

The Transition
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Canada's Opportunity Playbook:
Pathways to Strategic Decarbonization

ENERGY CARRIERS

Alternative Fuels

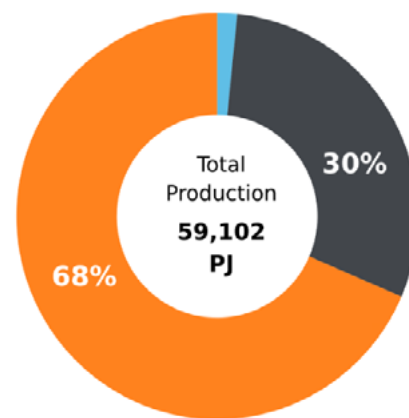


7.3 ALTERNATIVE FUELS

Function	Low-carbon substitutes for conventional fossil fuels ideal for hard-to-abate sectors (aviation, heavy freight, and industrial applications). Alternative fuels include blended fuels that require mixing with conventional fuels at specific ratios and drop-in fuels that can directly replace petroleum fuels without engine or infrastructure modifications.
GHG emissions	Production of alternative fuels currently contributes relatively small greenhouse gas emissions with no formal, comprehensive system to track these emissions separately. Canada's National Inventory Report appears to under-represent the growth of clean fuels mandated under federal regulations, with recent analysis suggesting renewable fuel consumption is undercounted by a factor of more than two at the national level compared with compliance-program data.
Options for decarbonization	Decarbonization Pathways: Sustainable Aviation Fuel (SAF). Niche Pathways: Hydroprocessed Esters and Fatty Acids (HEFA) SAF, renewable diesel, renewable natural gas (RNG), advanced biofuel, bio-synthetic and synthetic fuels (e-fuels). Dead-End Pathways: Biodiesel, ethanol (as transport fuels).
Stage of transition	Mature: Biodiesel, ethanol. Emergence: Renewable diesel, sustainable aviation fuel, renewable natural gas. Early emergence (R&D): Synthetic e-fuels
Nature of the problem today	Limited domestic production of biofuels, feedstock constraints, and higher production costs compared to fossil fuels.
Other systemic issues	Sustainability and land-use concerns, dependence on imports, infrastructure limitations, and competition with electrification strategies.
Strategic opportunities and concerns	Canada has abundant biomass resources, renewable electricity, and innovation capacity, but faces competition from international incentives and sustainability challenges.
Priorities for action	Scale domestic advanced biofuel production for selected applications, strengthen policy mandates, ensure sustainable feedstock, support infrastructure upgrades, and incentivize innovation.
Longer-term issues	Long-term feedstock and technology constraints require balancing hydroprocessed esters and fatty acids deployment with scaling advanced residue-based biofuels, while carefully assessing the role of higher-cost synthetic e-fuels (likely focused on export) and coordinating this transition with the managed decline of fossil fuel infrastructure and evolving global market conditions
Indicators of progress	Blending rates, production capacity, greenhouse gas intensity, sustainability metrics, market signals, and investment/cost trends.

7.3.1 Current Status

Canada's alternative fuels encompass several non-fossil energy carriers that can be used in place of conventional petroleum fuels and natural gas, including bio-based liquids (ethanol, biodiesel, renewable diesel, biocrude oils), synthetic liquids (power-to-liquid e-fuels), renewable gaseous fuels like biomethane/RNG, and others. Renewable propane, produced from non-fossil feedstocks and commonly emerging as a byproduct of renewable diesel and sustainable aviation fuel refining, is also beginning to enter the Canadian market as a low-carbon drop-in fuel.[159]¹ Deploying these fuels is a strategy to cut emissions in sectors that cannot be easily electrified. Transportation is a prime example with an estimated contribution of 22% of Canada's GHG emissions.[160] While electrification will reduce emissions from light- and medium-duty vehicles, many heavier or long-range transport applications and some industrial heating will likely continue to need high-density liquid or some form of gaseous fuel. Alternative fuels offer a way to decarbonize these fuel demands through drop-in low-carbon alternatives with lower lifecycle carbon intensities.



■ Biodiesel & Renewable Diesel
 ■ Ethanol
 ■ Other alternative fuels (1.6%)

Figure 15. Canada, Alternative fuel production (2023)

Source: Statistics Canada, 2025. Renewable fuel plant statistics, supply and disposition, monthly.[161]

Source: Natural Resources Canada, 2025. Energy Fact Book 2025-26.[162]

Energy density of "Other alternative fuels" was assumed to be 36.67 MJ/L, an average of fossil diesel and gasoline. In 2023, all co-processed fuels were produced in Burnaby refinery and Tidewater Renewables and were primarily a blend of gasoline or diesel.

