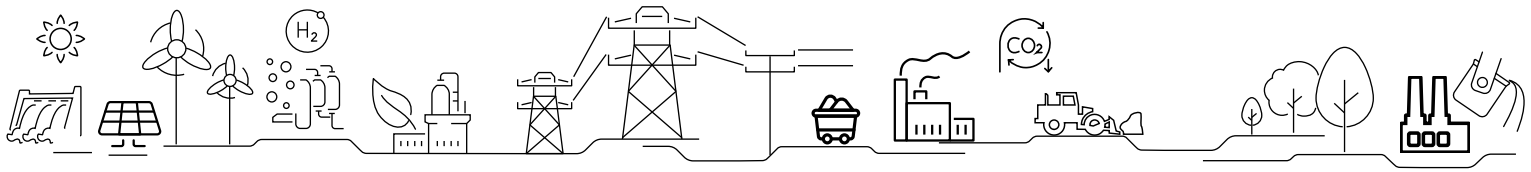
Industry organizations drive decarbonization by promoting energy efficiency, renewable energy, sustainable forestry, and net-zero roadmaps

Confederation of European Paper Industries	*The World Business Council for Sustainable Development*	*The National Council for Air and Stream Improvement*	*The Forest Products Association of Canada*	*American Forest and Paper Association*	*Ontario Forest Industry Association*
– Non-profit organization, supporting decarbonization through several initiatives – Committed to achieving net-zero emissions in the pulp and paper sector by 2050 through energy efficiency and fossil-free energy use – Accelerates adoption of carbon-reducing technologies like heat pumps, biogas, renewable electricity, solar heat, and energy storage	– The WBCSD´s Forest Solutions Group (FSG) is a global platform where forest products sector businesses collaborate on sustainable development – Decarbonization roadmap called the Forest Sector Net-Zero Roadmap	– Scientific research organization that supports the forest products industry (in the U.S. and Canada) in achieving its environmental and sustainability goals – White paper "Towards a net zero future in the forest products industry"	– "Policy Brief on Climate-Smart Forestry for a Resilient Future" report – "Innovative, Sustainable, Resilient: Forest Products Association Of Canada Recommendations From Canada's Forest Sector To Drive Economic Recovery and A Net-Zero Carbon Future" report	– Better Practices, Better Planet 2030 sustainability initiative – Members are committed to reduce total Scope 1 and 2 GHG emissions intensity 50% by 2030 from a 2005 baseline and to establish a goal by 2025 for relevant Scope 3 emissions – Reducing GHG emissions by investing in energy efficiency and clean energy. e.g., by using biomass energy	– Trade organization that represents companies involved in Ontario's forest sector – OFIA's strategic plan seeks to improve operating conditions for Ontario's forest companies, ensuring value for employees, communities, and shareholders while supporting climate change mitigation and a net-zero economy. – Involved in developing Ontario's forest biomass action plan

Forest industry fuel decarbonizing measures include increased use of biomass, electrification, energy efficiency, and carbon removal strategies

DECARBONIZATION MEASURES

- Fuel decarbonization in the forest industry primarily involves switching from fossil fuels to bio-based alternatives, such as biofuels and hydrogen, and electrifying processes, including transport[1].
  - For example, in the Nordics pulp mills have mostly replaced heavy fuel oil with tall oil pitch as an energy source. In other regions (e.g., Canada) pyrolysis oil could serve the same purpose
- Another key strategy is utilizing bioenergy with carbon capture and storage (BECCS) to become carbon-negative, along with improving energy efficiency, logistics optimization[1] and utilizing waste streams from forestry and other sectors



The most common use of biomass in the forest industry is the direct combustion of forest residues to generate heat and power for on-site operations.

CHP[1] systems using locally sourced forest residues offer a decentralized, stable energy supply that reduces dependence on imported fuels.

In addition, e.g., pyrolysis oil can be used to replace heavy fuels oil in industrial boilers and liquid biofuels can help decarbonize diesel-powered vehicles

1. Harvesting and transport are among the largest contributors to emissions within the forest sector, especially in remote regions.

FUEL DECARBONIZATION

Transport

Regulatory frameworks in the European Union and North America are the main drivers for transportation fuel decarbonization globally

KEY REGULATORY MECHANISMS FOR FUEL DECARBONIZATION

REGION	MECHANISM	STATUS	APPLICABLE SECTORS	IMPACT ON GLOBAL BIOFUELS MARKET	DEMAND FOR DROP-IN FUELS[1]
EUROPEAN UNION	Renewable Energy Directive III[2]	In force	Road transport, Maritime, Aviation, Heat & Power	High	Yes
	ReFuelEU and FuelEU Regulations[2]	In force	Maritime, Aviation	High	Yes
	Effort Sharing Regulation	In force	Road transport, Industry, Heat & Power	Medium	No / very limited
	Emission Trading System	In force	Maritime, Aviation, Industry, Heat & Power	Medium	No / very limited
U.S. AND CANADA	Inflation Reduction Act (U.S.) modified by OBBBA[3]	In force	Road transport, Aviation, Industry	High	Yes
	Low-Carbon Fuel Standards (U.S.)	In force	Road transport, Aviation	High	Yes
	Renewable Fuel Standard program (U.S.)	In force	Road transport, Aviation	Medium	No / very limited
	Clean Fuel Regulation (CA)	In force	Road transport	Low	No / very limited

Road transport · Aviation · Maritime · Heat & Power · Industry · Yes · No / very limited

1. The mechanism supports demand for drop-in biofuels, but does not necessarily have e.g., a dedicated blending target for them. | 2. RED III, ReFuelEU and FuelEU differentiate between 1G and 2G biofuels, promoting use of 2G fuels. | 3. One Big Beautiful Bill Act (OBBBA) is a new law that modifies or replaces some provisions of the IRA, particularly the clean energy tax credits and restrictions on foreign entities of concern

AFRY

Decarbonization strategies in other regions are in planning phase or more focused on low blend fuels – many also promote domestic production

KEY REGULATORY MECHANISMS FOR FUEL DECARBONIZATION

REGION	MECHANISM[1]	STATUS	APPLICABLE SECTORS	IMPACT ON GLOBAL BIOFUELS MARKET	DEMAND FOR DROP-IN FUELS[2]
BRAZIL[3]	Future Fuels program	In force	Road transport, Aviation	Medium	✓
	RenovaBio program	In force	Road transport	Low	—
CHINA, JAPAN	SAF blending obligation	Planned	Aviation	Low	✓
SOUTH KOREA	SAF, renewable diesel and maritime fuel blending obligation	Planned[4]	Road transport, Maritime, Aviation	Low	✓
INDIA[3]	Ethanol blending program	In force	Road transport	Low	—
INDONESIA[3]	B40 (FAME biodiesel) program	In force	Road transport	Low	—

Road transport · Aviation · Maritime · Heat & Power · Industry · ✓ Yes · — No / very limited

1. The mechanisms do not put any limits on 1G biofuels and do therefore not specifically drive 2G biofuels production and demand.
2. The mechanism supports demand for drop-in biofuels, but does not necessarily have e.g., a dedicated blending target for them.
3. Brazil, India and Indonesia have placed strong mechanisms to support domestic biofuels production, rather than utilizing imported biofuels.
4. Preliminary target for SAF blending has been approved; targets for renewable diesel and maritime fuels are still pending.

AFRY

International organizations set binding GHG reduction- and emission offset targets and support voluntary offtake agreements of renewable fuels

International Maritime Organization

- IMO GHG strategy adopted in 2023 has the following targets for international shipping decarbonization:
  - 40% reduction of CO2 emissions by 2030, compared to 2008;
  - Net-zero GHG emissions by/around 2050;
  - At least 5% of all energy used must be zero or low-GHG fuels and/or energy sources by 2030
- Ship operators are required to lower the emission-intensity of its energy usage each year or to make payments into a fund[1]

International Civil Aviation Organization

- Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), targeting to offset the future growth in global aviation sector's emissions from 2020 onwards
- The scheme's scope is limited to international flights between the committed countries[2]
- CORSIA is applied in phases with voluntary participation until 2027, and mandatory measures for 2027-2035
- Eligible emission reduction measures are
  - Blending sustainable aviation fuels[3]
  - Offsetting via established carbon offsetting schemes[4]

Zero emission maritime buyers' alliance & Sustainable aviation buyers' alliance

- ZEMBA and SABA are buyers' alliances offering tender platforms and support for voluntary offtake agreements of renewable fuels in maritime and aviation, respectively
- ZEMBA aims to accelerate the adoption of zero-emission shipping by aggregating demand for zero-emission maritime transport, organizing joint procurement and long-term offtake agreements for sustainable shipping services
- SABA aims to scale up the market for SAF. It enables its members to jointly procure SAF, support new production projects, and advocate supportive policies. The goal is to reduce aviation emissions and members' Scope 3 emissions to meet their climate targets.

HWY H2O

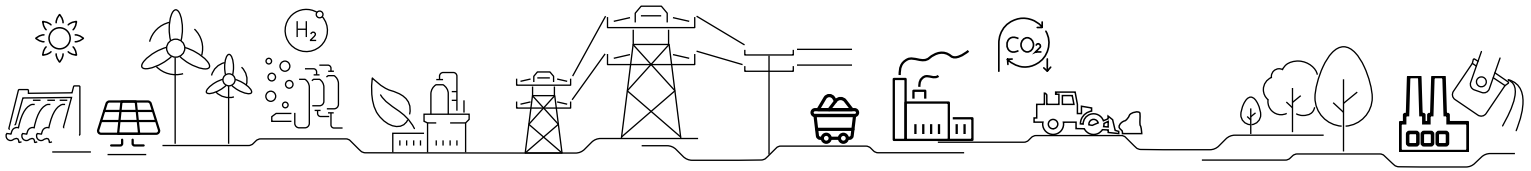
- A marine transportation corridor that connects the Atlantic Ocean to the Great Lakes. The corridor includes over 40 ports and supports intermodal connections (rail, road, and inland waterways)
- Highway H2O supports Seaway Corporations' efforts to cut GHG emissions and protect the environment through initiatives with port partners and stakeholders, including the Green Shipping Corridor to strengthen the supply chain.

1. Fuel intensity can be reduced via lower-emission fuels, on-board renewable energy use, wind propulsion or carbon capture and storage (CCS), or credits | 2. As of late 2025, 130 countries are committed to CORSIA, incl. Canada, U.S., and EU | 3. The blended fuels must meet only 10% GHG reduction compared to fossil aviation fuels | 4. e.g., American Carbon Registry, Climate Action Reserve and Verified Carbon Standard

Fuel decarbonization is centered around a range of bio-based and low emission fuels as well as new technologies and operational efficiency

DECARBONIZATION MEASURES

- Low blend fuels, e.g., biodiesel, bioethanol
- Drop-in fuels in road & maritime & aviation, e.g., renewable diesel, biomethanol (maritime), sustainable aviation fuels (SAF)
- Synthetic fuels, e.g., e-methanol
- Electrification
- New vehicle fleet (e.g., electric cars, lower emission/energy efficient cars, LNG ships, dual-engine ships)
- Operational efficiency
- Carbon capture and storage
- Utilization of onshore power supply (OPS)



Woody biomass can be used for ethanol, methanol and biomass-to-liquid (BtL) fuels incl. jet fuel.

Production technologies and processes are under development, but reaching commercial scale has proven challenging (e.g., Red Rock Biofuels case[1]) and currently there are no commercial scale plants for wood-based transportation fuels.

