SUSTAINABLE AVIATION FUELS

BLUEPRINT FOR CANADA

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EXECUTIVE SUMMARY

Aviation plays a crucial role in Canada's transportation network and economy, connecting Canadians across vast distances and facilitating trade, tourism, and investment. However, it is also a significant contributor to greenhouse gas (GHG) emissions. Canadian air carriers released 22 megatonnes of GHG emissions in 2023, marking over a 23% increase since 2005. Domestic aviation activity represents 5% of transportation emissions and 1.2% of total emissions in Canada.

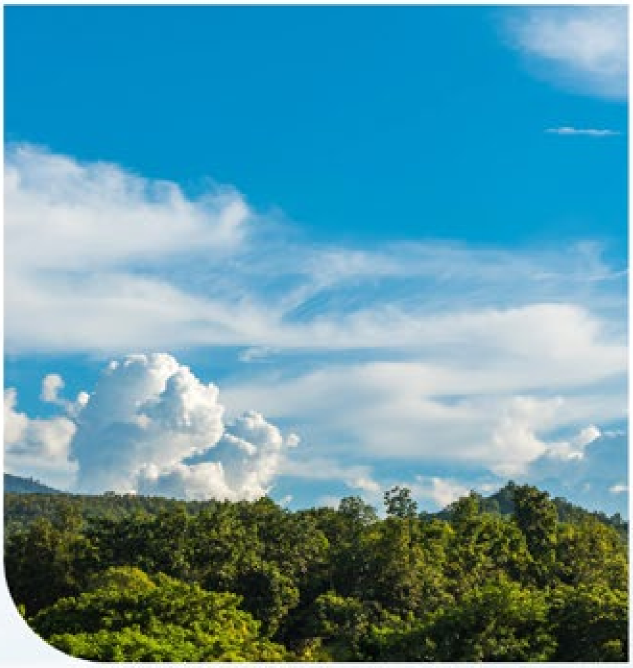
The use of sustainable aviation fuels (SAF) / low-carbon aviation fuels is the most technologically ready and commercially feasible pathway to significant emission reductions. This is being observed globally as countries and organizations invest in SAF production and use. To clearly signal SAF's importance to Canadian aviation, Canada's Aviation Climate Action Plan set an aspirational goal of 10% SAF use by 2030 (estimated to be 1 billion litres), sourced from a combination of international supply and domestic production.

This SAF Blueprint consists of an extensive body of evidence and outlines potential actions and measures, from both the public and private sectors, to help create a domestic SAF market that can provide Canada access to sufficient volumes of SAF to help meet its aspirational goal and set the path for net-zero emissions by 2050.

The production and use of SAF is both a long-term economic opportunity and a strategic environmental priority for Canada and its aviation sector.

The SAF Blueprint was a collaborative effort under the Sustainable Aviation Task Force which includes representation from across multiple levels of government, industry, and academia. It is the product of extensive consultation and cumulative insight gathered from stakeholders across the value chain.

As described by the Canadian Council for Sustainable Aviation Fuels (C-SAF) in its SAF roadmap (2023), Canada has the feedstock, refining expertise, innovation capacity, and domestic airlines to create a world-leading industry that contributes to meeting its own needs and those of other jurisdictions. To realize this promise, Canada must mobilize and align the entire ecosystem. Leveraging Canada's advantages for domestic production while also working to help fuel purchasers import SAF into the country can create tangible benefits for Canadians and organizations across the country including direct employment opportunities, long-term industrial competitiveness, and low-carbon options for consumers.



Benefits of developing a Canadian SAF market across the Canadian value chain.

- ✓ Domestic SAF production strengthens Canada's economy.
- ✓ Strengthens the competitiveness of Canadian air carriers (domestically and internationally) and airports.
- ✓ Creates and maintains high-paying jobs across aerospace, aviation, fuels, agriculture, and related industries.
- ✓ Creates dependable new market opportunities for Canadian agricultural and forestry feedstocks.
- ✓ Contributes to global efforts to address emissions and establish Canada as a leader in aviation decarbonization and meets international and corporate environmental commitments.
- ✓ Increases domestic energy security and affordability of clean fuels into the future, minimizing competition for expensive and limited global volumes, and potential disruptions to supply chains.
- ✓ Increases availability and affordability of low-carbon options for Canadian and international air travelers and organizations.

Current state of the Canadian SAF market

Today, there are policies and programs available to help grow a SAF marketplace in Canada. The federal government has established measures, several of which are aimed at supporting the production of a range of low carbon fuels, including SAF. At the provincial level, the Government of British Columbia (BC) has implemented regulations in support of SAF uptake, which include voluntary opt-in credits (until end of 2026), carbon intensity reductions for jet fuel (compliance is not limited to the use of SAF and started in 2026), and a volumetric SAF mandate (starting in 2028).

Despite this effort, a consistent Canadian SAF market has not yet developed and is currently emerging at a slower pace than many European countries and the United States (U.S.), where a combination of regulation and financial incentives are creating a more favourable investment climate. There is no sustained commercial production in Canada and, while there are recent instances where fuel purchasers have procured batches of SAF abroad for uplift in Canada, consistent global supplies are far from guaranteed as demand grows internationally.

Industry stakeholders have expressed concern that Canada's current approach will not lead to the consistent ability for SAF (domestically produced or imported) to be regularly uplifted in the country, while maintaining the competitiveness and affordability of Canada's air travel systems.

At the time of writing this Blueprint, the country is at an inflection point where the Government of Canada has made clear priorities of diversifying trade to reliable trading partners, advancing nation-building projects, increasing its climate competitiveness towards a low-carbon economy, and building itself into an energy superpower. This SAF Blueprint illustrates how increasing SAF uptake and developing a domestic market could contribute to these objectives, including by reducing reliance on imported fuels from the U.S. and other jurisdictions.

Core challenges

The most pressing issues impeding a Canadian SAF market transcend geographic boundaries and industries, requiring joint efforts from all market actors. Despite Canada's natural feedstock advantages and industrial expertise, focusing exclusively on domestic SAF production will not be sufficient to ensure availability and access. Instead, Canada will need to rely on a careful balance of importing SAF as well as building up domestic production, while overcoming the following core challenges:

The high cost of SAF compared to conventional jet fuel

- SAF can be 2-8 times more expensive than conventional jet fuel, depending on the production pathway used. The majority of commercial scale facilities in-service and in development on a global basis currently employ the HEFA process. As a result, in the short- and medium-term, the market price will depend primarily on the availability and pricing of feedstocks that are used in HEFA production.
- Policy exerts a strong influence on global prices as well. E.U. compliance obligations have created high demand in Europe and regional market prices are typically higher. In the U.S., prices fluctuate but recently have been lower. In the long-term, production costs of most SAF production technologies are likely to decline. However, even for the most economical and technologically mature pathways, it is unlikely that the cost gap between SAF and conventional jet fuel will completely close.
- From a procurement process and logistical perspective, securing and receiving SAF requires additional time to plan and coordinate with various stakeholders across the supply chain (e.g., fuel producers, distributors, airports, etc.). This additional effort, which can sometimes be lengthy, also contributes to the increased cost of procuring SAF.
- There is uncertainty and concern regarding how the cost premium of SAF may be absorbed by the sector and/or passed on to the end users (through ticket purchase price). Given that fuel typically accounts for more than 25% of commercial airline operating costs, any significant volume of SAF purchased would be a challenge for airlines (particularly smaller ones) to manage. While some airlines have procured small volumes, many have indicated that they would not be able to absorb the costs of large volumes of SAF use on their own and the inevitable additional increases

to ticket prices could impact affordability and pose significant risk to their competitiveness, particularly when compared to their international competitors.