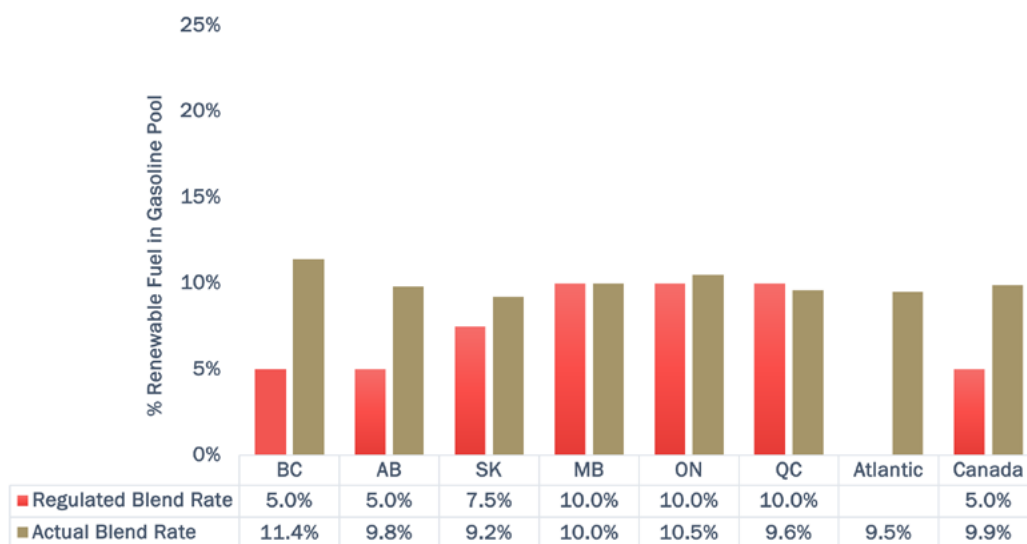


Figure 16. Renewable fuel content in gasoline by province (2024)

Source: Advanced Biofuels Canada & Navius Research, 2025[163]

¹ All noted references can be found in the full Playbook document.

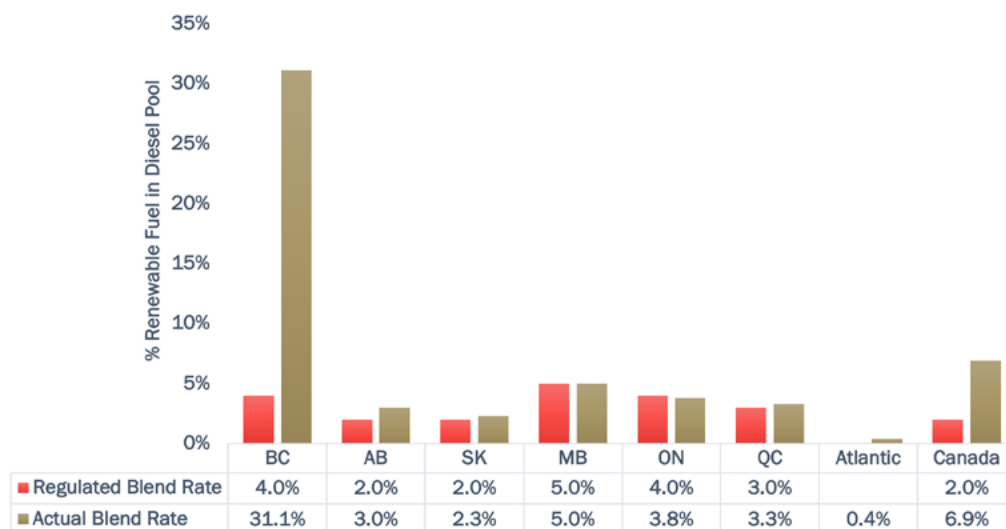


Figure 17. Renewable fuel content in diesel by province (2024)

Source: Advanced Biofuels Canada & Navius Research, 2025[163]

7.3.2 Nature of the Problem

Ethanol

Ethanol represents Canada's most established alternative fuel, with a history of blending into gasoline dating back decades. Federal renewable fuel regulations have set baseline requirements of 5% ethanol in gasoline, while several provinces have mandated their own standards—Ontario and Manitoba require 10% ethanol, Saskatchewan 7.5%, and all provinces have met or exceeded their standards.[160,164] In 2023, ethanol consumption reached four billion litres, representing 9.44% of the gasoline pool, while production of 1,756 ML fell short of domestic demand of 4,072 ML in 2024 (Figure 18).

Despite its maturity, the niche for ethanol is increasingly narrow. While ethanol can reduce emissions, demonstrating 55% lower carbon emissions than gasoline in 2023 (or about 5% emissions reduction for a 10% ethanol/90% gasoline blend), its application faces fundamental limitations that make it unsuitable as a long-term solution for achieving net zero. [163] Ethanol suffers from inherent technical constraints, including higher oxygen content, corrosivity, and lower energy density, that prevent it from being transported in existing

pipelines and limit conventional vehicles to blend levels of 10–20%.[165] Higher blends like E85 require flex-fuel vehicles and dedicated fuelling infrastructure, which are costly and limited in Canada.

More critically, ethanol's reliance on food-grade commodities raises sustainability concerns and intensifies the food versus fuel debate. Currently, approximately 400,000 tonnes of corn and wheat are used monthly for ethanol production, creating direct competition with food supply and contributing to potential land-use changes that can result in higher emissions than fossil fuels.[166]

For light-duty vehicles specifically, ethanol presents a dead-end pathway. As electrification becomes more viable for passenger cars and light trucks, ethanol makes an increasingly poor investment compared to BEV infrastructure. The modest but persistent 3% energy loss in E10 blends, infrastructure and blend-wall limitations that prevent higher concentrations, together with competition from other uses for bio-based feedstocks positions ethanol as fundamentally incompatible with deep decarbonization goals for LDVs.[167]