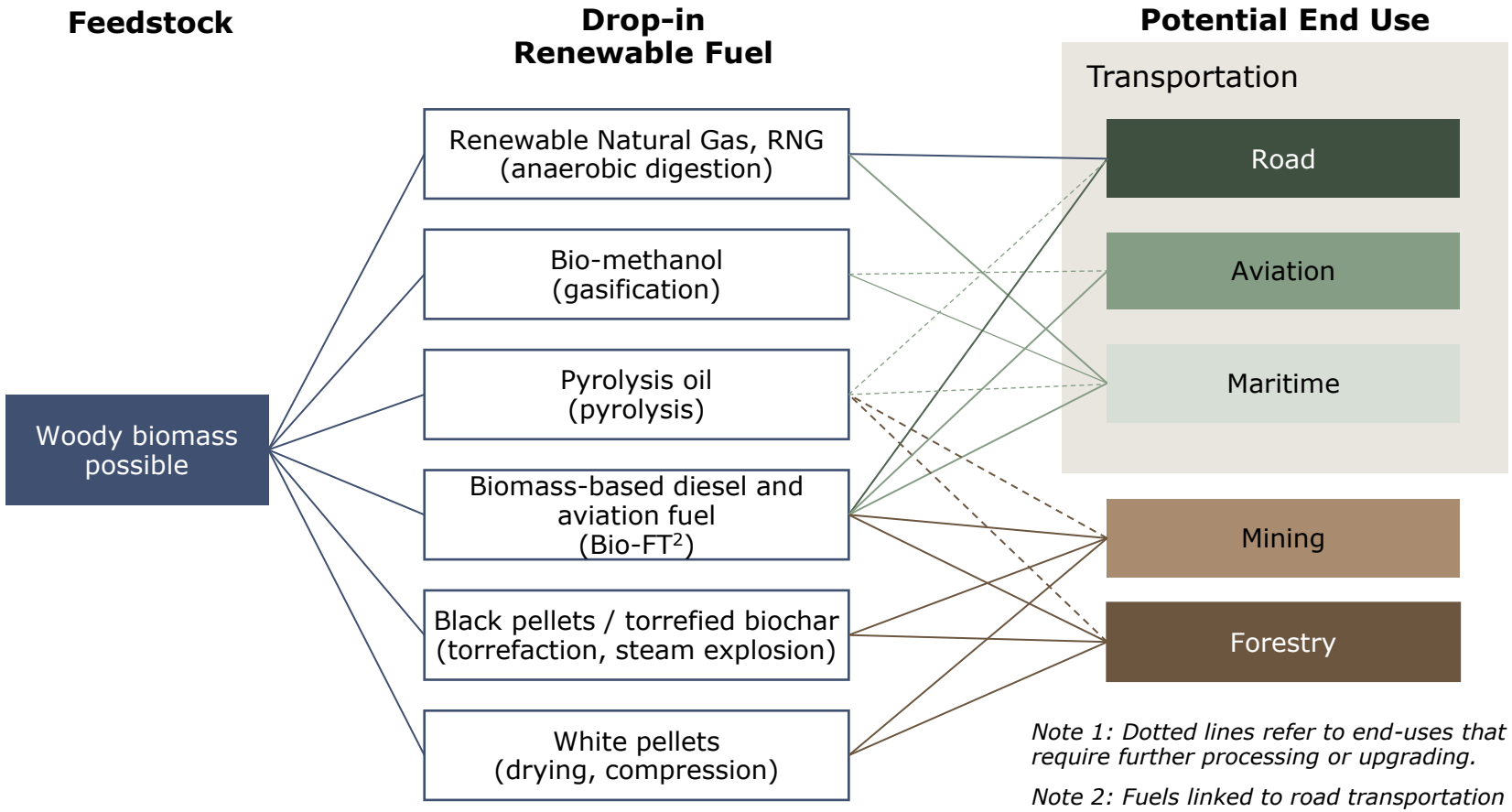
1. Red Rock Biofuels was founded in 2011 with the goal of converting woody biomass into low-carbon, renewable jet and diesel fuels. Construction of the flagship facility in Lakeview, Oregon faced persistent delays and financial trouble, and the facility was never completed. Lakeview RNG, a subsidiary of NEXT Renewable Fuels, acquired the Red Rock assets, with a new plan of producing renewable natural gas (RNG) and clean hydrogen from forest waste.

AFRY

FUEL DECARBONIZATION

Biofuel production pathways

Woody feedstock can be processed into drop-in renewable fuels that can contribute to fuel decarbonization of all three focus industries



Note 1: Dotted lines refer to end-uses that require further processing or upgrading.

Note 2: Fuels linked to road transportation also contribute to fuel decarbonization of mining and forestry industries

- In transportation, each sector has restrictions driven by regulations related to use of renewable fuels
  - Feedstock acceptability
  - Fuel specifications
- Sectors compete over same fuels, thus sector with highest paying capability/highest market price defines prices for other sectors as well
- RNG can be used as a drop-in fuel in in dedicated engines in maritime and road transportation
- Bio-methanol can be further processed to drop-in aviation fuel via the methanol-to-jet (MtJ) process. In maritime bio-methanol can be used in dedicated engines
- Upgraded[1] pyrolysis oil can be used in road, maritime, mining and forestry sectors. In forestry boiler retrofitting may also be needed.[3]
- Bio-FT is still pending its first commercial scale facility implementation

1. Upgrading include e.g., oxygen removal | 2. Fischer–Tropsch (FT) process, is a catalytic chemical method for producing liquid hydrocarbons such as diesel, naphtha, and jet fuel, from syngas | 3. Pyrolysis oil is in the process of getting ASTM approval. Upon approval, it is eligible for use in aviation

Woody biomass residuals in Thunder Bay could be converted into biofuels to lower emissions from mining, forestry, and transportation sectors

MAJOR INDUSTRIES IN THUNDER BAY

Mining, forestry, and transportation are large industries in Thunder Bay contributing to exports, employment and economic wealth, but also to carbon emissions.

Thunder Bay is a key regional hub in Canada's mining sector, with 10 active mines and over 18 major exploration projects

Thunder Bay's is home to Ontario's largest sawmill, a major pulp and paper mill, and to pilot plants and research centers within the forest bioeconomy sector

Thunder Bay is a key transportation hub in Canada, with the largest outbound port on the Great Lakes, one of the busiest airports in Ontario and highways/railways, supporting trade with the U.S. and across Canada

WHAT DO OTHERS DO

- Mining, forestry and transportation industries around the world are actively working on reducing carbon emissions, by for example replacing fossil fuels with biobased alternatives
  - ArcelorMittal in Quebec, is an example of a company that has, at its Port-Cartier pellet plant, partially replaced heavy fuel oil with pyrolysis oil made from forest residue, to reduce GHG emissions and reliance on fossil fuels

SUSTAINABLE FEEDSTOCKS

Thunder Bay's remote location and difficult logistics limits viable fuel decarbonization options. However, with Thunder Bay's excess biomass residuals, particularly from the primary forestry sector, they could produce various biofuels that would help mining, forestry and transportation industries to achieve carbon reduction targets and reduce reliance on fossil fuels.

AFRY

Content

Rising industrial activity in Northwestern Ontario is driving up diesel and aviation fuel demand, underscoring the need for resilient fuel supply chains

KEY FINDINGS

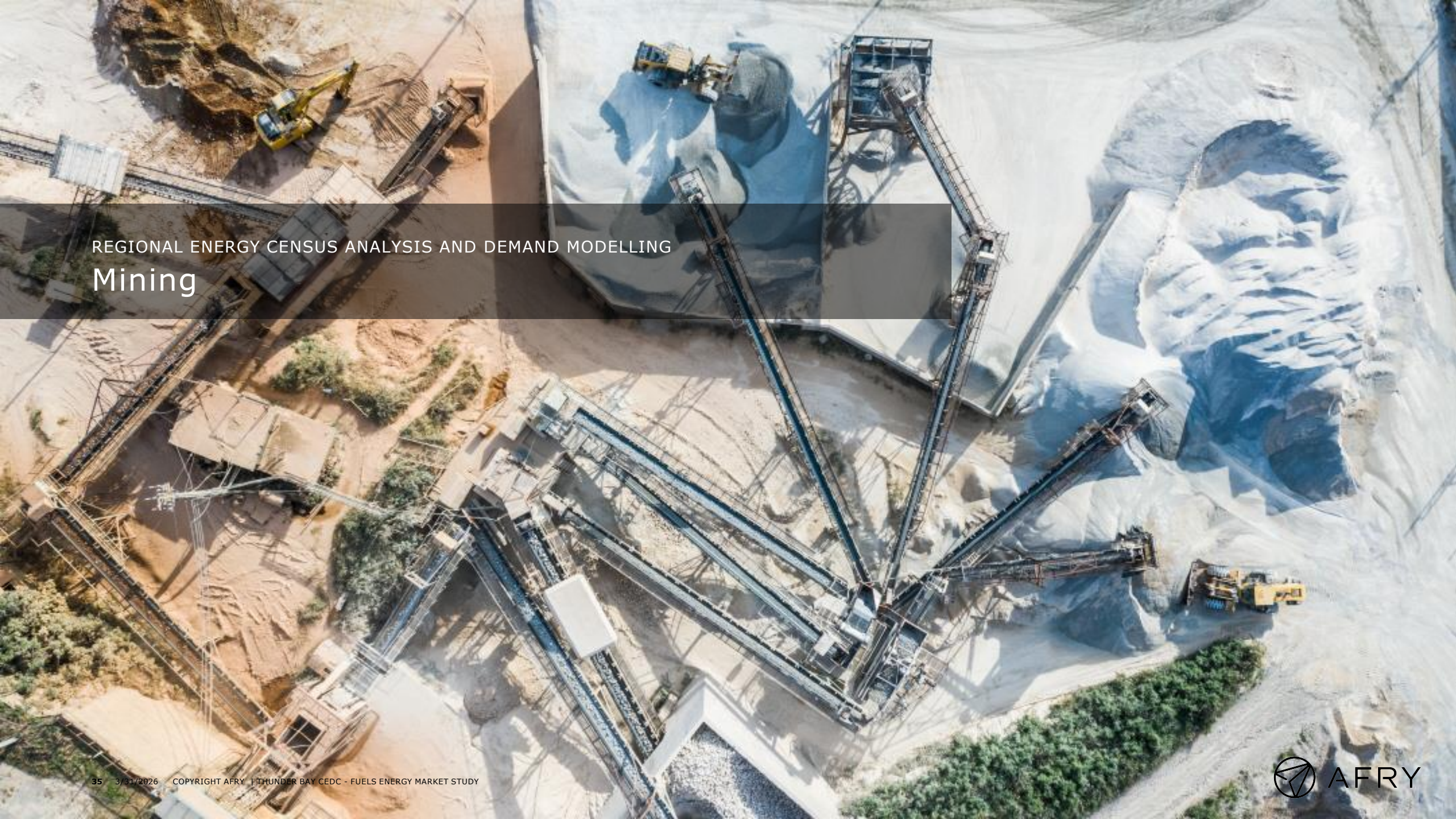
- Northwestern Ontario's abundant natural resources and strong mining network make it a top mining producer. Ontario's mining, especially gold, is set for growth due to global metal demand. Reliable energy, access to infrastructure and fuel are crucial for remote mining competitiveness.
- Fuel choices depend mainly on cost and supply reliability. With new mines opening, diesel demand in Northwest Ontario is expected to increase. Some degree of electrification is expected for fleet, but 100% electric is unlikely.

- Northwestern Ontario is vital to Ontario’s forest manufacturing, with sawmills, pulp and paper, and wood product makers supporting jobs but faces mill closures, supply chain disruptions.
- Industry players are hopeful about long-term housing demand market demand to increase forest activities but worry about short-term issues like mill closures, weak consumer demand, and uncertain policies. Biofuels could help use excess wood biomass, but high capital costs and building a market are some of the challenges.
- Fuel demand projections show industry demand decline under the current conditions, but stability is forecasted with High Development driven by housing recovery.

- Marine and aviation transportation are vital for Northwestern Ontario’s logistics, with a fairly stable outlook going forward supported by West-East traffic along the Great Lakes St. Lawrence Seaway as well as passenger and freight air transportation.
- Despite having stable traffic, ships are not typically refueling in the Port of Thunder Bay and there is currently no demand in building a bunkering facility at the port, so no marine fuel demand should be expected in the region for the next decade. With regards to aviation fuels, demand is expected to grow in all 3 scenarios over the next decade, mostly influenced by passenger flights.

1. Focus on marine and aviation.

AFRY

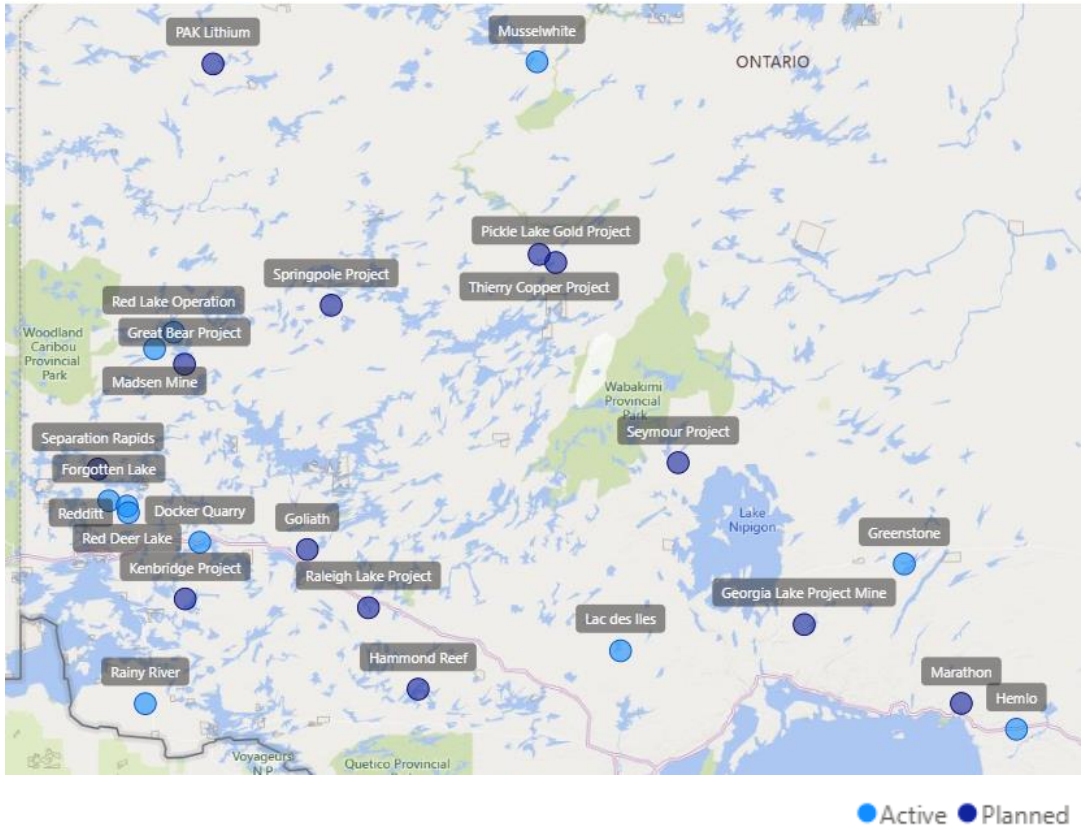


REGIONAL ENERGY CENSUS ANALYSIS AND DEMAND MODELLING

Mining

Northwestern Ontario's abundant natural resources and strong mining network helps secure its stance as a leader in mining output