Canadian production investment risk

- For investors and would-be Canadian SAF producers, there is uncertainty regarding the opportunity for a return on investment. Current Canadian policies do not create conditions for a positive operating margin nor a sufficient long-term demand signal, leaving would-be Canadian SAF producers unable to allocate or attract capital investment for Canadian domiciled facilities.

- Global demand for SAF volumes is growing and billions of dollars in global investment have been announced, but much of it depends on consistent policy signals and willingness to pay a premium. Producers are assessing opportunities across various jurisdictions and are looking to site in locations that offer the most stable, long-term, and compelling economic incentives, where existing supply chains can be leveraged, and where local demand centres can ensure offtake and minimize transportation costs. For example, the U.S. incentives under the Inflation Reduction Act and at the state-level have encouraged billions of dollars in announced projects.

- As mentioned, global demand for SAF is growing and even though several Canadian airlines and associations continue to emphasise the desire to use low-carbon fuel, producers have expressed the need for long-term, durable demand signals and a clear line of sight to a viable margin to support investment decisions.

- It would be challenging for Canadian SAF producers to take advantage of selling into the European market as most Canadian projects—at least in the near term—are likely to rely on feed and food crop resources (e.g., canola), and SAF derived from these feedstocks is not allowable under current European regulations. As a result, Canada mainly competes with the U.S. for investment dollars. The U.S. has some similar feedstock advantages but has greater refining capacity coupled with production-based incentives, which can reduce risk for investors. As a result, siting a project in the U.S. typically offers a stronger business case. It should be noted that producing fuel in Canada would not necessarily guarantee use in Canada, and produced fuel could be exported if there is a business case to do so.

- Depending on the technology pathway and the operating set-up, renewable diesel (RD) and SAF can be produced in the same facility. The decision to produce either fuel is an economic one and existing policy, regulatory, market conditions and operating costs tend to favour RD production.

  - The production of SAF requires greater volumes of feedstock than when producing RD (e.g., for the HEFA pathway), and additional hydrogen, heat and power making it a slightly more carbon–intensive fuel with a different co-product slate. Existing RD facilities may not have the processing units to produce SAF, resulting in added costs to install and operate additional equipment.

  - Canada could leverage its refinery capacity to produce co-processed SAF without the need for significant large-scale investment. However, the current 5% limit on the volume of renewable content permitted under ASTM International jet fuel specifications renders the business case unviable. At the time of writing, the blending limit is being considered for revision upwards to a 30% limit that would benefit the economics of producing SAF via co-processing.

Limited available supply globally

- The recent period of global market scarcity has led fuel purchasers (particularly those with high compliance obligations) to secure SAF supply through short- and medium-term offtake agreements, impacting near-term availability and driving up the price of imports into Canada. As a result, most SAF being produced globally is being imported by the European Union or the U.S. From a producer's perspective, the long-term offtake agreements are not yet sufficient to guarantee their own viability once their plants are built.
- Canadian airlines are left trying to secure any meaningful volumes available, as Canada's domestic context offers few supports and incentives for adopters. While some airlines have had recent success in procuring and importing SAF, other smaller carriers are unable to compete and are interested in the opportunities presented through book and claim, which has yet to be widely recognized and adopted. In the absence of any new measures or action, Canada will continue to depend on its airlines' willingness to pay a premium to import marginal volumes of SAF as available on the global market. The approach carries the longer-term risk that, if global scarcity persists, airlines may struggle to meet existing (or future) international compliance obligations and could experience decreased global competitiveness.

TABLE 01 | Ideal Evolution of SAF Production and Use in Canada

Potential evolution of Canadian SAF production, importation, and use			
	Where We Are Today	**Where We Can Be in 2-5 Years**	**Where We Can Be Beyond 2030**
Access to SAF	• No regular domestic production of SAF (including co-processed fuel) and no SAF production facilities beyond the front-end engineering design (FEED) stage. • Imports from U.S. and global markets started in 2022 and steadily increased up to 2025. Supply is limited. • Interest from airports, airlines, and other aviation operators in being active partners in a SAF market.	• SAF comprises up to 10% of aviation fuel used by Canadian operators (up to 1 billion litres annually) from a combination of imports and domestic production. • Regular and growing Canadian production of SAF at the latter end of the timeframe. • Increased biogenic content permitted for co-processing. • Blending facilities can support SAF use at one or multiple airports. • Ready access to imports from U.S. and global markets (both neat and pre-blended SAF).	• Additional production and importation of SAF as supported by the market, surpassing the aspirational goal and reaching higher volumes of SAF that are projected to help achieve net-zero aircraft emissions by 2050. In this scenario, Canada would need to continue to significantly rely on the use of imported fuel. Optimistically, domestic production, through the modelled pathways, would still meet less than half of demand.
Pricing and Demand	• SAF remains significantly more expensive than jet fuel, with the cost of production being greater than the policy benefits available within Canada. • SAF price exceeds aviation operators/ traveling passengers/ corporate customers' willingness and/ or capacity to pay (for large volume and long-term). • SAF production/ importation is eligible to earn credits under B.C.'s Low-Carbon Fuel Standard (LCFS) and Canada's Clean Fuel Regulations (CFR). Given that the B.C. LCFS credit and CFR credit are stackable, there is a benefit in selling SAF in B.C. compared to other Canadian locations.	• Cooperation across the SAF and biomass/low carbon electricity value chain, including pilot projects, feasibility studies, and construction of enabling SAF infrastructure. • Canada has a market in place that can help create demand, encourage suppliers to sell into Canada, and help minimize the cost premium of SAF. • Agree to a common approach to book and claim within Canada, enabling the purchase of SAF's environmental attributes by a variety of parties.	• Access and availability of SAF in volumes that enable meaningful emission reductions. • Reduced price gap between conventional jet fuel and SAF through policy support, technological advancements, and/or increased industry efficiencies.