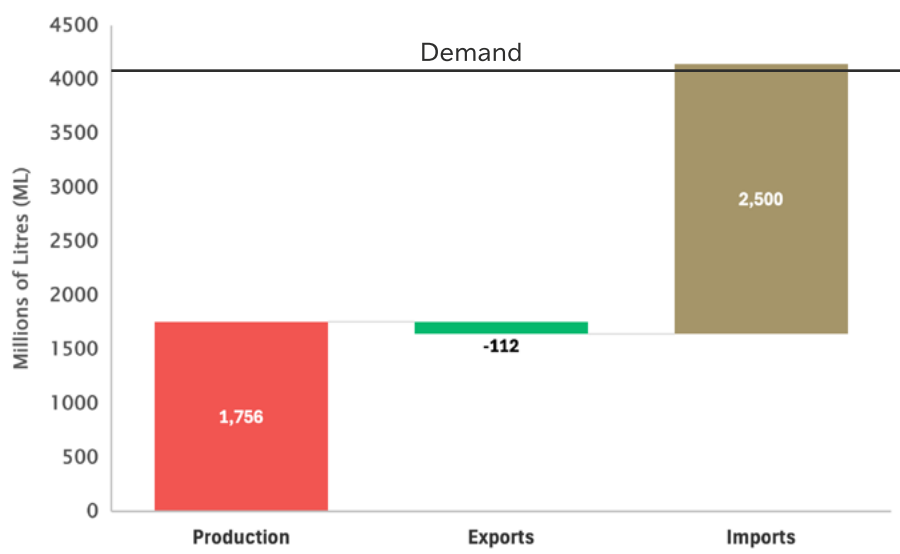


Figure 18. Canada's ethanol supply balance, 2024: Domestic production, trade, and total demand (ML)

Source: NRCan, 2024. Energy Fact Book 2025-26.[162]

Biodiesel and Renewable Diesel

Biodiesel and renewable diesel present a more promising pathway than ethanol, though they carry their own challenges and occupy different market niches. Canada's production of biodiesel and renewable diesel totalled 1,119 ML in 2024, while demand reached 1,005 ML, the first time Canada has filled the substantial supply gap previously filled by imports primarily from the U.S (Figure 19). Renewable diesel consumption more than doubled to 1.2 billion litres in 2023 relative to previous years—surpassing biodiesel for the first time in 2019—and was 2.2 times greater than biodiesel consumption (530 ML, up 14%).[163] Renewable diesel's compatibility with existing diesel infrastructure gives it a logistical advantage. Biodiesel and renewable diesel differ fundamentally in their production processes. Biodiesel is produced through transesterification of vegetable oils and fats, creating a blend-limited product (typically 5–20% with petroleum diesel), while renewable diesel undergoes hydrotreating to become almost chemically identical to conventional petroleum diesel, enabling 100% replacement without blend limits. Although renewable diesel's additional processing can

result in a higher carbon intensity than biodiesel, the chemical similarity of renewable diesel to conventional diesel provides better cold-flow properties and storage stability, enabling higher deployment volumes. The unrestricted blend limits allow renewable diesel to be deployed to meet overall carbon-intensity requirements set by the Canadian Clean Fuel Standard (CFS).

The niche for these fuels lies primarily in heavy-duty applications where their high energy density and compatibility with existing diesel infrastructure provide current advantages over electrification. In 2023, biomass-based diesel demonstrated 87% lower lifecycle carbon intensity than conventional diesel, making it valuable to sectors like long-haul trucking, marine shipping, and industrial heating where today battery electric alternatives remain technically and/or economically challenging.[163]

However, significant obstacles constrain their expansion. Biodiesel faces poor cold-weather performance challenges—blends above 5% have shown persistent gelling unless treated for cold flow and can cause engine challenges

unless properly tuned. Feedstock constraints represent another limitation with volatile prices and competition between food and fuel leading to price instability. Renewable diesel offers better characteristics compared to biodiesel by eliminating cold-weather and engine compatibility problems, but Canada's first standalone renewable diesel facility, owned by Tidewater Midstream, has encountered difficulties. While renewable diesel can be produced from various feedstocks, Tidewater relies on canola oil, tallow from meat processing, and tall oil from pulp and paper production—feedstocks chosen to leverage Canada's agricultural and forestry byproduct streams. But their limited availability constrains overall production capacity and increases processing costs. A second Canadian facility, Braya Renewable

Fuels in Come by Chance, Newfoundland and Labrador, was forced to shut down in January 2025 citing inability to compete with U.S. production tax credits and loss of blender's tax credits, but has since reopened under improved market conditions.[168] Meanwhile, provincial policy is tightening with B.C.'s updated LCFS now requiring renewable diesel and biodiesel be produced in Canada as of April 2025, with a similar requirement for ethanol as of January 2026.[169] At the same time, Imperial Oil's Strathcona Renewable Diesel facility in Alberta is now online and expected to produce up to 1 billion litres per year at full capacity, making it the largest renewable diesel facility in Canada and a major new source of low-carbon diesel for western Canadian markets.