ACTIVE AND PLANNED MINES IN NORTHWEST ONTARIO[1]



COMMENTS

- Mining is a cornerstone of Northwestern Ontario's economy, anchored by long-standing strengths in gold and base metals and supported by a mature ecosystem of suppliers, skilled labor, and Indigenous partnerships
- Ontario remains a national leader in mining output, generating 24% of Canada's total mineral production value—approximately CAD 13 billion—in 2024
- The province also accounted for nearly half of Canada's total gold production value, with roughly 2.5 million troy ounces produced that year, much of it concentrated in Northern and Northwestern Ontario
- Beyond gold, the region hosts significant deposits of copper, nickel, lithium, and platinum group metals (PGMs), reinforcing its strategic importance as Canada advances critical mineral development, supply chain resilience, and the energy transition
- As demand for critical minerals rises, Northwestern Ontario emerges as a key contributor to Canada's resource and energy security. Reliable fuel supply and energy security are vital for sustaining remote mining operations, where energy costs directly affect competitiveness and long-term investment

1. For this study, Northwest Ontario is defined as the regions on Thunder Bay, Kenora, and Rainy River | Sources: Ontario Mining Association, State of the Ontario Mining Sector 2025; Ontario Mineral Production Fact Sheet (2025)

AFRY

Ontario's mining industry, namely gold producers, are well positioned to grow considering the high global demand for metals and minerals

KEY INDUSTRY DRIVERS

GLOBAL DEMAND FOR MINERALS

Rising demand for gold, battery metals, and critical minerals due to energy transition policy and manufacturing needs, paired with rising geopolitical uncertainty affecting the supply chain, makes mining output from Ontario more valuable

POLICY SUPPORT

Reducing investment risk through provincial and federal programs improves project economics; examples of recent policy support includes the Special Economic Zones Act (SEZA) and subsidies like Critical Minerals Processing Fund (CMPF)

ABUNDANCE OF NATURAL RESOURCES

Ontario has a large reserve of metals and minerals and is the leading producer of gold in Canada

Increasing | No significant change | Decreasing

COMMENTARY

- Mines systems vary heavily based on a multitude of factors including, but not limited to, commodities, grade of product, tonnages, and mine type
- With global demand on the rise, mining companies are able to sell minerals, especially gold, at favorable prices
- Mining industry participants based in Ontario benefit from an abundance of natural resources and a supportive policy environment
  - The Special Economic Zones Act (SEZA) enables expedited permitting approvals for designated projects.
  - The Critical Minerals Processing Fund (CMPF), launched in December 2025, will provide a total of CAD 500 million for projects that accelerate the province's critical minerals processing capacity
- Companies have access to a secure and reliable energy supply in Ontario, with established fuel supply chains to support operations and grid connections generally available to enable a degree of on-site electrification

Sources: Government of Ontario; AFRY survey responses

The largest considerations for fuel mix within the mining industry are affordability and security of supply

ANONYMIZED SURVEY CONTRIBUTIONS

Grid constraints prohibit mines from full electrification. Additionally, outfitting mines with electric equipment is more expensive. **If there is a low-cost way** forward, then there will be change.

As a "green" company with a product destined for the e-vehicle sector, the company will push to utilize alternative sources of fuel and energy, especially those that are **affordable and readily available**.

Studies done on the use of biofuels for show that it is not an affordable option today for the mining industry. The best way forward is a partnership between fuel companies and First Nations to produce and sell biodiesel at a **low-cost premium** compared to conventional diesel. Reliability, location of the facility, quantity and security of supply are key for a successful fuel switch.

Where technically and economically feasible, **electrification is being prioritized** to reduce long-term emissions and mitigate exposure to volatile fuel markets.

COMMENTS

- As part of this study, AFRY interviewed industry participants on their views on fuel demand and the efficacy of decarbonization in the mining sector through the increased use of biofuels
  - Four industry participants submitted survey responses
- Industry participants highlight the same issue across the board: affordability and security of supply are the main considerations when making decisions associated with fuel mix
- Industry participants are willing to switch to biofuels as long as the quantity and quality of supply are enough and the fuel is able to be reliably purchased
- Mining is an energy-intensive industry which relies upon a steady supply of fuels including, but not limited to diesel (generally for operations), natural gas (for heating needs), among others
- All industry participants surveyed work with a third-party fuel supplier for their operations
  - Therefore, these third-party distributors must be the party which adopts the switch
- Mining participants also highlighted that, despite grid constraints, electrification is a preferred method of achieving decarbonization and is being pursued as the top option when the cost and technical aspects are feasible

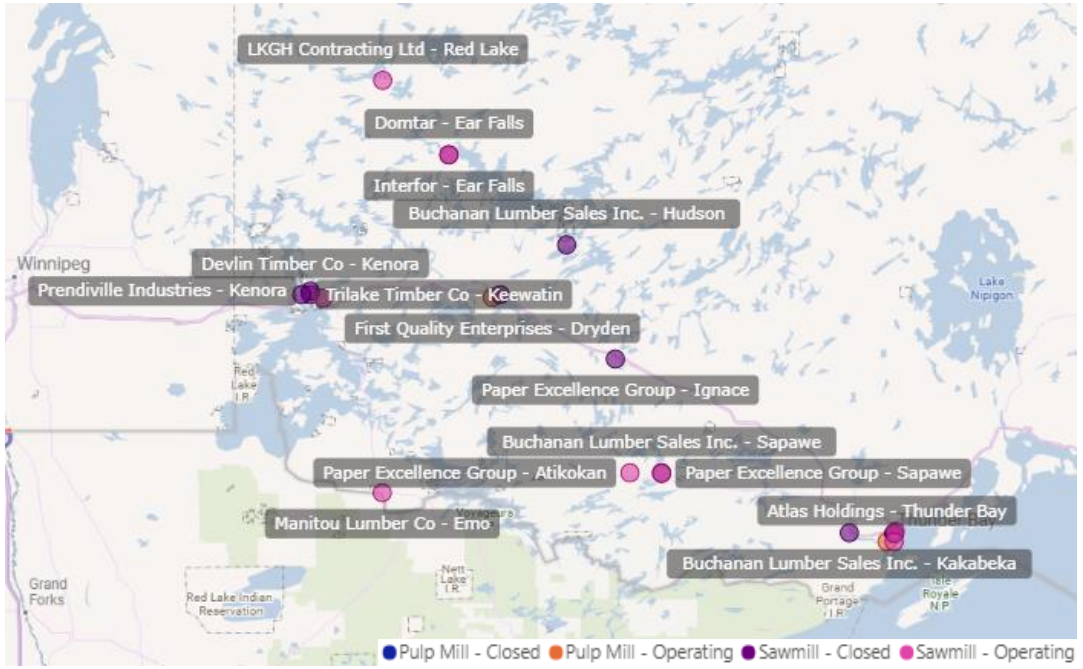
Sources: AFRY survey responses; Statistics Canada

REGIONAL ENERGY CENSUS ANALYSIS AND DEMAND MODELLING

Forestry

Forestry in Ontario significantly contributes to GDP but faces challenges like mill closures, logistics issues, and labor shortages that increase costs

WOOD SUPPLY HEATMAP AND PULP MILLS IN NORTHWEST ONTARIO



Company / Facility name	Status	Capacity kt/a
Atlas Holdings / Thunder Bay	Operating	1 350
First Quality Enterprises / Dryden	Operating	660

Source: Government of Ontario

COMMENTS

- Forestry remains a foundational industry in Northwestern Ontario, contributing to a provincial forest sector that added $5.4 billion to Ontario's GDP
- Northwestern Ontario plays a critical role in Ontario's primary forest manufacturing base, hosting sawmills, pulp and paper facilities, and wood product manufacturers that anchor regional employment and supply chains
- Operating pulp mills are located in northwestern Ontario, close to the province's large wood supply regions. These mills are strategically located in regions with abundant woody biomass
- In 2023, the forest industry provided $5.4b to Ontario's overall GDP, with total revenues of $21.6b
- Despite strong contributions to the province's GDP, the forestry sector has dealt with headwinds in recent years
- Pulp and paper mill closures, for example, has decreased wood utilization, highlighting the need for a functioning "forest bioeconomy"
- In order to find new pathways for wood utilization, Ontario has passed legislation aimed at supporting the forestry industry

With global demand for wood products at a low, the forestry industry is facing a downturn which can only be mitigated by finding new consumers

KEY INDUSTRY DRIVERS

ABUNDANCE OF NATURAL RESOURCES

Ontario's large forest base and regulated forest management system provides long-term fiber supply certainty

POLICY SUPPORT

Government programs, such as Forest Biomass Action Plan (FBAP) and Advanced Wood Construction Action Plan (AWCAP), that support mill modernization, wood product production, utilization of forest biomass, and workforce development help support the industry

GLOBAL DEMAND FOR WOOD PRODUCTS

Due to the recent closure of pulp mills and sawmills in the region, and a downturn in the North American housing market, demand for wood has decreased

Increasing No significant change Decreasing

Sources: Ontario Forest Sector Strategy Progress Report (2025); AFRY survey responses

COMMENTARY

- Ontario's forests represent a large supply of woody materials.
  - Primary wood manufacturing plants in Northwestern Ontario continue to anchor regional employment and forest supply chains, but many are operating under pressure
- Recent years have seen curtailments and reduced capacity driven by high operating and energy costs, fiber availability challenges, aging assets, high transportation cost, and volatile global markets
- In response, policy and industry efforts are increasingly focused on stabilization and modernization, including improved fiber utilization and integration with emerging bioeconomy opportunities to strengthen long-term competitiveness
- Ontario faces an underutilization issue in the forestry sector yet still earned CAD 21.6 billion of revenue in 2023
- As population growth continues worldwide, the demand for wood products will likely recover
  - In the short-term, solutions and government support will be necessary to keep the sector functioning

AFRY

Industry players, though acknowledging a potential comeback, generally have a pessimistic view of the short-term future of forestry in Ontario

ANONYMIZED SURVEY RESPONSES

The forestry sector is **retracting dramatically** in Ontario, similar to the 2009-2011 downturn. Several new facilities must open within the next three years to use abundant and under-utilized hardwoods, or there will be no industry left.

In the long-term, the forestry industry will come back as demand increases in the future, likely due to housing shortages in North America. However, today, and throughout the short-term, economic and climate winds are **not conducive to a healthy industry**

Homebuilding in the U.S. is the largest driver for the forestry industry today. With homebuilding at a **current low**, it is difficult to see the industry rebounding in the short term. Energy is the biggest opportunity for forestry, but there are **mixed signals** from the government based on the current subsidies in place.