	• Aviation operators have made voluntary commitments through the Aviation Climate Action Plan and/or their corporate plans and have made batched procurements. • Early efforts are being made by various parties to develop book and claim systems.	• Reduced price gap between conventional jet fuel and SAF through policy support, technological advancements, and/or increased industry efficiencies.	
Sustainability Requirements	• Current differences in sustainability criteria and varying life-cycle assessment methodologies create administrative burden and market arbitrage (i.e. B.C.).	• Improved awareness and clarity on the differences in sustainability criteria methodologies between the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), national and subnational levels, starts to reduce barriers to SAF procurement for new purchasers. • Available and updated information on lifecycle assessments of anticipated Canadian SAF pathways, helping Canada to better leverage its feedstock advantages and identify how the carbon intensity of Canadian fuels and feedstocks can be improved.	• Over time, global sustainability standards may start to align around a common methodology, such as CORSIA. Canada monitors developments and pursues refinements to its own methodology as appropriate.

A Way Forward

This SAF Blueprint for Canada integrates views compiled through a consultative process to identify a potential path to meet Canada's aspirational goal for SAF use. This considers current and projected SAF production, opportunities for importation, book and claim, sustainability standards and emissions reporting. The Blueprint concludes with the following pillars of actions that both government and non-government stakeholders across the value chain may consider, which would help increase availability and access to SAF in Canada.

TABLE 02 | Pillars of Actions to Help Achieve the Aspirational Goal

Pillar 1: Strategic Partnerships

Strategically use existing and new partnerships (domestic and international) to explore opportunities that support SAF production, importation, and use.

To help address: high cost / investment risk / limited supply

- Continue to collaborate through the Sustainable Aviation Task Force, across multiple levels of government, and non-government stakeholders, industry sectors and the public through Canada's Aviation Climate Action Plan. Members should prioritize discussions on deployment, with a view to sharing knowledge, insight, best practices, and lessons learned.
- Work with all levels of government to consider how existing and potential incentives could be stacked and to avoid misalignment of policies across regions.
- Leverage international events and fora to pursue initiatives that will both attract direct foreign investment in SAF production and accelerate opportunities for Canadian companies in global markets.
- Liaise with airports, airlines, and aircraft manufacturers, as well as governments and other actors across the value chain, to explore opportunities for collaboration, including the formation of green aviation corridors.

Pillar 2: De-Risk Investment

Explore opportunities to establish programs, long-term policies, and business models to encourage industry and governments to invest in growing a SAF market. Governments at all levels, as well as industry stakeholders, will have a role to play in de-risking SAF.

To help address: high cost / investment risk / limited supply

- Consider long-term policies that could help de-risk the private sector investment needed to establish SAF production and distribution infrastructure and create SAF demand certainty.
- Assess opportunities to provide support for domestic production, importation, and/or SAF use, specifically to help address the price premium for SAF.
- Find opportunities to consolidate existing Canadian demand.
  - Develop a Canadian demand forecast in collaboration with key industry associations and Canadian airlines.

Pillar 3: Build Supply Chains and Establish Supporting Infrastructure

Investigate options to help accelerate the development of regional supply chains, including for lower-carbon feedstocks, to unlock future SAF pathways that will be needed beyond 2030 and ensure preparedness and ability to handle and blend SAF volumes produced domestically or imported.

To help address: investment risk / limited supply

- Develop an evergreen project pipeline with pilots, demonstrations, and first commercial projects to identify where infrastructure is required as the market evolves.
- Develop regional infrastructure and supply chain feasibility studies and activation plans (including types of feedstocks, location of local SAF production facilities with feedstock available, locations to receive, blend and integrate SAF into conventional fuel supply chain, etc.).
  - Assess opportunities at high traffic airports (i.e., Vancouver, Toronto, Calgary, Montreal, Edmonton) to establish regional pilot SAF supply chains.
  - Explore public-private-partnerships to build blending facilities.
- Regional stakeholders could lead action-oriented strategies to identify and address barriers to unlocking the regional supply chains of feedstocks deemed high potential for Canada (e.g., agriculture and forest residues), with a focus on collection and delivery logistics.

Pillar 4: Codes and Standards

Consider updating existing—and developing new—codes and standards to enable and accelerate SAF uptake and remove barriers to deployment, domestically and internationally.

To help address: investment risk / limited supply

- Conduct a gap assessment of relevant fuel specifications to confirm there are clear guidelines for SAF storage, handling, and dispensing standards.
- Examine measures to support organizations that wish to contribute to the expansion of ASTM International's co-processing blending limits and approved feedstocks for SAF.
- Through ICAO and other international fora, continue to advocate the sustainability and life-cycle carbon intensity of Canadian feedstocks.

Pillar 5: Accelerate Technology Development and Innovation

Investigate opportunities for further R&D, developing research priorities, and ensuring collaboration between domestic and international stakeholders to ensure Canada maintains its competitive edge and global leadership.

To help address: investment risk / limited supply

- Continue to support research and development to enable the build-out of existing and new SAF pathways, both domestically and with international partners.
- Explore opportunities for support through the ASTM International process of increasing SAF Blend rates to reach 100%, where possible.
- Examine measures to de-risk first-of-a-kind production facilities, support the commercialization of new technologies, and understand future infrastructure requirements.

Pillar 6: Emissions Accounting and Book and Claim

Consider participating in the development of a domestic and/or international book and claim mechanism, recognized by government and international partners, to further increase demand and equitable access to SAF.

To help address: high cost / investment risk / limited supply

- Conduct additional comparative analyses to understand and clarify the similarities and differences between emissions accounting methodologies and potentially streamline the use of different methodologies.

- Compile life cycle assessment studies of anticipated Canadian SAF pathways under different regulatory regimes to help Canada to better leverage its advantages to support low-carbon intensity SAF production, including identifying areas in the lifecycle of the fuel that have a high GHG footprint and could be improved.
- Explore a consistent framework and guidance for the use of book and claim systems in Canada for domestic and international flights, noting the need for its recognition under global standards like GHG Protocol.
    - It is important to clarify the interaction between international, national, and provincial policies relevant to SAF purchase, blending, and use to identify how the environmental attributes of SAF can be claimed and attributed to domestic and international flights while avoiding double counting.
    - Consider how best to enable end users (e.g., organizations) to purchase SAF environmental attributes or certificates and help to grow the market for SAF.

Pillar 7: Education and Awareness

Promote and ensure individuals, organizations, governments, and communities are aware of the opportunities and benefits of SAF to the Canadian economy and environment.

To help address: high cost / investment risk / limited supply

- Pursue opportunities to educate passengers and business partners on the benefits of SAF use from both environmental and economic perspectives.
- Develop publicly-accessible cost calculators for assessing the cost of SAF and its impact on aviation service costs.
- Continue to enable corporations and cargo customers to contribute to paying the SAF premium through opt-in programs.
- Continue to publish studies and highlight current and future efforts to advance SAF in Canada.