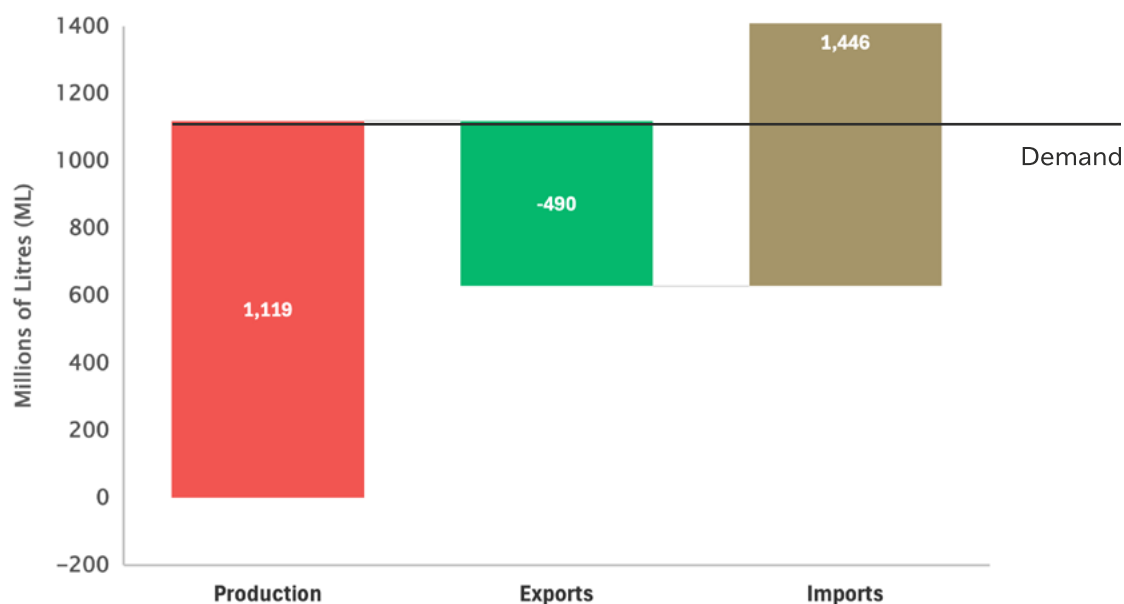


Figure 19. Production, imports, exports, and total demand of biodiesel and renewable diesel, Canada, 2024
 Source: NRCan, 2024. Energy Fact Book 2025-26.[162]

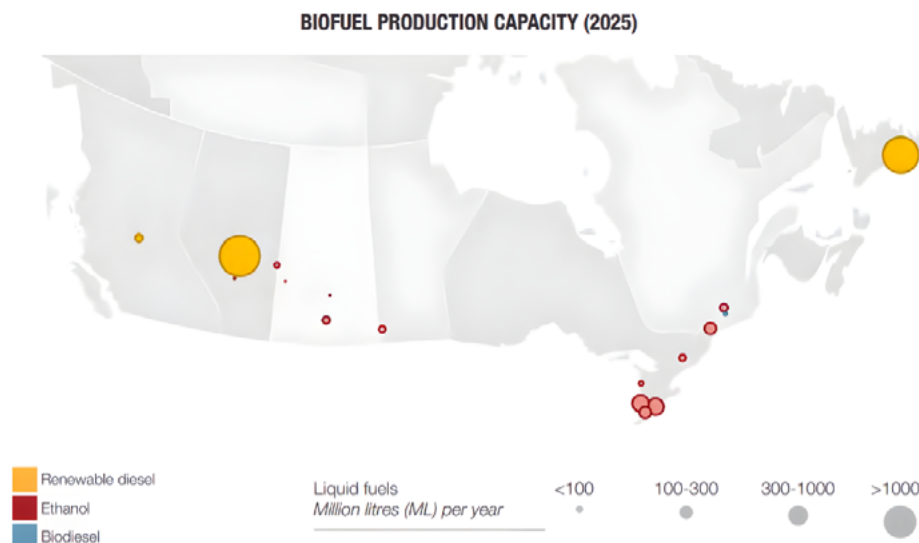


Figure 20. Biofuels production facilities and capacities in Canada, 2025

Source: NRCan, 2024. *Energy Fact Book 2025-26*. [162]

Sustainable Aviation Fuels (SAF)

Sustainable aviation fuels represent the most critical alternative fuel for achieving net-zero emissions given aviation's unique requirements.

The niche for SAF is clear: commercial aviation currently has no reasonable alternative for long-haul flights. Unlike light-duty transport, which can transition to electrification, or short-haul shipping, which may use hydrogen, aviation's energy density requirements and safety considerations make liquid fuels indispensable for the foreseeable future.

However, SAF faces economic and production constraints. SAF is in the emerging phase of transition with current production representing less than 1% of aviation fuel demand globally and remaining virtually absent commercially in Canada, where volumes are still limited to imported SAF and pilot-scale projects and assessments. [170,171] Air Canada's recent purchase of approximately 78 million litres of unblended SAF from Neste constitutes the airline's first commercial import of SAF into Canada and highlights the country's current reliance on overseas production. [172] Economic barriers are also

present with costs two to seven times more than conventional jet fuel. [171]

Most SAF today relies on the Hydroprocessed Esters and Fatty Acids (HEFA) process, accounting for 86% of global SAF production. [171] HEFA draws on waste oils, animal fats, and used cooking oil, as well as virgin vegetable oils — principally canola in the Canadian context — the same feedstocks competing with biodiesel and renewable diesel production. [173] Concerns about indirect land-use change have historically weighed on the carbon credentials of crop-oil HEFA, but emerging evidence suggests those impacts may be overstated for Canadian canola with a stable cropland base. Additionally, Canadian canola is already exported for overseas crushing — so redirecting supply to domestic fuel production largely replaces an existing commodity flow rather than creating new demand. Even with a more favourable outlook, sustainable feedstock supply limits HEFA to a minority of Canadian SAF demand, positioning it as a viable near-term niche pathway within its feedstock scope rather than a full-system solution. As SAF demand scales toward the estimated 24 million tonnes (30 billion litres)

globally required by 2030, feedstock availability will become further constrained,[174] making Fischer-Tropsch routes based on residues and waste—covered below under Advanced Biofuels—essential to meet the balance of aviation fuel demand.