Source: AFRY survey responses

COMMENTARY

- As part of this study, AFRY interviewed industry participants on their views on fuel demand and the efficacy of decarbonization in the forestry sector through the increased use of biofuels
  - Five industry participants submitted survey responses
- The forestry industry in Ontario has plentiful access to natural resources
- However, recent mill closures and reductions in demand from end-consumers have disrupted long-existing and specialized supply chains, heavily impacting wood prices
  - Participants cite that due to lack of infrastructure, they must build roads through areas where no product is generated
- Participants mentioned that mixed signals from the provincial government add create a more nebulous view for the short-term
- Energy is seen as a possible solution to the oversupply of woody biomass, hardwood in particular
  - Survey participants also highlight the likely higher cost of wood-to-fuel, raising the question of how to build a sufficient consumer base
- In the longer-term, an increase for North American housing demand is expected as population increases

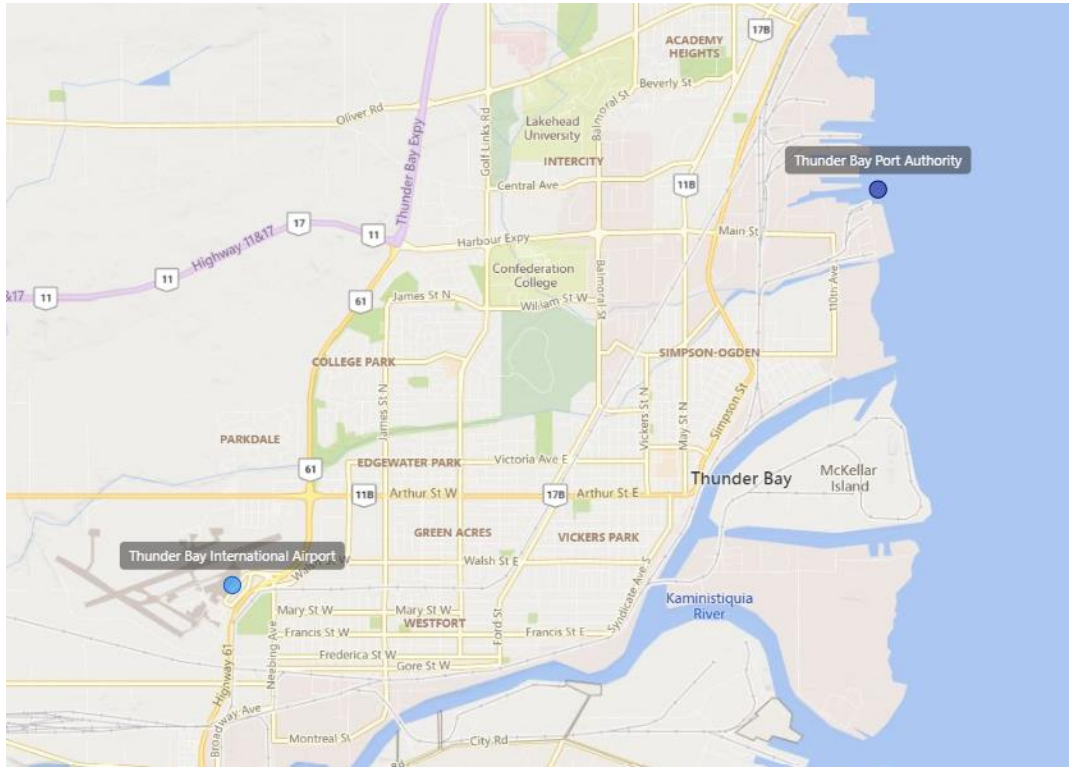
AFRY

REGIONAL ENERGY CENSUS ANALYSIS AND DEMAND MODELLING

Transport

The two major transportation hubs in Northwestern Ontario are the Thunder Bay International Airport and the Thunder Bay Port Authority

AIRPORT AND PORT IN THUNDER BAY



COMMENTS

- Regional connectivity is of top importance in Thunder Bay considering the heavy industry players which operate in the area
- The Thunder Bay Port Authority is the furthest inland port on the St. Lawrence Seaway and transported more than 10m tonnes of cargo in 2024
- The Thunder Bay International Airport serves over 700k passengers on an annual basis and expects this number to grow to 1m within the next 10 years

The key driver for aviation and marine transport growth within Northwest Ontario is mainly the economic development

KEY INDUSTRY DRIVERS

ECONOMIC DEVELOPMENT

As industry grows within Ontario, so will the need for transport

CHANGES IN POPULATION

Ontario's Ministry of Finance predicts modest population growth in the Northwest, which will increase fuel needs for transport

INTERNATIONALIZATION

As the Northwest Ontario region's industry grows, the need for more international transport services will increase, primarily towards the United States

Increasing | No significant change | Decreasing

COMMENTARY

- Marine and aviation transportation are vital for Northwestern Ontario's logistic, with a fairly stable outlook going forward supported by West-East traffic along the Great Lakes St. Lawrence Seaway as well as passenger and freight air transportation
- The largest drivers for transport in Northwest Ontario are population growth and economic development
  - Additional population growth will likely require more aviation needs
  - Similarly, as industry grows in the Northwest Ontario region, namely mining, the need for aviation fuels will increase
- In the medium term, once the trade relationship between Canada and the United States becomes clearer and more stable, demand for international travel could support additional growth, especially in the aviation

AFRY

While switching the biofuels is a consideration for decarbonization for the Thunder Bay Port and Airport, refueling operations are third-party managed

SURVEY RESPONSES

Currently, all fueling operations for the Airport of Thunder Bay are fulfilled by **third party vendors**. Biofuels producers are interested in being connected to these third-party distributors.

Electrification is part of the Airport of Thunder Bay's sustainability plan, but actually meeting these goals may prove to be difficult due to the **cost of electric equipment** and the remote location of the airport.

The Port of Thunder Bay does not bunker vessels, and we do not purchase marine fuel. Ships source their own bunkers through their ship agents. It is **very rare for a vessel to need fuel** while in Thunder Bay, and when it happens, they usually arrange it through Sterling Fuels in Sarnia. Most vessels refuel in larger ports such as Montreal or Detroit, and **no ship owner has indicated a need for a bunkering facility here**.

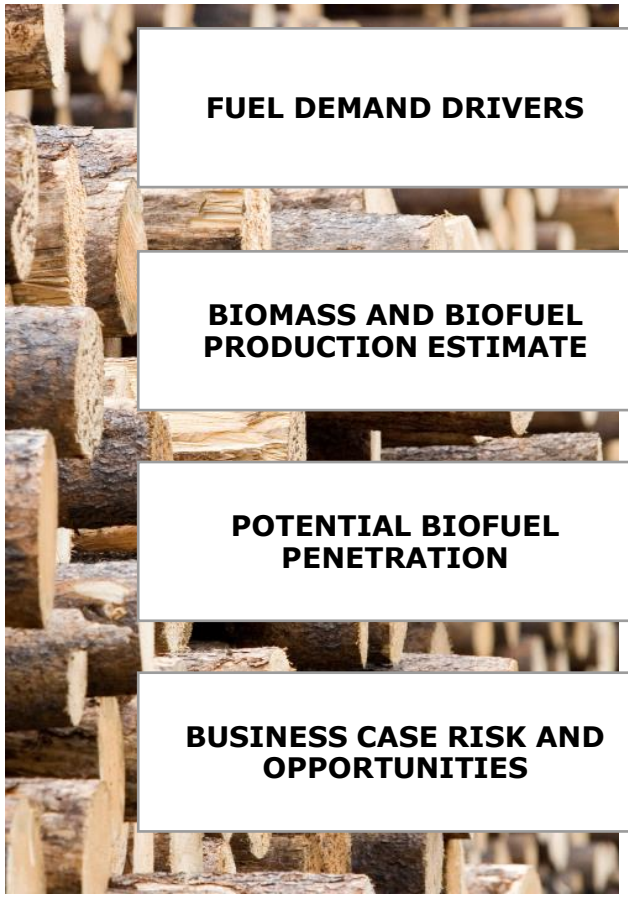
Source: AFRY survey responses

COMMENTS

- As part of this study, AFRY interviewed industry participants on their views on fuel demand and the efficacy of decarbonization in the transport sector through the increased use of biofuels
  - Two industry participants submitted survey responses
- Aviation fuels are the main transport fuel in use in the region, as the large majority of ships do not refuel at the Port of Thunder Bay
  - Currently, there are no sustainable aviation fuel (SAF) or blending requirements in Canada and Ontario. As these mandates come online in the future, the need for biofuels in the region will increase
  - Despite having stable traffic, ships do not typically refuel in the Port of Thunder Bay and there is currently no push from stakeholders to build a bunkering facility at the port, so no significant marine fuel demand should be expected in the region for the next decade

Content

Though Thunder Bay has enough woody biomass to produce an adequate quantity of biofuels, policy supports remain key to meaningful adoption



FUEL DEMAND DRIVERS

BIOMASS AND BIOFUEL PRODUCTION ESTIMATE

POTENTIAL BIOFUEL PENETRATION

BUSINESS CASE RISK AND OPPORTUNITIES

KEY FINDINGS

- Mining focuses on fuel costs and supply reliability due to high energy needs, with new mines in Northwest Ontario likely increasing diesel use. Forestry's remote sites make biofuel adoption difficult, despite supportive policies. Fuel demand may drop under the Status Quo but stay steady with housing market growth. Without mandatory sustainable aviation fuel rules, use of biofuels is limited, while aviation fuel demand is expected to rise moderately from domestic travel and freight growth.

- The Thunder Bay region has about 3 million GMT of woody residuals, which could produce up to 1 billion liters of renewable fuel via catalytic pyrolysis at a 25-30% yield. However, high CAPEX makes wood-based advanced biofuels costly. Removing the downstream upgrading step could cut CAPEX by 40–50%. Grants and tax incentives may help reduce costs as refineries expand.

- Potential biofuel penetration in the Thunder Bay region will reach 5% for the mining sector (7.1m liters diesel, 5% for the forestry sector (2.3m liters diesel), and 1.5% for the aviation transport sector by 2035 (7m liters aviation turbo fuel; 36k liters aviation gasoline) though risks associated with electrification and high pricing remain.

- Potential challenges involve adoption by consumers and industry, blending requirements, infrastructure development, price volatility, and transportation issues, all of which could impact the feasibility of projects.
- Thunder Bay possesses sufficient woody biomass to generate renewable fuels exceeding current demand; however, expanding production by 2035 will necessitate substantial investment, supportive policies, strong user engagement to drive adoption, and cost reductions such as tax incentives.

AFRY

Heavy industry in Northwest Ontario is fuel-intensive; Policy assistance will be key for biofuels adoption

- In general, fuel cost is the most important factor for industry players when considering a fuel transition
- Policy support for the building of a production facility, transport, and end-consumer purchasing for biofuels will be necessary to ensure a smoother transition
- Modelling for fuel needs has been conducted for the mining, forestry, and aviation transport sectors with the study period ending in 2035
- Each modelling scenario has three cases – Status Quo, Medium Development, and High Development – which have been defined per industry
- Fuel drivers considered include strength of policy support, electrification ambitions, final purchasing cost, and efficiency of the final biofuel product

Fuel cost and security of supply are the top considerations for mining participants given the energy-intensive nature of the industry

KEY FUEL DRIVERS

PERCEIVED COST & SECURITY OF SUPPLY

Fuel cost and security of supply will be the top factor for fuel switch consideration, as fuel is central to mining operations; without government support, biofuels will be more expensive

ELECTRIFICATION

Where economically and technically possible, industry players will electrify, reducing the need to switch to biofuels; 100% electrification is unlikely due to grid and transmission constraints

POLICY

Clean Fuel Regulations (CFR) mandates a 15% reduction in the carbon intensity (CI) of gasoline and diesel by 2030 relative to 2016 levels

EFFICIENCY OF BIOFUEL

The ratio of biofuel needed to replace a gallon of conventional fuel is generally greater than one, potentially posing an obstacle, as a greater quantity of fuel is needed for the same operation

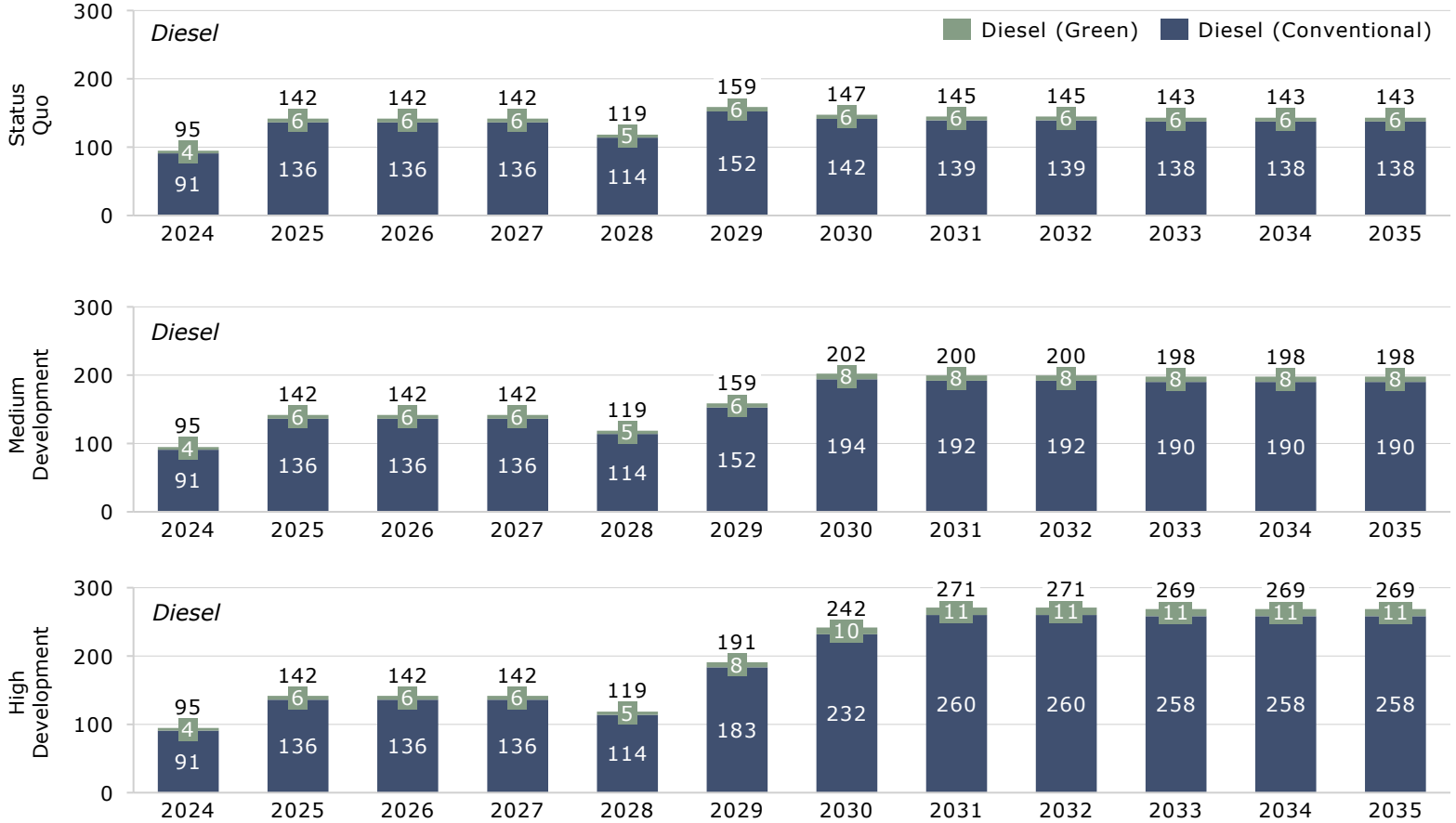
Increasing No significant change Decreasing