Canada has strong potential to become a nation that uses and produces large volumes of SAF. However, without new and expanded actions across the sector, it is unlikely to see the level and speed of investment needed to create a market and meet the aspirational goal. All market actors in Canada can consider—in the near term—building on existing efforts and adding new pieces to better address the core challenges facing SAF uptake in Canada. Implementing the findings of this report would help Canada's aviation sector lead the green transition in a way that also boosts competitiveness, strengthens energy security, and provides economic benefits across the entire value chain.

The release of this Blueprint is meant to serve as a framework for government(s) and industry to consider and potentially implement actions and next steps under Canada's Aviation Climate Action Plan.

The Canadian air transport sector is economically deregulated and operates on the user-pay principle, meaning that Canada's air carriers, major airports, and air navigation services provider are all private entities that are operationally and financially independent of government. The system's users pay the total cost of the services they receive, which can represent a meaningful proportion of the ticket price, depending on the flight. To ensure the overall effectiveness of a way forward for SAF, it will be important that parties consider any impacts on important elements such as affordability, competitiveness, economic opportunity, and environmental benefits.

Following the release of this document, there will be ongoing engagements with public and private stakeholders, as well as academia, to help shape the direction forward. These engagements will be managed through the Sustainable Aviation Task Force and its SAF Subgroup.

Glossary

ASTM	ASTM International
ATAG	Air Transport Action Group
AtJ	Alcohol-to-jet
B.C. LCFS	British Columbia's Low Carbon Fuel Standard
CAGR	Compound annual growth rate
CCS	Carbon capture and storage
CFR	Clean Fuel Regulations
CI	Carbon Intensity
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CO_2	Carbon dioxide
C-SAF	The Canadian Council for Sustainable Aviation Fuels
DAC	Direct air capture
eFuels	Electrofuels
EV	Electric vehicle
FID	Final investment decision
FT	Fischer-Tropsch
GGS	Greening Government Strategy
GHG	Greenhouse gas
GREET	The Greenhouse gases, Regulated Emissions, and Energy use in Technologies
HDRD	Hydrogenation-derived renewable diesel
HEFA	Hydro processed fatty acids
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IACAC	International Aviation Climate Ambition Coalition
IEA	International Energy Agency
IRA	Inflation Reduction Act
LCA	Life-cycle Assessment
LCFPP	Low Carbon Fuel Procurement Program
LCFS	Low Carbon Fuel Standard
LTAG	Long-term global aspirational goal
LUC	Land use change
MSW	Municipal solid waste
NRCAN	Natural Resources Canada
ODT	Oven-Dry Tonnes
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PtL	Power-to-liquids
R&D	Research and development
RIN	Renewable identification number
SAF	Sustainable Aviation Fuels
SBTi	Science Based Targets Initiative
SIF	Strategic Innovation Fund
SIP	Synthesized Iso Paraffin
SBC	Synthetic Blend Component
TRL	Technology Readiness Level
UCO	Used cooking oil

SECTION 1

INTRODUCTION

Purpose of the Sustainable Aviation Fuels Blueprint

The purpose of this Sustainable Aviation Fuels (SAF) Blueprint is to identify potential additional actions and measures, from both the public and private sectors, to help create a SAF market that ensures Canada has sufficient availability and access to SAF to meet its aspirational 10% SAF use by 2030 goal and set the path for net-zero emissions by 2050. Within this core purpose, there were five additional objectives:

- Assess current and projected domestic SAF production;
- Assess the opportunity for SAF importation and international collaboration;
- Discuss the potential impact of sustainability standards and emissions reduction accounting and reporting;
- Confirm infrastructure needs for storage, blending, and distribution to major airports; and,
- Consider the roles of stakeholders.

Background and Context

In 2022, Canada released its 2022-2030 Aviation Climate Action Plan (the Action Plan), a joint government and industry initiative that sets a vision of net-zero aircraft emissions by 2050. It also includes a description of the various pathways needed to decarbonize the sector and a series of actions to be taken for each in the near-term (see Appendix 1 for the Action Plan's net-zero vision). A Sustainable Aviation Task Force was also formed, co-led by T.C. and the National Airlines Council of Canada, to be responsible for its implementation. Membership consists of representatives from across federal departments, provinces and territories, aviation and other relevant industry associations, environmental non-government organizations, and academia.

The Action Plan was developed in wide recognition of a growing need to shift Canadian aviation's dependence on the use of carbon-intensive fossil fuel towards low-carbon alternatives. Aviation in Canada released 22 megatonnes of GHG emissions in 2023, marking over a 23% increase since 2005. Aviation is considered a hard industry to decarbonize, even among other transportation sectors, in part due to the scale of technological advancements required to commercialize high-potential decarbonization pathways, the cost of alternatives, and the long investment cycles associated with fleets and existing infrastructure.

The Action Plan recognizes the use of low-carbon SAF as the most impactful way of achieving significant in-sector emission reductions in the near- and medium-term, and that SAF has a significant role to play in long-term aviation decarbonization and Canada's economic future. Beyond addressing climate and environmental impacts and improving air quality, a low-carbon transformation of Canadian aviation offers significant new opportunities for Canadians, including high-skill jobs in clean fuels blending and production, the growth of leading-edge domestic innovation, and access to new markets for products sourced from Canada's farming and forestry sectors.

To amplify the need and the opportunity for SAF use in Canada, the Action Plan set an aspirational SAF use goal by 2030. It is estimated that 10% of fuel use by 2030 will amount to one billion litres.

SAF is globally recognized as an important means of reducing GHG emissions

The International Civil Aviation Organization (ICAO) and its Member States have formally recognized that the successful development and deployment of SAF will be critical to reducing emissions. It has identified SAF as a key pathway to achieving its Long-term Aspirational Goal of net-zero carbon emissions by 2050 for international aviation. It is also seen as a means of realizing a near-term vision of decreasing the carbon intensity (5%) of aircraft fuel used by 2030.

At the 30th meeting of the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (November 2025), Canada endorsed the Belém 4x Pledge on Sustainable Fuels, an international pledge which aims to increase sustainable fuel production and use – including SAF - by at least four times 2024 levels by 2035.

What is Sustainable Aviation Fuel?

Sustainable aviation fuels – also referred to as Low-Carbon Jet Fuel in B.C. (B.C.) and alternative jet fuel in California – are a category of liquid hydrocarbon fuels derived from non-petroleum sources that meet pre-established and recognized sustainability criteria. SAF is produced to have identical performance and safety characteristics as conventional jet fuel using ASTM International approved pathways and blend limits, which permits it to be used as a "drop-in" fuel in existing aircraft engines. This feature is key to SAF's potential as a near- and medium-term aviation decarbonization solution, as investment cycles for aircraft are long and modifying / replacing existing aircraft fleets can be extremely expensive.