Canada's SAF ecosystem is at an early but pivotal stage. According to a roadmap produced by the Canadian Council for Sustainable Aviation Fuels (C-SAF), the Transition Accelerator, and the Energy Futures Lab, Canada could produce up to 1.2 billion litres annually by 2030, meeting the 10% target.[175] However, unlocking this potential requires mobilizing sustainable feedstocks, investing in at least 10 commercial-scale plants, and putting in place strong policy incentives and offtake agreements.

In Europe, regulatory measures are driving uptake with the EU's ReFuelEU Aviation regulation legally mandating escalation of SAF and e-SAF (synthetic aviation fuel produced from renewable electricity and captured CO₂) shares in fuel pools through 2050. Canada, as a participant in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), is pursuing a federal target of 10% SAF in domestic jet fuel by 2030, while British Columbia has introduced its own 2030 requirement of 3% SAF and a 10% reduction in carbon intensity.

Renewable Natural Gas (RNG)

RNG is produced by upgrading biogas from organic waste sources—including landfills, wastewater treatment plants, agricultural operations, and municipal solid waste—to pipeline-quality gas with a methane content of 90% or greater.[176]

The niche for RNG lies in applications where existing natural gas infrastructure provides distribution advantages and where direct electrification faces technical or economic barriers. This includes industrial heating

processes and residential heating in regions with established gas networks. RNG can be injected directly into existing natural gas pipelines without infrastructure modifications, making it immediately compatible with current systems. However, RNG remains in early stages of deployment, comprising only 0.36% of gas delivered by Canadian utilities in 2021. Moreover, Canada's full realistic biomethane potential (estimated at 91-160 PJ/year) represents only 2-4% of national gas demand, limiting RNG's role to a supplementary blending strategy.[177] Some provinces are also exploring RNG as a tool for peak demand management. In Quebec, dual-energy heating systems are being deployed to manage winter grid peaks, while gas distributors are being pushed to reduce fossil gas use and increase renewable gas within a broader plan to reach 100% renewable energy in buildings by 2040.[178]

The obstacles to RNG expansion include limited feedstock availability relative to total natural gas demand, collection and processing costs, and competition with direct electrification strategies. Production requires either anaerobic digestion systems for wet organic waste or gasification systems for dry biomass, both requiring significant capital investment. The Canadian gas industry has so far failed to meet its 2016 target of a 5% RNG blend nationally by 2025—national RNG capacity reached only about 17.1 PJ in 2025, against the roughly 184 PJ a 5% blend would require—while British Columbia's CleanBC strategy mandates 15% renewable gas content by 2030.[177,179,180]

Advanced bio- and synthetic fuels

Along with hydrogen (explored in section 7.2), advanced biofuels and synthetic fuels are widely viewed as the main scalable options for decarbonizing sectors that will remain difficult to electrify, particularly long-haul aviation and portions of marine shipping. Both advanced biofuels and synthetic fuels

are designed to produce drop-in, energy-dense fuels compatible with existing aircraft and fuel infrastructure, but they differ fundamentally in their primary inputs and near-term readiness.

Synthetic Fuels (Power-to-Liquids / Power-to-X)

Synthetic fuels (often called e-fuels) are produced by combining electrolytic hydrogen (from water electrolysis powered by low-carbon electricity) with captured CO₂ to synthesize hydrocarbons or other energy carriers through Power-to-Liquids (PtL) or broader Power-to-X (PtX) routes. In principle, these fuels can approach very low lifecycle emissions when electricity is near-zero carbon and the carbon feedstock is sourced from the atmosphere (i.e., direct air capture) or other eligible non-fossil streams.

The primary strategic niche for synthetic fuels is hard-to-abate demand where liquid fuels remain indispensable, long-haul aviation, some marine applications, select industrial uses, and, in some systems, as a form of long-duration or seasonal energy storage when clean electricity is abundant.

However, the dominant constraints are electricity intensity and thermodynamic efficiency. Current PtL pathways convert only a fraction of input electricity into usable liquid fuel energy, making costs highly sensitive to the availability of abundant, ultra-low-cost clean power. Synthetic fuel production is also tightly coupled to the cost and performance of enabling technologies (green hydrogen production, CO₂ capture including Direct Air Capture, and advanced fuel synthesis systems) which remain capital-intensive and complex. As a result, synthetic fuels are unlikely to contribute at large scale in the near term but may become important by mid-century for residual emissions in sectors with limited alternatives.

Advanced Biofuels (Biomass-to-Liquids /FT Fuels)

Advanced biofuels provide a nearer-term pathway to drop-in fuels by converting sustainably sourced biomass residues, such as forest or agricultural residues, into liquid hydrocarbons. A key route is Biomass-to-Liquids (BtL), in which biomass is gasified into syngas and upgraded through Fischer-Tropsch (FT) synthesis to produce renewable diesel and SAF. Relative to first-generation biofuels derived from crop oils, residue-based pathways can reduce food-versus-fuel concerns and may leverage established forestry and agricultural supply chains, though they remain constrained by sustainable feedstock availability, transport logistics and costs, and project economics.

Canada has emerging examples of this approach. Expander Energy's Carseland Bio-Synfuels facility (25 ML/y) is positioned as a first-of-a-kind bio-synthetic diesel and SAF project with stated ambitions for near-zero carbon intensity fuel performance with the addition of carbon capture and storage (CCS) for the concentrated bio-CO₂ produced in the gasification-plus-FT process. Highbury Energy's Fort Frances planned biorefinery (20 ML/y) is expected to produce drop-in SAF and renewable diesel with an explicit longer-term objective of reaching near-zero fuel carbon intensity through CCS as well.[181]

Overall, advanced biofuels represent the more credible near-term route to scaling next-generation drop-in fuels from residues, while synthetic fuels are the longer-term option that becomes compelling primarily under conditions of very low-cost, near-zero-carbon electricity and scalable, low-cost CO₂ capture and hydrogen supply.