FUEL PROJECTION METHODOLOGY

- AFRY used a combination of publicly available historical data, industry participant survey responses, and industry and government reports, fuel usage benchmarks from industry studies, publicly available mine data, and estimated annual output to create a three scenarios for fuel needs for the mining sector
  - The study period for AFRY's fuel projections for the mining industry extends until 2035
- Projections provided should be considered high-level as fuel needs between mining operations vary significantly based on geography of the mine, ore grade, tonnage, mine type, fleet needs, etc.
  - Due to the high degree of fuel-need variance, AFRY projections only consider the use of diesel, though other fuels can be used in smaller quantities (i.e., natural gas for heating purposes)
- Other assumptions made include:
  - 40% of energy needs are met through electrification
  - Policy in Ontario requires fuel producers to blend at least 4% of renewable content into diesel has been accounted for in all projection cases

With a strong mining industry and multiple mines coming online in the short-term, the need for diesel in Northwest Ontario will increase

FUEL DEMAND IN NORTHWEST ONTARIO (MILLIONS OF LITERS)



CASE DESCRIPTIONS

STATUS QUO

Mines which are already operating or sure to come online are considered. This includes seven gold mines, one platinum grade metals (PGM) mine, and four granite quarry operations

MEDIUM DEVELOPMENT

One gold mine is assumed to come online in addition to the mines in the Status Quo case

HIGH DEVELOPMENT

AFRY assumes lithium prices will increase, allowing two lithium mines to come online, in addition to one more gold mine

Sources: Engeco/WEIR, Mining Energy Consumption Study (2021); International Platinum Group Metals Association, PGM Lifecycle Assessment (2022); National Stone Council, Granite Dimensional Stone Quarrying and Processing Life Cycle Inventory (2008); Publicly available mining reports; AFRY survey responses; AFRY Management Consulting analysis

The remote nature of forestry operations makes biofuels substitution in the current context difficult; though, policy could drive adoption

KEY FUEL DRIVERS

POLICY

Clean Fuel Regulations (CFR) mandates a 15% reduction in the carbon intensity (CI) of gasoline and diesel by 2030 relative to 2016 levels

ELECTRIFICATION

Where economically and technically possible, industry players will electrify, reducing the need to switch to biofuels; 100% electrification is unlikely due to grid and transmission constraints

PERCEIVED COST & SECURITY OF SUPPLY

Fuel cost and security of supply will be the top factor for fuel switch consideration, as fuel is central to forestry operations; without government support, biofuels will be more expensive

EFFICIENCY OF BIOFUEL

The ratio of biofuel needed to replace a gallon of conventional fuel is generally greater than one, potentially posing an obstacle, as a greater quantity of fuel is needed for the same operation

Increasing No significant change Decreasing

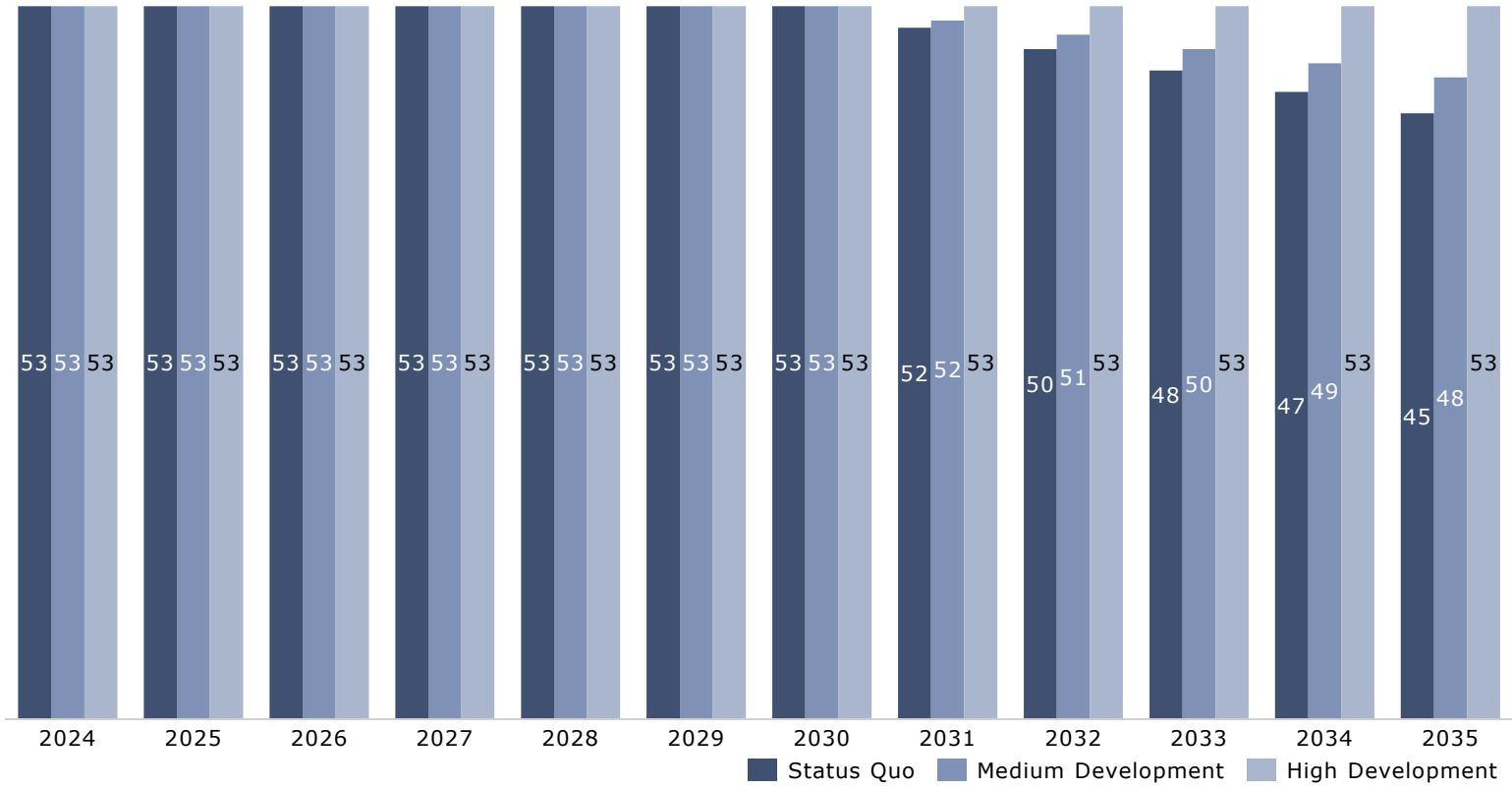
FUEL PROJECTION METHODOLOGY

- AFRY used a combination of publicly available historical data, industry participant survey responses, and industry and government reports, and fuel usage benchmarks from industry studies, to create a three scenarios for fuel needs for the mining sector
  - The study period for AFRY's fuel projections for the forestry industry extends until 2035
- Projections provided should be considered high-level
- Due to the way historical fuel usage values are collected, AFRY projections for the forestry sector combine diesel, light fuel oil, and kerosene needs, though other fuels can be used in smaller quantities (i.e., natural gas)
- AFRY projections only consider fuel usage between residuals collection to the gate of pulp or sawmills
- Other assumptions include:
  - While a full switch to electrification isn't possible due to the remote and rough terrain, cold weather, and lack of infrastructure, electrification will contribute to a drop in demand for fuel in the future

Fuel demand projections show industry decline under Status Quo, but stability with High Development driven by housing recovery and new mills

FUEL DEMAND IN NORTHWEST ONTARIO (MILLIONS OF LITERS)[1]

Diesel, Light Fuel Oil, and Kerosene



CASE DESCRIPTIONS

STATUS QUO

The industry is expected to retract by 15% between 2030 and 2035 due to significant mill closures due to loss of end-use consumers (e.g., housing industry downturn in North America)

MEDIUM DEVELOPMENT

The industry is expected to retract by 10% between 2030 and 2035 due to some mill closures, as well as a slight recovery of North American housing demand

HIGH DEVELOPMENT

AFRY assumes that the industry will be able to maintain fuel demand levels throughout the projection period as North American housing demand makes a comeback

1. Fuel producers are mandated to mix diesel with 4% renewable content; this value is not being provided because diesel, light fuel oil, and kerosene are reported as consolidated for the forestry sector in historical reports | Sources: Statistics Canada, Forestry Secondary Energy Use and GHG Emissions (2022); AFRY survey responses; AFRY Management Consulting

The lack of mandatory sustainable aviation fuel adoption goals creates an obstacle in the more expensive adoption of biofuels

KEY FUEL DRIVERS

POLICY

Canada has set a voluntary goal to reach 10% sustainable aviation fuel (SAF) use by 2030 through its Aviation Climate Action Plan (2022)

ELECTRIFICATION

Where economically and technically possible, industry players will electrify, reducing the need to switch to biofuels; 100% electrification is unlikely due to grid and transmission constraints

PERCEIVED COST & SECURITY OF SUPPLY

Fuel cost and security of supply will be the top factor for fuel switch consideration, as fuel is central to mining operations; without government support, biofuels will be more expensive

EFFICIENCY OF BIOFUEL

The ratio of biofuel needed to replace a gallon of conventional fuel is generally greater than one, potentially posing an obstacle, as a greater quantity of fuel is needed for the same operation

Increasing | No significant change | Decreasing

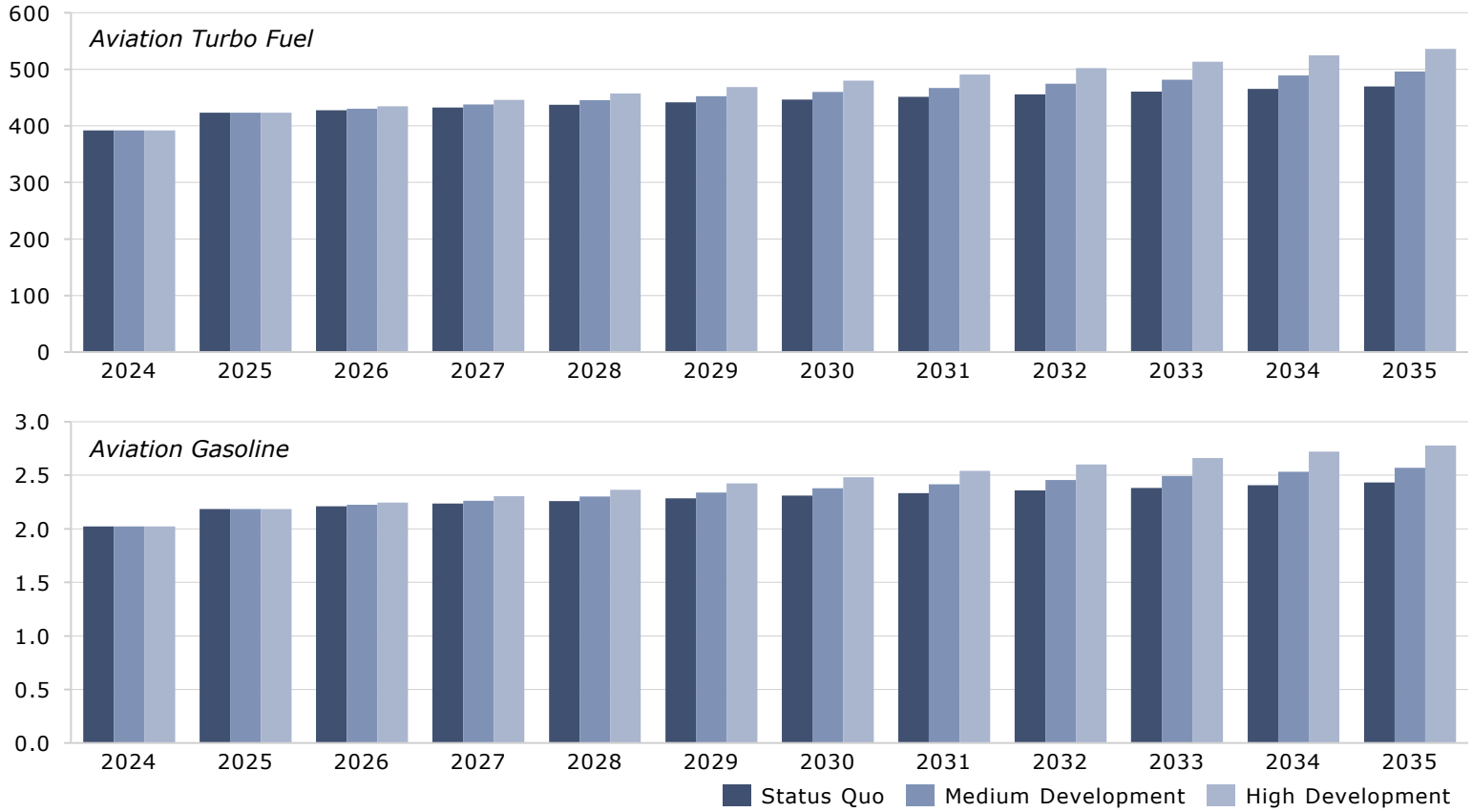
Sources: Transport Canada, Aviation Climate Action Plan (2022); AFRY survey responses