The feedstocks used to produce SAF can be bio-based, such as food waste (oil and fats), crops (such as canola, corn, and soybeans), forestry and agricultural residues, or municipal waste. It can also be produced from captured carbon dioxide and hydrogen. Given the significant volumes of SAF that will be necessary to decarbonize global aviation, the global aviation industry will need to depend on a wide variety of feedstocks and conversion technologies.

The vast majority of global SAF production capacity uses the Hydroprocessed Ester and Fatty Acid (HEFA) technology pathway, which typically relies on vegetable oils, animal fats and used cooking oils as feedstocks. Other SAF production pathways that can use a wider variety of feedstocks have been demonstrated but are not yet as commercially viable. Once produced, SAF needs to be blended with conventional jet fuel for use in existing aircraft, engines, and fueling infrastructure.

There are eleven ASTM International-approved conversion processes for SAF production. Six of these processes are approved for use as a drop-in fuel with up to 50% blend with conventional jet fuel and could potentially be used as a 100% drop-in in the future (a limiting factor, among other things, is the challenge to produce aromatics). Two other processes, Synthesized Iso-paraffin pathway (SIP) and Hydroprocessed Hydrocarbons, Esters and Fatty Acids (HC-HEFA-SPK) processes, are limited to a 10% blend. There are also three approved routes for co-processing (which is the inclusion of renewable content as part of the conventional petroleum refining process) up to a 5-10% blend limit.

TABLE 03 | Conversion Processes of SAF

Conversion process	Feedstocks	Maximum Blend Ratio
Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene (FT)	Biomass	50%
Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids (HEFA)	Vegetable oils, animal fats, used cooking oils	50%
Synthesized iso-paraffins from hydroprocessed fermented sugars (SIP)	Biomass used for sugar production	10%
Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources (FT-SKA)	Biomass	50%
Alcohol to jet synthetic paraffinic kerosene (ATJ-SPK)	Ethanol, isobutanol and isobutene from biomass	50%

Conversion process	Feedstocks	Maximum Blend Ratio
Catalytic hydrothermolysis jet fuel (CHJ)	Vegetable oils, animal fats, used cooking oils	50%
Synthesized paraffinic kerosene from hydrocarbon - hydroprocessed esters and fatty acids (HC-HEFA-SPK)	Algae	10%
Synthetic Paraffinic Kerosene with Aromatics (ATJ-SKA)	C2-C5 alcohols from biomass	50%
Co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery	Vegetable oils, animal fats, used cooking oils from biomass processed with petroleum	5%
Co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery	Fischer-Tropsch hydrocarbons co-processed with petroleum	5%
Co-Processing of HEFA	Hydroprocessed vegetable oils, animal fats, used cooking oils	10%*

*DEFSTAN 91-91 has approved to 30%, but ballot has not yet passed at ASTM
Source : https://www.icao.int/environmental-protection/GFAAF/Pages/conversion-processes.aspx

Why Does Canada Need SAF?

Alternative technologies offer more limited scope for decarbonization

Canadian air carriers are continuously making investments in their fleets and have adopted better technical and operational practices that have successfully improved fuel efficiency. However, the emissions benefits from these improvements are being outpaced by the significant overall growth in aviation sector activity.[1] As a result, GHG emissions are continuing to rise year over year in Canada's aviation sector and additional solutions are needed to realize Canada's ambitions.

1 https://tc.canada.ca/en/corporate-services/2020-2021/aviation-action-plan-reduce-greenhouse-gas-emissions-aviation-2020-2021-annual-report

Research and development on advanced aircraft propulsion technologies, such as electric and hydrogen, continues to progress, but realizing the full potential of these solutions will take decades and may still have limited applications. Hydrogen and electric aircraft propulsion technologies could start to become commercially available in the 2030s, but their application will likely be limited to smaller aircraft even over the long term. ICAO projects that hydrogen-fuelled aircraft could account for just 1.9% of global aviation energy share by 2050, with growing uptake only over the 2050s and 2060s.[2]

As indicated in Canada's Aviation Climate Plan, continued progress to advance these pathways is needed and will play an important long-term role in decarbonization and Canada's economic prosperity, but SAF is an important technologically and commercially feasible in-sector pathway that can lead to significant emission reductions by 2050.

Supporting Canadian business and corporate commitments

Global guidance and best practices for setting a market-recognized corporate sustainability commitment prioritize value chain emissions (Scope 1, 2, and 3[3]), abatement, and approved insets to reach "zero" emissions by 2050.[4] In Canada, many corporations are working to reduce value chain emissions (Scope 3 emissions). Programs such as Canada's Net Zero Challenge also offer businesses the opportunity to develop and implement net-zero plans which can provide benefits, including offering a competitive position in a decarbonizing world, the ability to attract new investment, and the ability to become more resilient against market disruptions.[5] For corporations that have reduced or eliminated their Scope 1 and 2 carbon footprints but rely on air transport to move goods or personnel, the few options available to reduce Scope 3 emissions include travelling or transporting less, purchasing offsets, or purchasing SAF (or SAF certificates).

Economic benefits

- **Economic benefits of domestic fuel production:** In 2024, Canada's refineries produced 6.4 billion litres of jet fuel[6], primarily serving the domestic market but also exporting to countries like the U.S. and China (noting that Canada also imports significant volumes of jet fuel to meet its demand). As the aviation industry transitions to new energy sources over the coming decades, developing the supply chains, infrastructure and facilities for SAF production could enable Canada's refining sector to continue to benefit from serving the aviation industry through diversification into new products.

  Similar to the significant growth observed in other clean fuels sectors (such as the near doubling of liquid renewable fuel exports since 2019), the establishment of domestic production could enhance multiple value chains. New employment opportunities can be expected, both in constructing and operating the plants (which can leverage existing skilled labour within the energy sector), as well as moving, delivering, and storing finished fuel. In addition, domestic SAF production would benefit Canada's aerospace manufacturing sector. The Canadian aviation sector is a major customer for Canadian aircraft, parts and services, and the transition to SAF will also support the decarbonization of Canada's aerospace industry. Further opportunities can be found further down the value chain in production or alternative use of feedstocks, storage, delivery, supplying raw materials and equipment to farmers, as well as in research and development. Air Transport Action Group (ATAG) predicts that 14 million jobs can be created globally in SAF by 2050.[7] A different study by Rhodium Group modelled employment opportunities associated with a 189 million litre per year SAF facility and found that HEFA plants tend to offer fewer direct jobs during operation (at 45 jobs) relative to other technology pathways (between 140 and 470 jobs at the same size). However, over 60%

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2 ICAO Long-term Aspirational Goal Special Supplement (2022) https://www.icao.int/sites/default/files/environmental-protection/Documents/EnvironmentalReports/2022/ENVReport2022_Special-Supplement-on-LTAG.pdf

3 The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions

4 https://ghgprotocol.org/corporate-standard

5 Government of Canada. "Net zero Challenge", accessed May 2024.

6 Stats Can - Petroleum products by supply and disposition

7 Air Transport Action Group, "Sustainable aviation fuel," accessed 2024

of the employment opportunities associated with HEFA plants are in the supply chain (at 1000 jobs).[8] The use of feedstocks like agricultural and forestry residues, as well as selling more feedstock crops such as canola and soybean in the domestic market, can provide market diversification opportunities and additional income to Canadian farmers, the Canadian forest sector, and feedstock providers. In the case of HEFA, with well over 50% of production cost being feedstock related, significant economic benefits would flow to canola and soybean producers.