7.3.3 Net-Zero Pathways

Achieving Canada's net-zero emissions target by 2050 requires a fundamental reorientation of alternative fuel strategy away from the current piecemeal approach toward a comprehensive, technology-specific deployment framework. Strategic prioritization and resource allocation are essential to advancing beyond the Clean Fuel Regulations and provincial policies. To reach net zero by mid-century requires transition of all applications to fully zero- or near-zero-carbon fuels.

Several key pathways can be identified, each with distinct sectoral roles and uncertainty about ultimate market shares. Given deep uncertainty about technology costs, fuel availability, and adoption rates—for example, how rapidly electrification could overtake slower hydrogen and renewable diesel development—the information should be treated as a portfolio of pathways.

Sustainable biofuels from non-food feedstocks

The pathway requires expanding sustainable biofuels produced from non-food feedstocks and waste streams. Second-generation biofuels derived from cellulosic materials (agricultural residues, wood waste, and forest biomass) can avoid food competition challenges while leveraging Canada's significant biomass potential. Advanced processing facilities that convert cellulose and waste into fuels through gasification and Fischer-Tropsch and other thermochemical pathways must be developed, coupled with carbon capture and storage systems to achieve net-negative-emission fuels.[160,182] That said, sustainable biofuels should be prioritized for applications where high energy density and drop-in compatibility with existing infrastructure provide the greatest value.

Synthetic hydrocarbon E-fuels

Synthetic hydrocarbon production using clean electricity and recycled carbon represents a longer-term and potentially necessary complement to advanced biofuels, particularly for aviation applications where bio-feedstock availability will prove insufficient. E-fuel development should focus on applications where electrification is technically infeasible and where the energy storage characteristics of liquid fuels provide system value. However, realistic deployment timelines place e-fuels as post-2035 solutions requiring sustained research and development investment and early deployment in niche, high-value markets, notably aviation and potentially long-distance marine shipping.

Sectoral fuel allocation and primacy of electrification

Strategic fuel allocation becomes critical given finite resources. Light-duty transport should transition primarily to electrification, reserving liquid biofuels—including renewable diesel and other advanced fuels—for heavy-duty trucking, aviation, marine shipping, and industrial heating where alternatives are limited. This requires explicit policy frameworks that prevent alternative fuels from competing with electrification in sectors where batteries provide greater solutions, while acknowledging that the eventual balance between electrification, hydrogen, and renewable fuels in freight and off-road applications continues to be uncertain. Economically, capital for alternative liquid and gaseous fuels is best directed toward long-haul freight, aviation, marine, and industrial heat markets, rather than light-duty road transport.

Renewable Natural Gas as a targeted bridge

Renewable natural gas expansion should focus on waste methane capture and industrial applications where gas provides processing advantages, while recognizing its bridging role rather than permanent solution status. The development of regional biomethane networks can provide near-term emissions reductions while supporting agricultural waste management. In a systematic view, RNG plays a time-limited, niche role: targeting high-leverage waste streams and specific industrial users rather than broad, system-wide gas substitution.

Cross-cutting CCUS and infrastructure integration

The integration of carbon capture utilization and storage technologies across fuel production pathways offers potential for bio-CO₂ as feedstock and net-negative emissions. This will be particularly important for offsetting residual emissions in sectors where complete decarbonization is elusive. The coordinated development of CO₂ transport and storage infrastructure alongside fuel production facilities will be critical.

Taken together, these pathways represent a systematic map of uses based on alternative fuel type. Policy design and investment strategy should therefore emphasize flexibility and periodic review, scaling up those pathways that prove most compatible with rapid electrification and cost-effective emissions reductions.

Competitiveness Implications

When Braya Renewable Fuels shut its Newfoundland facility in early 2025, it cited a specific cause: inability to compete with U.S. production tax credits. When Air Canada made its first commercial SAF purchase (78 million litres from Finland's Neste), it did so because no Canadian producer could supply the volume. Canada's SAF production is virtually zero at commercial scale. The pattern is consistent: feedstock leaves, refined product returns, and the conversion-stage value where margin and industrial capability concentrate accrues elsewhere. Imperial Oil's Strathcona renewable diesel facility and B.C.'s new domestic production mandate show this can be reversed when investment or regulation intervenes. But the gap that matters most now is fiscal: absent a federal framework competitive with U.S. and EU regimes, refining capital will keep flowing to jurisdictions that offer producers greater certainty, and offtake relationships will form around non-Canadian supply. Canada continues to be the only G7 nation without a federal bioeconomy strategy.

7.3.4 Priorities for Action

Secure and stabilize feedstock through regional bio-hubs

A key priority must be establishing regional bio-hubs—sub-provincial clusters organized around an anchor conversion facility—that aggregate and preprocess feedstocks such as wood residues, agricultural wastes, and CO₂ streams before conversion. In this context, regional refers to feedstock catchment areas rather than entire provinces or single cities. Each hub may focus on a subset of compatible feedstocks and products, with modular expansion around the anchor facility rather than attempting to integrate all possible streams from the outset. While more complex than single-molecule hubs (i.e., hydrogen hubs), this can reduce risk by diversifying feedstocks and end-markets within a defined geography.