FUEL PROJECTION METHODOLOGY

- AFRY used a combination of publicly available historical data, industry participant survey responses, and industry and government reports, and data provided by the Airport of Thunder Bay to create a three scenarios for fuel needs for the mining sector
  - The study period for AFRY's fuel projections for the forestry industry extends until 2035
- Projections provided should be considered high-level
- Due to the lack of fuel needs at the Port of Thunder Bay, AFRY projections for the transport sector are limited to the aviation industry
- AFRY projections only consider fuel usage for airplanes and neglect fuel needs for operations at the airport
- Other assumptions include:
  - AFRY assumes there will not be a mandatory SAF goal set during the study period due to the nascent stage of regulation setting, the need for Canadian airlines to remain competitive on the global stage, and the expected higher cost of such biofuels

The need for aviation fuels is projected to grow moderately due to an anticipated increase in domestic passengers and freight needs

FUEL DEMAND IN NORTHWEST ONTARIO - AVIATION (MILLIONS OF LITERS)[1]



CASE DESCRIPTIONS

STATUS QUO

Domestic air passengers are expected to increase by 1.7% between current 2024 values and the end of the study period, while freight needs remain constant

MEDIUM DEVELOPMENT

Domestic air passengers are expected to increase by 2.2% between current 2024 values and the end of the study period, and freight needs grow by 2.5%

HIGH DEVELOPMENT

Domestic air passengers are expected to increase by 2.9% between current 2024 values and the end of the study period, and freight needs grow by 5%

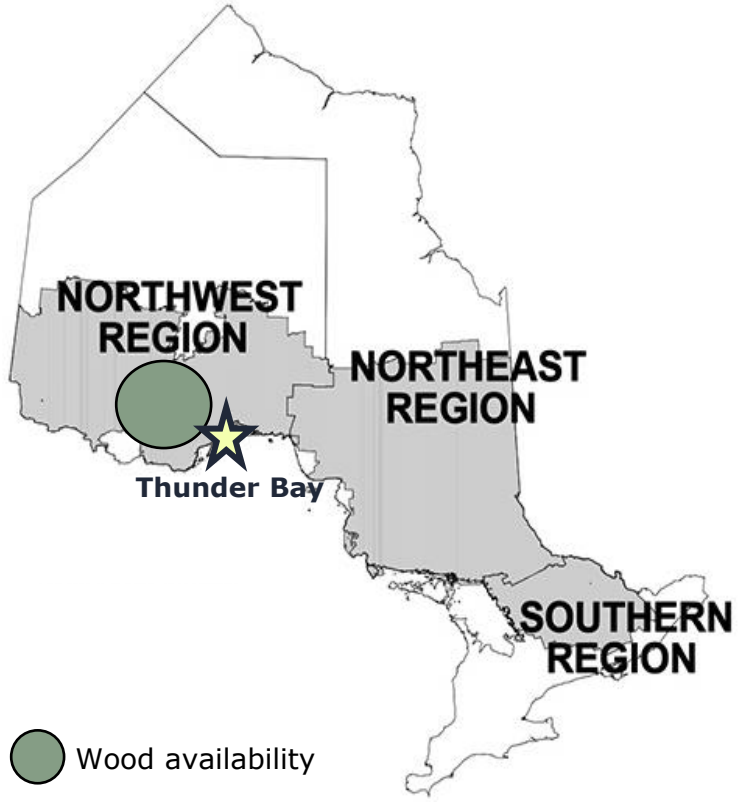
1. Biofuels usage expected in the sector has not been mandated yet, and is therefore not considered | Sources: Statistics Canada, Aircraft movements (2022); Thunder Bay International Airport; AFRY survey responses

Based on earlier analysis, there is ~ 3 million GMT of woody residuals available in the region to be used as feedstock for advanced biofuel production

COMMENTS

- A large share of Ontario's permitted forest harvest offers a readily available, sustainable source of feedstocks suitable for biofuel production
- Unmarketable wood—trees or tree parts that are not economically feasible to harvest—constitutes an untapped resource with significant potential
- In Ontario, around 8 million GMT of residual materials are accessible for use as feedstock in advanced biofuel manufacturing
- Approximately **3 million GMT** of unmarketable residuals are available in the Northwest region
- The majority of this immediate and usable feedstock comes from sawmill residuals and fully utilized slash
  - Nevertheless, challenges remain with transport infrastructure and legislated eligibility pathways

ONTARIO HARVESTING RESIDUES SUPPLY BY REGIONS



Note: Refer to the CRIBE Wood Biofuel Roadmap in Ontario report (2025)

AFRY

Based on earlier analysis three production pathways were selected for biofuel due to their promising integration possibilities and/or economics of scale

	HYDROLYSIS & FERMENTATION	CATALYTIC PYROLYSIS	GASIFICATION & FT SYNTHESIS
Assessed product	**Ethanol**	**Bio-crude (aka bio-oil)**	Drop-in fuels
Suitable feedstock	? ✓	✓	✓
Technology readiness	TRL 4-8	TRL 8-9	TRL 7-8
Fuel upgrade possibilities	Alcohol to Jet	Drop-in fuels	Not applicable
Product Yield (Mass/Energy)	21% / 32%	24% / 56%	20%/ 44%
Typical plant size *(biomass input/product output)*	250 kt (dry) / 50–75 ML	130–250 kt (dry) / 50–100 ML	800–1,200 kt (dry) / 80–280 ML
CAPEX, MCAD *(CAPEX for typical plant size)*	500–600	350–550[1]	1,600–2,700
By-products	Lignin, Methane, CO_2	Biochar	Biochar

Lower CAPEX costs and higher level of technology readiness makes catalytic pyrolysis the ideal production pathway

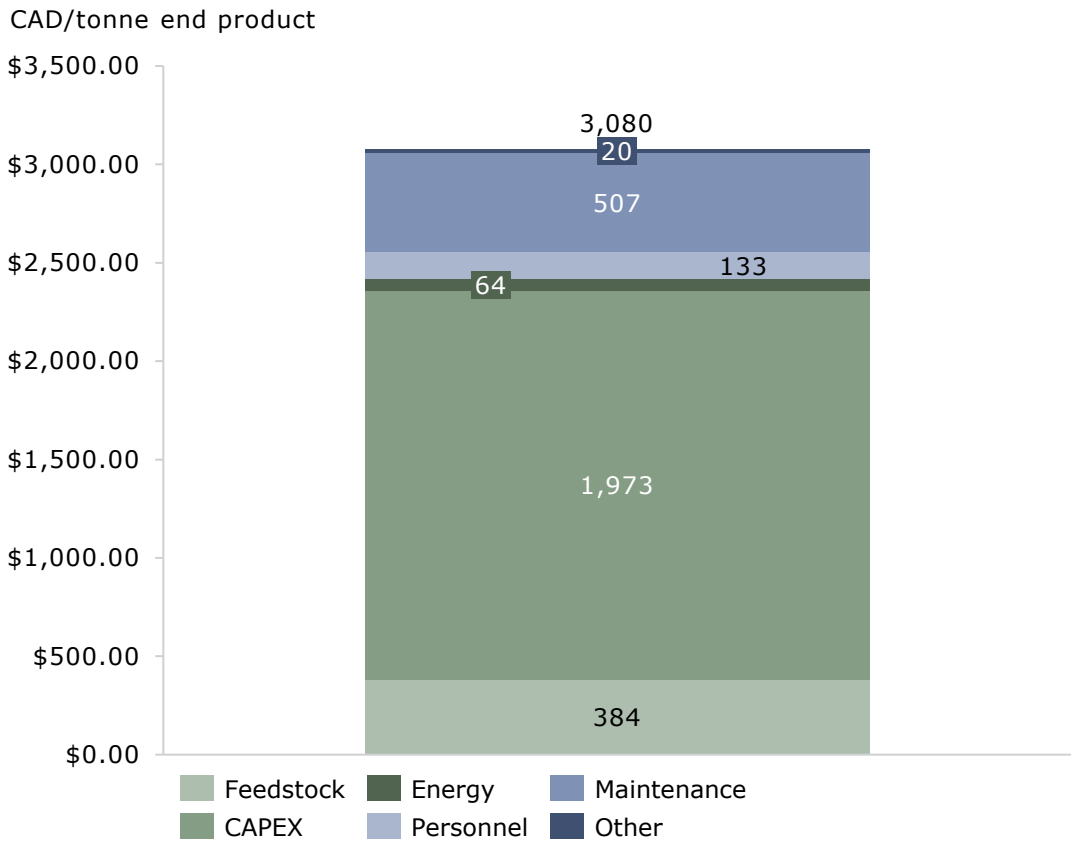
✓ Proven suitability for softwood ✗ Proven unsuitability for softwood ? Theoretically suitable for softwood but lack of operational examples

1. CAPEX corresponding to bio-crude production only; additional CAPEX for up-grading to fuels: 800–1,050 MCAD.

AFRY

Catalytic pyrolysis is one of the top three technologies, costing around 3000 CAD/t, plus additional upgrading to meet transport fuel standards

CATALYTIC PYROLYSIS PLANT



COMMENTS

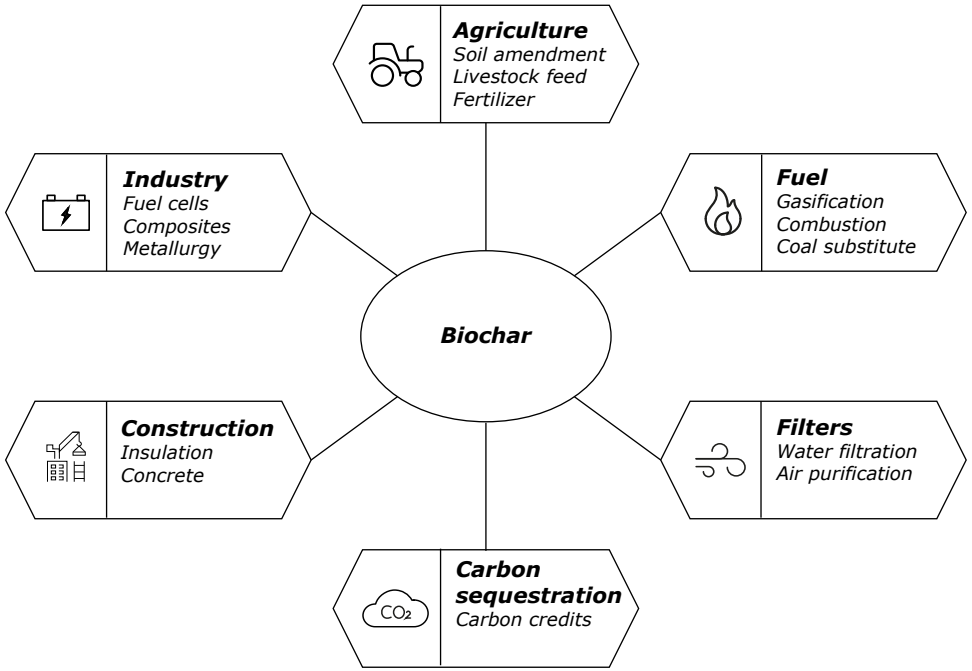
- The approximately 3 million GMT of woody biomass residuals available in the Thunder Bay region could be converted into up to roughly **1 billion liters of renewable liquid fuel** through a catalytic pyrolysis pathway at an assumed 25% mass yield, producing biochar and a syngas-rich non-condensable gas stream as co-products
- However, advanced biofuels from wood-based feedstocks are currently uncompetitive on a cost-basis mainly due to high CAPEX
- Total CAPEX cost can be reduced up to 40–50% in catalytic pyrolysis if the upgrading step[1] to final fuel in downstream is removed from the concept
- Grants and tax incentives could help bridge the cost gap as advanced biofuel refineries scale up in the future
- There is potential to decrease CAPEX costs through the colocation of a biofuels production facility with existing pulp mills