In theory, with its experienced refining sector, abundant feedstocks, and close trading relationships, Canada has potential advantages that could aid in the development of exports (including SAF technology) in the long-term. However, achieving a scale of production that could support both domestic use and export would require the creation of a very compelling investment climate capable of attracting a significant level of investment in the sector.

- **Ensuring future competitiveness through reliable access to affordable imports and creating additional linkage to other markets:** Global competition for limited SAF volumes is currently very high, and end users are already reporting serious challenges with procuring near-term volumes that meet their specifications at an affordable price (see Section 6 for more details). In the future, there may be risks if Canada falls behind the pace of global aviation decarbonization. Failing to establish the right market structures and partnerships that ensure global fuel suppliers can effectively and consistently sell SAF into Canada may restrict airlines' options to meet existing (or future) global compliance obligations or potentially result in additional costs and decreased overall competitiveness. Canadian airports could also be affected if limited or no SAF use impacts their ability to maintain / attract new international routes.
- Investment in domestic production is another way to ensure reliability of SAF supply and support competitiveness. Going further, the use of Canadian feedstocks in domestic production (rather than exporting feedstocks to the U.S. for processing, which is occurring today) could mitigate against supply chain disruptions and further increase security of supply for the aviation sector.

Operational benefits:

- **Improving aircraft performance:** Depending on the type of SAF, it can have a higher energy content and combustion efficiency than traditional jet fuel. As a result, for the same volume of fuel, SAF can provide more energy which can potentially result in increased range for aircraft. Neat SAF contains fewer-to-negligible aromatics (e.g., naphthalene), meaning it burns cleaner in aircraft engines, reduces build up and deposits, which can potentially lead to longer engine service life.[9] It should be noted however, that current SAF aromatics specifications in ASTM D7566 require at least 8% aromatics content by volume to ensure material compatibility such as fuel seal swelling properties to prevent fuel leakage.

Environmental benefits:

- **Reducing GHG emissions:** The key benefit of SAF is that it is not fossil-based and therefore its use, compared to conventional fuel, helps limit the incremental GHG emissions from aviation on a lifecycle basis. Compared with petroleum-derived jet fuel (and depending heavily on the feedstock, production pathway, and LCA methodology), the use of neat SAF results in GHG emissions savings. For example, SAF derived from used cooking oil via the HEFA production pathway achieves at least 84% GHG emissions savings using ICAO's default value for this SAF pathway. The value could rise to more than 100% when considering SAF pathways based on feedstocks that significantly increases soil carbon. ICAO captures this as negative induced land use change GHG emissions for several SAF

8 https://rhg.com/wp-content/uploads/2022/12/Sustainable-Aviation-Fuels_Decarbonizing-Aviation.pdf

9 The U.S. Department of Energy Bioenergy Technologies Office, "Sustainable Aviation Fuels," accessed 2024

pathways, particularly those based on herbaceous energy crops.[10] Considering other available and future technologies and out of sector measures available to decarbonize the global aviation sector, the International Air Transport Association (IATA) projects that the use of SAF could contribute around 65% of the reduction in global emissions needed by aviation to reach net zero CO_2 emissions by 2050.[11] Canada's own projections from its Aviation Climate Action Plan 2022-2030 expect that SAF could contribute up to 46% of the emissions reductions needed to reach net zero Canadian aircraft emissions by 2050.[12]

- **Reducing non-CO_2 impacts:** Contrails (also referred to as condensation trails) form behind jet engines in ice-supersaturated regions and can transform into clouds, which are understood to have a warming effect. A study published in 2024 by Airbus, Rolls-Royce, Neste and the German Aerospace Centre (DLR) demonstrated that a 100% SAF blend can reduce the soot particles produced when flying, which led to a 56% reduction in the volume of contrail ice crystals compared to the use of Jet A-1 fuel. The study estimates SAF could result in at least a 26% reduction in the contrails' climate impact.[13] SAF-powered flights also generate fewer conventional pollutants (e.g., sulfur oxides and particulates) that contribute to local air quality issues around airports.[14] It should be noted, that as an alternative, conventional jet fuel could be produced with lower aromatics and sulfur content to reduce contrails. There are still large scientific uncertainties relating to how contrails affect overall cloudiness over time (natural & human induced), including the incremental climate effect of contrails and contrail-cirrus.
- **Improving feedstock utilization:** Increased global demand for bio-based feedstocks to support low-carbon aviation could result in a concurrent increase in global research and development (R&D) and understanding of practices for the more effective cultivation and utilization of the feedstock from existing agricultural and forestry industries by suppliers and producers. Research and development that leads to higher density yields from feedstocks and more effective utilization could help to minimize environmental risks associated with land use change.
- **Environmental benefit of SAF feedstocks:** Depending on the production pathway, the production of SAF can help reduce waste, such as municipal solid waste and agriculture residues. Some bio-based feedstocks that can be used in SAF production can also help to reduce erosion and improve water quality and quantity, increase biodiversity, and help to store carbon in the soil, which delivers on-farm benefits. The use of manure and municipal waste to produce renewable gas as a feedstock for SAF production can also displace the use of petroleum fossil fuels, while also keeping methane gas out of the atmosphere.[15] To ensure that these benefits can be realized, strategic investments and policies could help to support innovation in biomass crop usage and renewable energy production for use in SAF processing.

10 https://www.sciencedirect.com/science/article/pii/S1364032121006833?via%3Dihub

11 https://www.iata.org/en/programs/sustainability/sustainable-aviation-fuels/#:~:text=We%20estimate%20that%20Sustainable%20Aviation,in%20order%20to%20meet%20demand

12 https://tc.canada.ca/sites/default/files/2022-11/canada-aviation-climate-action-plan-2022-2030.pdf

13 https://www.theengineer.co.uk/content/news/study-finds-saf-cuts-warming-effect-of-aircraft-contrails#:~:text=%E2%80%9CThanks%20to%20ECLIF%20studies%2C%20we,are%20for%20decarbonising%20air%20transport.%E2%80%9D

14 https://www.eesi.org/articles/view/an-introduction-to-sustainable-aviation-

15 The U.S. Department of Energy Bioenergy Technologies Office, "Sustainable Aviation Fuels.", accessed 2024

How Much SAF Will Canada Need?