These hubs ensure reliable, stable supplies and lower costs by co-locating:

- Feedstock collection and preprocessing facilities;
- An anchor biorefinery (either dedicated biorefineries or retrofit support for existing petroleum refineries) to handle bio-crude, bio-oils, and Fischer-Tropsch (FT) intermediates, with capacity that can be expanded as additional feedstock becomes available;
- Logistics coordination and shared infrastructure (including storage and CO₂ handling) to minimize transport emissions and costs.
- Federal incentives for refitting existing refinery infrastructure or deploying new biorefineries will catalyze early adoption and unlock domestic value addition.

Build integrated regional fuel hubs

Once feedstock security is in place from bio-hubs, develop integrated regional fuel hubs that co-locate conversion technologies (i.e., pyrolysis, gasification, electrolysis) alongside end-users. This approach captures value domestically while minimizing transport costs and embedded emissions from larger feedstocks. Strategic positioning near biomass or CO₂ sources can dramatically reduce the cost and logistical barriers that constrain deployment.

Align alternative fuels with hard-to-electrify sectors

Given the finite sustainable feedstock resources, alternative fuels should be prioritized where the most value is added and directed toward sectors where electrification is currently not possible and may remain out of reach, including some heavy-duty trucking, aviation, marine shipping, and certain types of industrial heating.

Accelerate commercial-scale RD&D and demonstration

Accelerated RD&D should move beyond pilot projects toward first-of-a-kind (FOAK) commercial facilities demonstrating scalability and economic viability. Priority should focus on cellulosic pathways for SAFs, advanced biomass conversion technologies, and integration of CCS to achieve net-negative emissions.

Develop early-stage hydrogen and CO₂ infrastructure

The development of hydrogen and CO₂ supply hubs underpins both e-fuel production and broader decarbonization of hard-to-abate sectors. There should be a focus on early infrastructure development to break investment chicken-and-egg cycles while supporting multiple industrial applications concurrently.

Strengthen policy, procurement, and strategic coordination

Policy frameworks require strengthening and refinement to create predictable demand signals supporting long-term investment. While Canada's Clean Fuel Regulations provide a foundation, achieving net zero may need more aggressive carbon intensity requirements. Public and private procurement by government fleets, military operations, and crown corporations can provide necessary early demand signals. Canada remains the only G7 nation without a federal bioeconomy strategy tying biomass use to emission-reduction targets. A national policy framework should:

- Link climate goals explicitly to sustainable biomass deployment;
- Tighten carbon intensity requirements under the Clean Fuel Regulations;
- Leverage government, military, and crown-corporation procurement to provide early, predictable demand signals.

Standardize carbon accounting and life-cycle assessment

Common emissions accounting standards and verification systems should also address the fundamental gap undermining investor confidence. Current LCA methodologies create uncertainty—both from absent indirect land use change accounting, which can overstate benefits, and from reliance on legal global economic models whose indirect land-use change assumptions may overstate impacts for feedstocks like Canadian canola. Standardized systems provide credibility needed for large-scale investment.

Incentivize domestic value-add production

Finally, policy frameworks should incentivize value-added processing within Canada to create economic benefit while reducing costs through shorter supply chains. Fostering domestic capabilities must address Canada's position as a raw material exporter importing refined products.

 Fails to meet criteria

 Meets in some respect

 Not promising

 Potentially meets criteria

 Meets criteria

ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
	ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
Deep lifecycle emission reductions with forestry and other organic residues.	Higher direct production cost than HEFA but cheaper per tonne of CO₂ abated. Still requires policy support and offtake certainty.	Strong domestic potential. Integrated biorefineries, forest and agricultural residue value chains, and Canadian opportunities in gasification and FT.	Integrated FT-SAF at commercial scale is pilot/demo. Limited Canadian deployment.	Drop-in replacement for jet fuel. No aircraft or fuelling infrastructure changes required.	Biomass and residue supply chains emerging. FT synthesis and low-carbon H₂ infrastructure not yet at scale. Aviation blending infrastructure is in place.	Generally positive. Waste valorization and residue use are supported by communities.	Forest sector and waste managers for waste valorization. Federal government funding R&D.	Multiple co-benefits: waste diversion, forest management support, co-production of renewable diesel. No food competition or land use change concerns.
Moderate to deep lifecycle reductions depending on feedstock/crop chosen and associated land use changes. Crop-oil HEFA can exceed some fossil fuel intensities. Would require removals for net zero.	High costs relative to fossil jet fuel. Viability depends on policy support.	Moderate opportunity for domestic production in crop oil (i.e. canola) regions. Limited Canadian IP. Technology is imported.	Commercial globally. Canadian facilities are emerging.	Drop-in replacement for jet fuel. No aircraft or fuelling infrastructure changes required.	Compatible with existing blending and distribution infrastructure. Sustainable feedstock supply is the main constraint on domestic scale.	Virgin crop oils face growing food-vs-fuel and land-use concerns. Concerns less acute for Canadian canola given its stable cropland base.	Some airlines and airports actively purchasing fuel, limited by cost and supply. Federal regulations in progress; some provinces are further ahead.	Waste-oil and tallow feedstocks provide waste valorization option. Risks from indirect land-use change and pressure on food/feed markets.