1. Upgrading downstream includes deoxygenation and hydrogenation

AFRY

Biochar has a range of applications, most of which require activation to enhance specific biochar properties

OPPORTUNITIES UTILIZING BIOCHAR AS A BY-PRODUCT

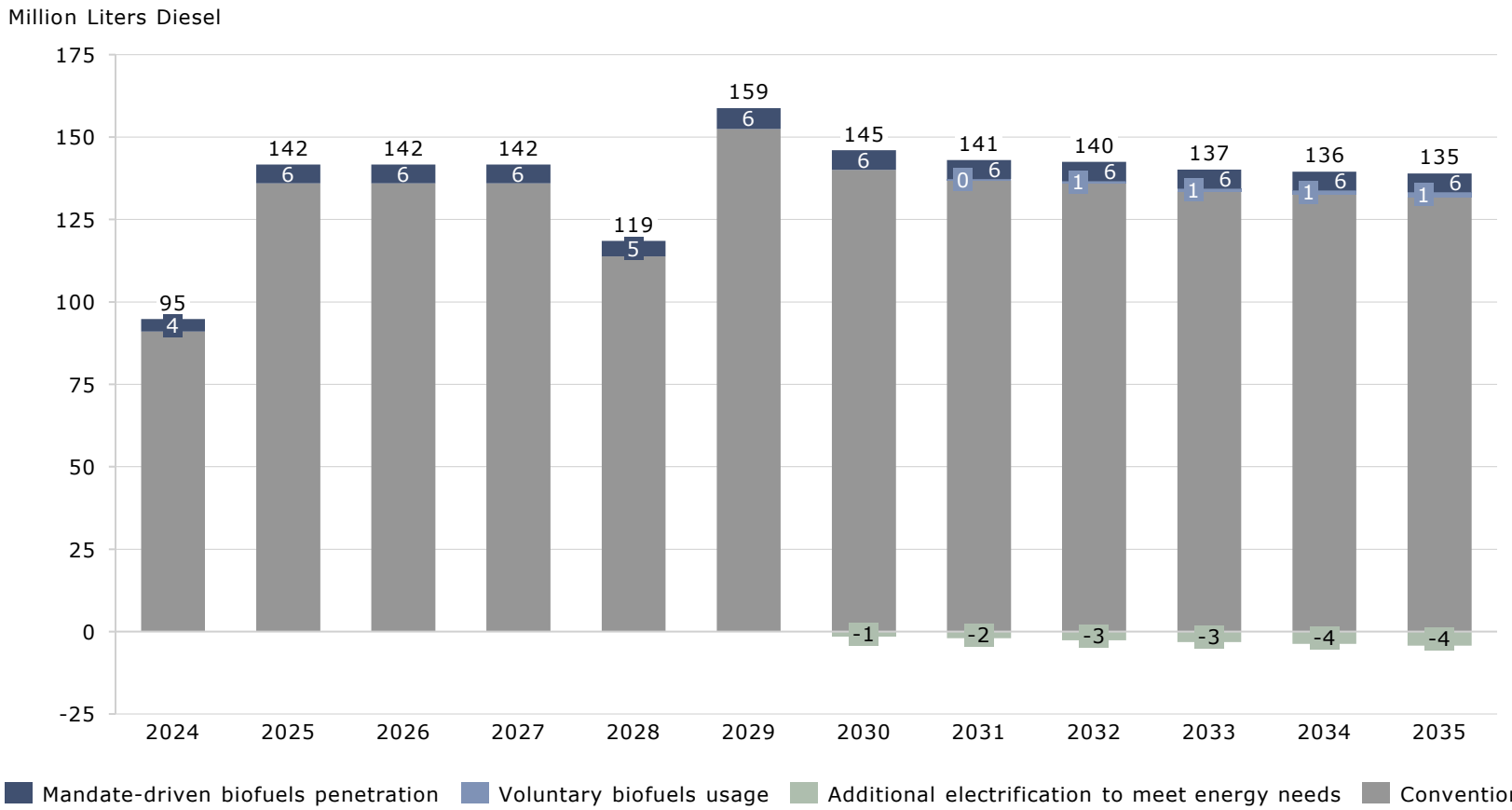


- Biochar is an unavoidable by-product from pyrolysis, which can be utilized for several applications
- Applications for biochar include:
  - Biochar improve soil health and sequester carbon from atmosphere
  - Biochar applications at industry include air/water filters, composites, reduction agents in steel and silicon production, and substitute for concrete
  - Biochar pellets and briquettes have great energy-density for industrial or residential heating, and they can replace the fossil-based coal
  - Biochar can be used as a livestock bedding and food supplement for animals
- Required post-treatment:
  - Refinery grade biochar can be mainly used only for soil improvement and heating applications
  - Specific applications require improved biochar features, such as high porosity and high surface area. These key feature can be improved by activating carbon with oxidizing gases at high temperature

AFRY

AFRY estimates that biofuels penetration in the mining sector will reach 5% by 2035; though, risks to this include unfavorable pricing and electrification

BIOFUELS PENETRATION FOR MINING



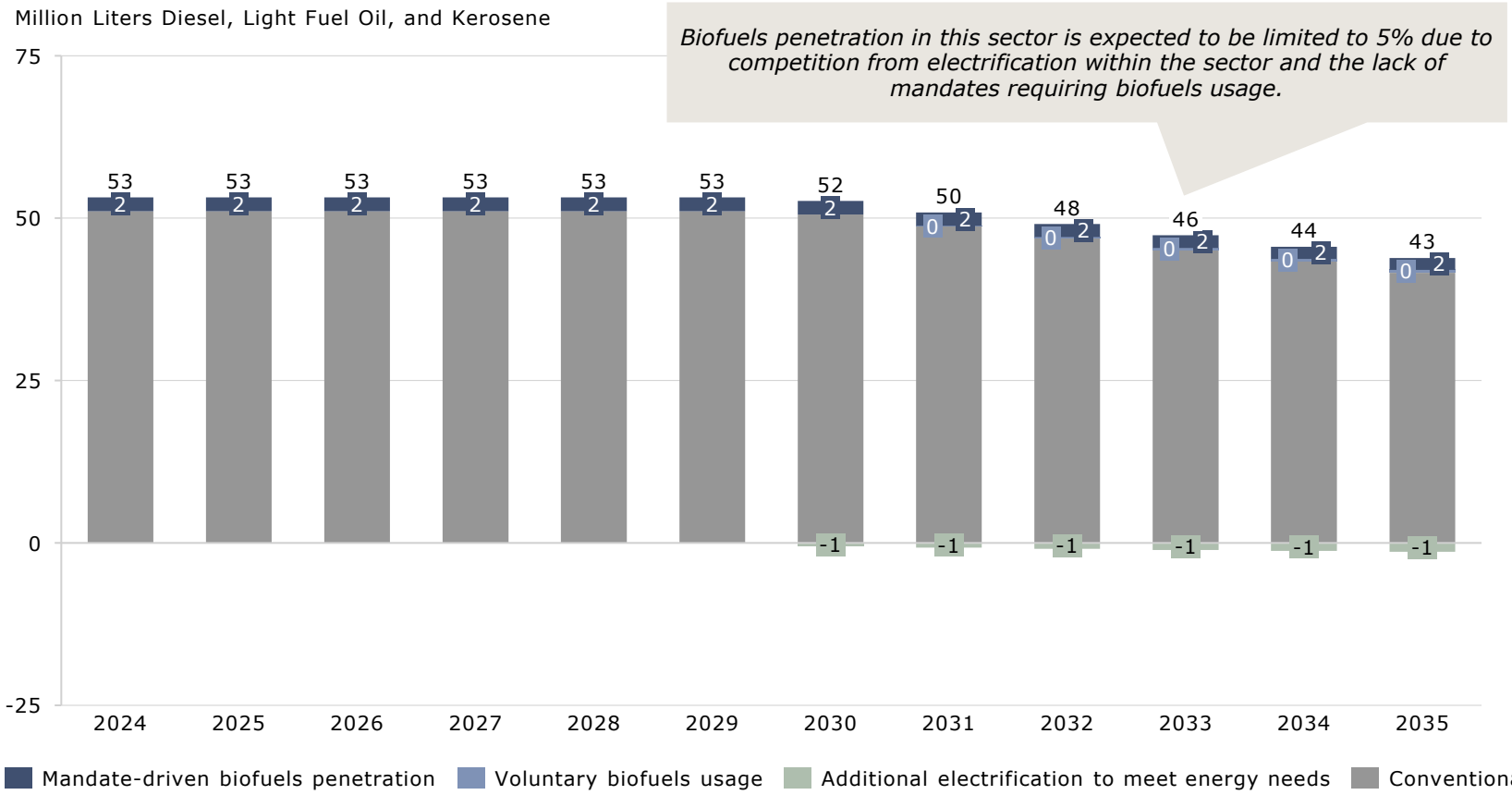
MINING

- Modelling of potential biofuels penetration during the study period only considers the Status Quo case; there is potential for greater biofuels penetration based on Medium and High Development cases
- Reduction of CAPEX for a biofuels facility will create a more affordable landscape and encourage adoption
- Biofuels penetration for mining fuels will reach 5% by 2035
- Mandate-driven penetration will remain at 4% due to the current standards.
- Companies may buy small quantities of biofuels voluntarily as favorable policies reducing cost for consumers are passed.
- Some electrification will require less procurement of fuels for mining, overall reducing total 2035 fuel needs to 135 million liters diesel

Sources: AFRY survey responses; AFRY Management Consulting

The forestry sector, though on the decline, may reach 5% biofuel penetration by 2035; though fuel pricing and electrification rates must be considered

BIOFUELS PENETRATION FOR FORESTRY



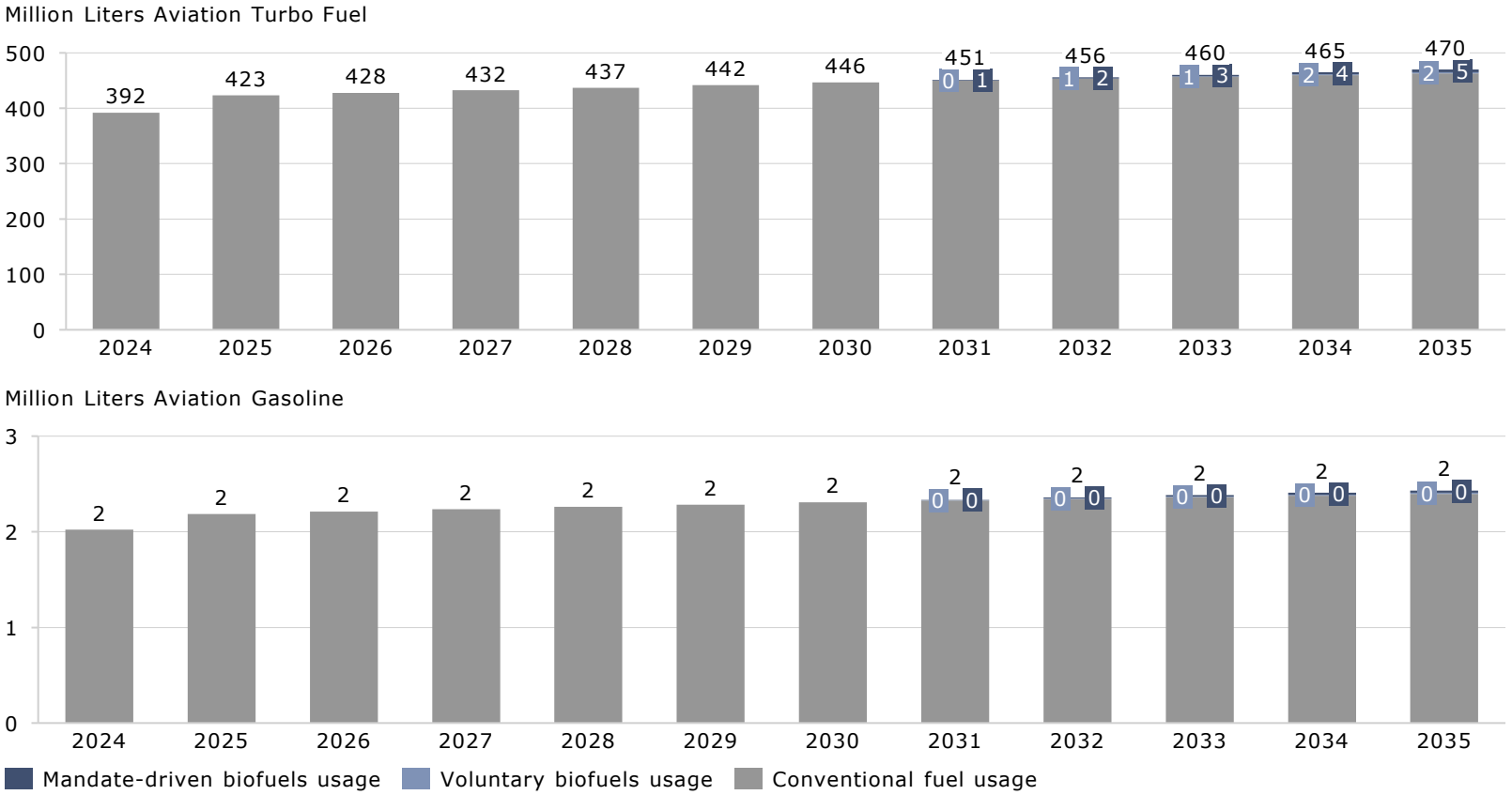
FORESTRY

- Modelling of potential biofuels penetration during the study period only considers the Status Quo case; there is potential for greater biofuels penetration based on Medium and High Development cases
- Retraction of the forestry industry can be contained if new end-users are found for forest products (i.e., for biofuel production)
- Biofuels penetration will reach 5% by 2035.
- Mandate-driven penetration will remain at 4% due to the current standards
- Companies may begin purchasing small quantities of biofuels voluntarily as prices reduce due to increased production and supportive policies after 2030
- Some electrification will require less procurement of fuels for forestry, overall reducing total 2035 fuel needs to 43 million liters diesel, light fuel oil, and kerosene