Achieving Canada's aspirational goal of 10% SAF use will require approximately 1 billion litres in 2030. Due to the various pathways possible to help reach net-zero emissions, the amount of SAF ultimately required to achieve net-zero is unknown at the present time, with a wide range of possibilities, but might be in the range of 8 billion litres annually. Supply chains to support both the domestic production and import of significant volumes of SAF for blending and uplift in Canada will take time to build, and it is likely that, at least in the near- and medium-term, relatively few airports in Canada will have reliable and consistent access to SAF.

As of 2025, there is no commercial SAF production in Canada. As being experienced across many jurisdictions, in Canada there have been announcements of potential project investments totalling an estimated nameplate production capacity of over 1 billion litres per year. Some of the announcements identify that they could be scheduled for completion by 2030. However, as of the time of writing of this report, in all cases there have been no recent updates from the potential producers, and none have reached final investment decision (FID). As 2030 approaches, the likelihood of commercial production by that time decreases based on a number of reasons, including those mentioned in this report. In theory, if every announced project in Canada were to be realized, SAF from domestic production alone could exceed the volumes required for the 10% aspirational goal. However, this outcome is unlikely. One potential project represents more than half of the announced projects by volume (including its expansion). Although this announced capacity anticipates that it would be online during the year 2030, delayed investment decisions will result in Canada relying on imported SAF to meet its goal.

In short, realizing the 10% aspirational goal by 2030 through domestic production alone is incredibly unlikely (see Section 5 for more details). Some international SAF volumes will likely continue to be available for import into Canada, but global demand is growing for scarce supply, compounded by policy uncertainty in the United States which is resulting in both uncertainty around feedstock flows and additional investment delays. Biofuel refineries are expected to come online within the decade, but many are on a similar construction schedule and will also face timeline-related risks (see Section 6 for more details). In the longer term, it is highly likely Canada will need to rely on a balance of imports and domestic production to decarbonize its aviation sector.

Navigating the low-carbon transformation of the aviation industry

Driving sustainable change in Canadian aviation will require an approach that balances the necessity to achieve meaningful lifecycle emissions reductions on an accelerated timeline with the need to ensure that Canada's aviation transportation network remains competitive and affordable for its consumers. In Canada's user pay system, where the system users pay the total cost of the services they receive, any additional costs of purchasing SAF are likely to be passed directly onto consumers. Ensuring that Canadians remain connected with access to affordable transportation while the industry is undergoing this major shift toward decarbonization is a key priority when considering measures to support the growth of a SAF marketplace in Canada.

User fees affect costs and competition

Canada follows a user-pay model. Fees airlines and passengers pay cover most of the costs of building and running airports and air navigation services. According to a report by the Competition Bureau Canada, these fees can make up to thirty cents of every dollar that passengers pay airlines (30%) for traditional full-service airlines (amounts vary depending on the flight). Those costs take up an even higher share of what passengers pay for flights on ultra-low-cost carriers (ULCCs).[16]

Key fees can roughly break down to:

- Fuel tax – **1%**
- The Air Travellers Security Charge – **3%**
- Nav Canada air navigation charges – **5%**
- Airport fees – **20%**

16 https://competition-bureau.canada.ca/en/how-we-foster-competition/education-and-outreach/publications/cleared-take-elevating-airline-competition

Policy Landscape in Canada

In 2021, the Canadian Net-Zero Emissions Accountability Act enshrined in legislation the Government of Canada's commitment to achieve net-zero GHG emissions (economy wide) by 2050. It established the 2030 GHG emissions target as Canada's Nationally Determined Contribution under the Paris Agreement (40-45 percent below 2005 levels by 2030). In December 2024, Canada set a 2035 target of 45–50% below 2005 levels.

The 2030 Emissions Reduction Plan outlines a sector-by-sector path for Canada to reach its 2030 emissions reduction target. A commitment under the 2023 Progress Report is to advance the development of this SAF Blueprint.

Though new and/or expanded measures would help create a SAF market in Canada, there are various measures in place (nationally and provincially) that can support SAF production and use in Canada. These include:

- Canada's participation in ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) will mandate offsetting requirements for obligated Canadian operators' international flights, requiring the purchase of CORSIA eligible fuels, and/or the purchase and cancellation of emissions units.
- Budget 2021 announced a Clean Fuels Fund (CFF) ($1.5 billion investment over 5 years) to increase Canadian clean fuel production capacity. The Fund provides capital investment support to build new or expand existing clean fuel production facilities (including facility conversions), FEED studies, the establishment of biomass supply chains, and address gaps and misalignment in codes, standards, regulations, distribution, and end-use of clean fuels. Budget 2024 announced the retooling of the CFF and extended the program to 2030. In Budget 2025, $175M of the CFF budget was repurposed for the Biofuel Production Incentive. The CFF will not receive new proposals, and a reduced number of eligible projects from the second call for proposals will receive funding.
- The Canada Infrastructure Bank (CIB) provides concessionary financing for clean fuels production facilities (including SAF) under its Green Infrastructure Investment Stream. Budget 2024 announced that CIB will invest at least $500 million in biofuel production through this stream. In addition to construction finance, the CIB also can offer loans to support FEED studies during the development phase through its FEED Capital Initiative.
    - In 2024, the Canada Infrastructure Bank, the Clean Fuels Fund, and provincial governments partnered to support Azure's FEED studies for SAF production facilities in British Columbia (B.C.), Manitoba, and Ontario.
- The Energy Innovation Program (EIP) supports research, development and demonstration projects and other science-related activities by investing in the work of Indigenous communities, Canadian businesses, federal labs and other organizations. These groups are focused on creating innovative clean energy technologies, expanding and integrating existing solutions, and fostering the clean energy ecosystem through the sharing of information and knowledge.

For instance, the 2021 Clean Fuels and Industrial Fuel Switching call for proposals under the EIP focused on clean fuels production for use in hard-to-abate sectors and industrial fuel switching.

  - Greenfield Global Inc. received $1 million under EIP's Clean Fuels and Industrial Fuel Switching Call. The project focuses on producing renewable diesel and SAF from waste biomass.