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Heavy Duty Diesel End Users											
Renewable Diesel	Niche Pathway Drop-in fuel compatibility and strong lifecycle reductions. Supports hard to electrify end users. Long term net-zero alignment requires sustainable feedstocks and removals.	Deploy Continue support to ensure cost parity. Provide education to end-users on drop-in capabilities.	 Drop-in fuel, delivering significant lifecycle CO ₂ cuts. Net zero requires sustainable feedstocks and complementary carbon removal.	 Currently requires support for price parity.	 Potential for domestic production and associated jobs.	 Commercial and rapidly scaling.	 Fits existing diesel engines and distribution networks without retrofit. Better cold-weather performance than some alternatives.	 Uses existing storage and pipelines but can be difficult to procure.	 Concerns of competition with food crops.	 Interest from hard hard-to-electrify industrial end users (i.e. trucking fleets). Developing interest from fuel producers to supply emerging markets, but confusion remains with properties of other alternative fuels.	 Improves air quality while retaining energy density. Risk of locking in diesel dependency for end users who could otherwise electrify.
Biodiesel	Potential Dead-End Pathway Provides near-term emission reductions using existing engines and infrastructure. Blending limits and feedstock availability limit uptake.	Don't Prioritize Not drop-in. Provide information on the quality differences between renewable diesel and biodiesel.	 Can cut tail-pipe CO ₂ significantly, but blending limitations exist with unmodified engines. Net zero requires sustainable feedstocks and complementary carbon removal.	 Costs greater than fossil fuel diesel.	 Creates domestic demand for used cooking oil and canola oil, boosting farm and refining sectors. Competes with food.	 Commercial, but climate-grade quality still improving.	 Compatible with diesel engines to B20. Cold weather performance and material sedimentation limit higher blends.	 Separate heated tanks are needed in winter. Logistics become complex above the B20 blend.	 Generally positive when made from wastes. Land-use change for virgin crops draws scrutiny.	 Can be less relevant than renewable diesel.	 Improves lubricity and reduces particulate matter. Offers a practical bridge until zero-emission drivetrains dominate.

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Heat and Power Production											
Renewable Natural Gas (RNG)	<i>Potential Niche Pathway</i> Complements hard-to-electrify end uses and applications. Limited feedstocks constrain scale.	Enable Support projects that reduce methane emissions from waste. Focus funding on projects with secured long-term end users.	 Moderate GHG reduction. Methane capture benefits. Net-zero requires sustainable feedstocks and complementary carbon removal.	 Viable with support. Cost competitive under supportive policy environment.	 Creates jobs in waste management and valorizes agricultural residues.	 Emerging commercial.	 Compatible with existing pipelines and end-use equipment.	 Fully compatible with gas networks. Limited by feedstock availability and interconnection.	 Varying acceptance. Issues with increased traffic and odours. Seen as waste valorization.	 Seen as economic addition for agricultural and waste management. Gas utilities to leverage existing networks.	 Reduces fugitive methane. Potential for fertilizer production.
 Light Duty Vehicles											
Ethanol	Dead-End Pathway Limited lifecycle emissions reductions and sustainability concerns make ethanol unlikely to have a meaningful role in net zero.	Dismiss Not net-zero in its primary use of light duty vehicle decarbonization. Support transition to other pathways.	 Limited GHG reductions. Food-vs-fuel controversies over land use and feedstocks.	 Affordable and viable with support.	 Low value-add. Small rural jobs. Competes with food.	 Fully commercial.	 Compatible with gasoline blending up to E10. Higher blends need flex-fuel vehicles.	 Incompatible with existing pipelines beyond 10% blends. Requires new infrastructure.	 Mixed: accepted historically but declining due to sustainability concerns.	 Provincial regulators and oil refiners. Limited OEM engagement.	 Reduces gasoline emissions modestly. Supports legacy ethanol plants.

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Advanced Bio and Synthetic Fuel Pathways											
Advanced Biofuel (Biomass-to-liquids)	Niche Pathway Delivers deep emissions reductions where sustainable feedstocks/ biogenic CO ₂ and low-carbon electricity exist, but restricted by localized and limited ability to obtain feedstocks.	Incubate Support R&D projects.	 Achieves high emissions reductions but requires substantial biomass feedstocks/biogenic CO ₂ and clean power. Feedstocks used must be decarbonized. May still require removals.	 High production costs due to complex multi-step conversion. Requires supportive policy environment.	 Creates integrated biorefineries and supports biogenic carbon capture build-out. Some provinces developing demonstration projects.	 Pilot/ demonstration.	 Drop-in compatibility with all diesel engines and aviation turbines.	 Requires biomass or biogenic carbon supply chains, gasification plants, and synthesis facilities. Forestry residue supply chain exists.	 No particular concern.	 Forest sector and waste managers for waste valorization. Federal government funding R&D.	 Multiple co-benefits: waste diversion, forest management support, co-production of renewable diesel and SAF. No food competition or land use change concerns.
Synthetic / E-Fuel	<i>Potential Niche Pathway</i> Potential for net-zero compatibility with offset or directly captured CO ₂ and low-carbon hydrogen.	Don't Prioritize Watch to see if economics or maturity improve; support if progress is made.	 Potential for deep lifecycle reductions. Carbon intensity depends directly on the H ₂ source and how CO ₂ is captured or offset.	 Not viable. High electricity input and low conversion efficiencies. Costs hinge on low-carbon H ₂ and CO ₂ capture/offset maturing at scale.	 Long-term manufacturing potential. Requires new industrial clusters.	 R&D/Concept.	 Drop-in compatibility with all diesel engines and aviation turbines.	 Requires low-carbon hydrogen, captured or offset CO ₂ (i.e. from direct air capture), and synthesis plants. No existing supply chain.	 Public awareness is low. Acceptance will depend on framing. Conceptually attractive as a “drop-in” net-zero fuel.	 Research institutions, energy ministries as a long-term feedstock-secure fuel production pathway.	 Unaffected by biomass supply chain instabilities.