Sources: AFRY survey responses; AFRY Management Consulting

Aviation transport could reach 1.5% biofuels penetration by 2035; though, policy mandates for SAF usage are necessary to aid adoption

BIOFUELS PENETRATION FOR AVIATION TRANSPORT



AVIATION TRANSPORT

- Modelling of potential biofuels penetration during the study period only considers the Status Quo case; there is potential for greater biofuels penetration based on Medium and High Development cases
- Biofuels penetration will reach 1.5% by 2035, though an upside case exists if wood-to-fuel pathways are certified and tied to fuel usage mandates
- Though there is a voluntary goal for 10% SAF usage by 2030 through Canada's Aviation Climate Action Plan (2022), there is no mandate yet.
- AFRY has assumed a 1% adoption of SAF by 2035 to begin in 2030 as aviation companies begin to voluntarily purchase small quantities of SAF
- Even if mandates for SAF begin after 2030, certified pathways for woody biomass to SAF do not exist yet
- Electrification of significant aviation fleets is not likely to occur before 2035.

Sources: AFRY survey responses; AFRY Management Consulting

Kickstarting biofuels production is capital-intensive and requires industry player buy-in, strong regulatory support, and a robust supply chain

RISKS FOR BIOFUEL ADOPTION

- The Northwest region has sufficient woody biomass to produce renewable fuels in volumes exceeding current demand. While the technology is proven, biofuel production remains capital-intensive and will require strong policy support and commitment from fuel users to increase market penetration and meet a larger share of Ontario's fuel demand by 2035
- Adoption risk is a key challenge, as achieving higher biofuel use depends on consumer and industry willingness, blending mandates, and infrastructure readiness
- Scaling production will also necessitate measures to reduce costs, such as targeted tax incentives, grants, or other financial support mechanisms to make biofuel economically competitive

PRICE VOLATILITY OF BIOFUELS

- Many survey participants submitted responses noting that, though they felt open to switching to biofuels, the potentially higher cost of the fuel would prohibit them from moving forward
- A lack of consistent or predictable pricing will also negatively impact biofuel producers' ability to scale production

CHANGE IN POLICY

- To properly incentivize this transition, there must be adequate policies in place which make it easier for heavy industry to make the switch from conventional fuels to biofuels, which is not a 1:1 change
- These policy supports including assisting with a rapid and convenient permitting process, subsidizing production costs, tax incentives for industry participants that purchase

AVAILABILITY OF WOODY BIOMASS

- However, limited or inconvenient access to woody biomass poses a risk to consistent production of biofuels
- Issues with transport logistics, labor shortages, inclement weather poses a threat to the utilization of Ontario's abundant supply of woody biomass

HIGH CAPEX

- The development of a biofuels production facility will require significant capital investments
- There is potential to reduce the CAPEX cost through colocation of the biofuel production facility with existing wood manufacturing facilities due to existing infrastructure and assets that can be repurposed

AFRY

Biofuel production from woody biomass in Northwest Ontario offers benefits: job creation, improved energy security, and diversified revenue stream

RISK MITIGATION AND OPPORTUNITIES

- Biofuel production risks—such as price volatility, policy changes, high capital costs, and feedstock logistics—can be mitigated through long-term offtake and biomass contracts, modular project design, diversified revenue streams (fuel, biochar, carbon credits), and co-location near feedstock sources
- As the forestry industry retracts, more biomass becomes available for use in biofuels production, though feedstock eligibility criteria must be defined
- Beyond risk management, biofuel development offers significant economic opportunities, including the creation of skilled, local employment across feedstock collection, logistics, and plant operations, as well as the stimulation of regional economic growth
- It also enhances energy security by producing domestic renewable fuels for Ontario. Additionally, biofuel facilities can generate value from co-products such as biochar and process gases, contribute to carbon reduction and broader climate goals, and serve as anchor assets within emerging low-carbon industrial clusters

EXISTING GOVERNMENT SUPPORT

- Though policy supporting a fuel switch to biofuels has not yet been passed, the Forestry Ministry of Ontario is interested in promoting such a transition and is looking to work with industry participants to promote investment into diversification of technologies

PARTICIPATION IN THE BIOCHAR MARKET

- Biochar is an inevitable by-product of pyrolysis which has a variety of uses for the construction, agriculture, and metallurgy sectors
- The additional cost associated with producing biofuels could be recuperated through the sale of the by-product biochar
- Recently, there have been many developments on biochar carbon sequestration opportunities including Microsoft deal with Exmond

COLOCATING AT EXISITING MILLS AND USE OF REFINERIES IN SOUTHERN ONTARIO FOR PRODUCTION

- A key strategy involves retrofitting legacy pulp mill and refinery assets to integrate biorefineries, leveraging their skilled workforce, supply chains, and existing conversion facilities to produce biofuels
- Proximity to Southern Ontario’s existing refinery infrastructure and evolving regulatory landscape, as well as the Thunder Bay Port Authority offers avenues to sell excess biocrude and bionaphtha produced.

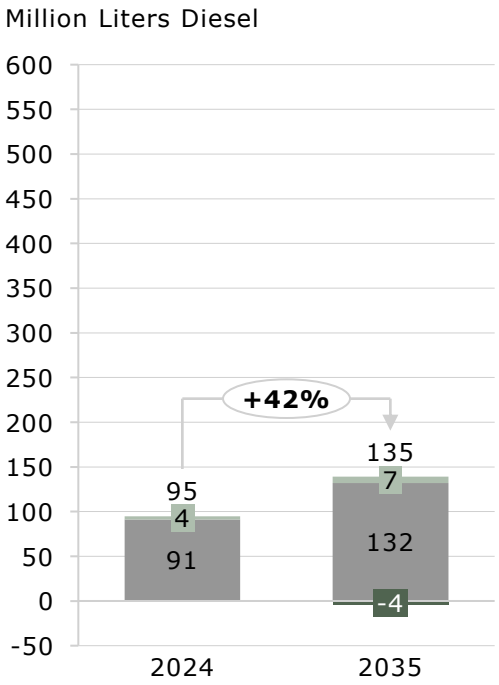
JOB CREATION AND ENERGY SECURITY

- Biofuel development in Ontario, particularly in the Thunder Bay region, presents significant opportunities for local job creation across biomass collection, logistics, and plant operations
- By producing domestic renewable fuels, these projects can enhance regional energy security and reduce reliance on imported fossil fuels, while supporting the growth of a low-carbon industrial cluster in Northern Ontario

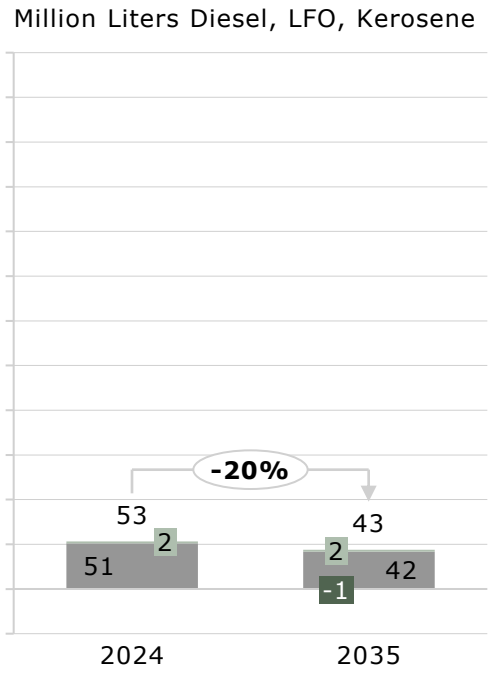
AFRY

Total increasing fuel needs paired with a rise in underutilized woody biomass creates an opportunity for biofuels production in Northwest Ontario

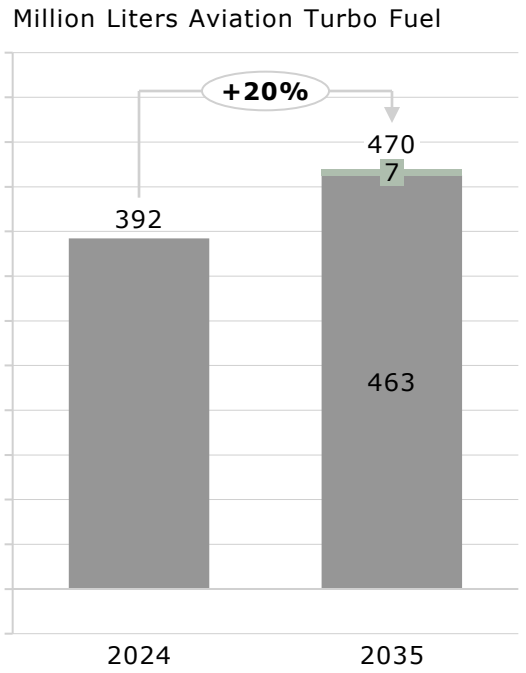
MINING FUEL NEEDS

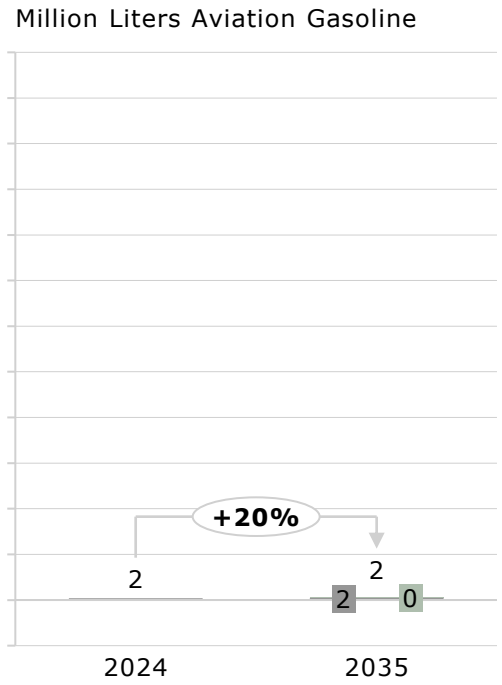


FORESTRY FUEL NEEDS



AVIATION FUEL NEEDS





Based on the Status Quo case, mining diesel needs grow by 42%, aviation turbo fuel needs grow by 20%, and forestry fuel needs shrink by 20% between 2024 and 2035.

AFRY

There are several factors to consider for a business case for a biofuels production facility in Thunder Bay

Available, affordable, and eligible biomass	✓?	Though there is approximately ~3 million GMT of woody biomass available in Northwest Ontario, it is unclear what percentage of this biomass would be eligible for biofuels production and what the cost would be to transport the biomass to biofuels production facilities
Project costs	?	Project costs for biofuels production facilities are high, though avenues exist to reduce CAPEX costs by 40-50%; still, additional regulatory support from the provincial government will be necessary to further reduce costs to make the biofuel end-product competitive in the market
Market validation	✓	There is a clear and strong demand for fuel, especially among heavy industry sectors
Bankable offtake agreements	?	The development of bankable offtake will require clear CI pathways and regulatory support to reach an affordable price point
Availability of needed technology and infrastructure	✓	Multiple technology pathways exist; One pathway for production of biofuels in Northwestern Ontario is catalytic pyrolysis; Assets and infrastructure already exist within the region, though some modernization may be needed
Community and indigenous partnerships	✓	Based on surveys issued by AFRY, all industry participants are open and ready to collaborate with indigenous and local communities

Additional regulatory support from the provincial level is needed for wood-to-fuel pathway certification and financial incentives.

✓ Strong case ? Additional investigation required

AFRY

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Making Future