- Under the Clean Fuel Regulations (CFR), fuel suppliers that produce or import SAF and other low-carbon fuels are eligible to create compliance credits. This credit market provides some financial incentive for SAF production or import into Canada as fuel suitable for use in aviation is able to create credits while facing no regulatory reduction requirement itself.
- The Government of Canada's Greening Government Strategy (GGS) establishes targets for reducing GHG emissions from federal air and marine operations, including a goal of purchasing at least 20% low-carbon fuels for domestic operations by 2030. Some federal SAF purchases are supported by the Low-Carbon Fuels Procurement Program which offsets the cost premium of low-carbon fuels used in federal air and marine operations.
- Support for innovative projects across multiple sectors and technologies is also available from the Strategic Response Fund (formerly the Strategic Innovation Fund).
  - In 2023, the Strategic Innovation Fund announced support of $350 million to establish Canada's new Initiative for Sustainable Aviation Technology (INSAT). This initiative seeks to accelerate the green industrial transformation of the aerospace industry, with one of its four focus areas being the transition to alternative fuels, in addition to hybrid and alternative propulsion, innovative aircraft architecture and systems integration, and aircraft support infrastructure and operations.
- The Government of B.C. has implemented a Low Carbon Fuel Standard (LCFS) for aviation fuel, which requires fuel suppliers to decrease the carbon intensity of aviation fuel over time by blending low-carbon fuels with conventional jet fuel and/or by credits generated by on-road applications. It also has volumetric renewable content requirements for jet fuel supplied to B.C. (starting at 1% in 2028 and increasing 1% annually to 3% in 2030). Suppliers of low carbon fuel can also earn credits in the B.C. LCFS carbon market. Credits are also awarded to initiative agreements, which are determined annually.
  - In February 2025 the Government of B.C. announced regulatory changes that will require eligible renewable fuels to be produced in Canada (this does not apply to jet fuel / SAF). The regulatory changes boost the renewable fuel requirement for diesel from 4% to 8%. As of April 1, 2025, the additional 4% renewable fuel requirement for diesel must be met with eligible fuels produced in Canada.
- In 2024, B.C. also launched the B.C. Low Carbon Jet Fuel Incentive Program. Through incentives, the program is offering cash or credit incentives to eligible applicants to help offset the higher costs of SAF/lower carbon jet fuel compared to traditional jet fuel until December 31, 2026.
- In the near term, B.C. is the most likely jurisdiction in Canada for SAF use and production, given the existing market-based incentives available through the B.C. LCFS, in combination with the credits available through the CFR.

SECTION 2

METHODOLOGY

The development of the SAF Blueprint was a collaborative multi-stakeholder effort that brought together Canadian insights and experience from across the SAF supply chain. To build a perspective on the size of the opportunity and how the marketplace for import and production could develop in Canada, the following key steps were completed. Recognizing that data and reporting around SAF, particularly in Canada, is still emerging, insights and experiences from members of the Sustainable Aviation Task Force's SAF Subgroup were leveraged where information was not publicly available.

- Jurisdictional scan of SAF market development in the United Kingdom, U.S., Europe, South America and Asia.
- Analysis of the potential impact of policy interventions using global examples.
- Review and validate key findings and assumptions of core studies, including the *C-SAF Roadmap: Building a feedstocks-to-fuels SAF supply chain in Canada* and other relevant reports.
- Development of a Maximum SAF Production Scenario to quantify the impacts of technology development and feedstock market dynamics.
- Industry interviews focused on global policy progress on jet fuel; feedstock uses and availability including imports and exports; experiences in Canadian SAF procurement, supply and demand; and the impact of standards and certifications.
- Multiple working sessions and workshops with the SAF Subgroup and the Sustainable Aviation Task Force, which included representation from over 90 stakeholders from across the value chain.

Maximum SAF Production Scenario

The Maximum SAF Production Scenario was developed based on a Deloitte global SAF volume model that was refined to reflect Canadian data using assumptions that were validated by the SAF Subgroup. Based on projected availability of Canada's feedstocks and the advancement of technologies that are currently at a pre-commercial stage of development, it estimates potential volumes of SAF that could be produced in Canada for 2030, 2040 and 2050. The results were reviewed and validated with the SAF Subgroup and compared to government and external studies. It should be noted, however, the Maximum SAF Production Scenario was built exclusively on feedstock availability and technological readiness. A summary of the scenario's inputs and outputs is available in Appendix 2.

Core studies

Several recent studies that offer an exploration of how the SAF market could develop in Canada were leveraged and compared with the findings from Deloitte's analysis for the SAF Blueprint. These include:

- The **C-SAF Roadmap** (published in June 2023) went beyond earlier Canadian studies by exploring feedstock availability, technology pathways, and potential supply chains to develop a SAF market in Canada. It sought to reframe aviation decarbonization for Canada to seize its economic opportunities in the supply chain. C-SAF aligned its member ecosystem around a target for the production and use of 1 billion litres of SAF with at least a 50% reduction in carbon emissions by 2030. A two-year action plan with priorities was formulated based on 5 action areas: Policy and Programs, Sustainability, Feedstocks, SAF Production Capacity, and Technology and Innovation.
- The Centre for Greening Government's Enhancing Collaboration among SAF End-Users and Canada's Aviation Climate Action Plan.
- **Deloitte's 'Reaching Cruising Altitude: A Plan for Scaling Sustainable Aviation Fuel'** report made the case for Canadian SAF and explored the barriers and opportunities within policy and funding, leadership and accountability, accounting and reporting, and partnerships and collaborations, along with action plans for each.

Additional references

In addition to the core studies, the project team that developed the SAF Blueprint and its Maximum SAF Production Scenario also reviewed relevant SAF and biomass reports, and collected raw data from federal and external sources including, but not limited to:

SAF Reports	Biomass Reports	Raw Data
• Natural Resources Canada – Possible production of SAF in Canada • C-SAF Roadmap: Building a feedstocks-to-fuels SAF supply chain in Canada • Centre for Greening Government – Enchancing Collaboration among SAF End-Users • Deloitte – Global SAF research • Waterfall Group – Sustainable Aviation Fuel Market Outlook • Canada's Aviation Climate Action Plan 2022-2030 • + Others	• Deloitte, C-SAF and TC – Growing Canada's Sustainable Aviation Feedstock: Workshop Report • IET – Biomass and carbon neutrality report • Agriculture and Agri-Food Canada - 2020 Analysis of Canadian Biomass Inventory in Support of BioFuel Production • USDA – Biofuels Annual • CBSCI – HEFA Production & Feedstock Selection 2019 • + Others	• Statistics Canada • Feasibility study of Canadian bio jet fuel supply chain • Wood Pellet Association of Canada • Canola Council of Canada • Canadian Agri-Food Trade Alliance (CAFTA) • Government of Canada's annual crop inventory database • Grain Farmers Ontario • + Others
		

SECTION 3

GLOBAL PERSPECTIVE: CURRENT STATE OF SAF

The global aviation industry and fuel producers have been investing in SAF technologies and infrastructure for 15 years, but it has only been recently that growth in SAF investment has started to accelerate. In 2024, global SAF production volumes reached 1.3 billion litres, doubling the previous year's level of production for the third year in a row (see Table 04 below). According to ICAO's tracker of SAF facilities (which is based on publicly available announcements), there are 37 facilities in service and a further 11 facilities under construction (see Figure 01 below). As of November 2025, a total of 104 airports worldwide had announced that they have a continuous availability of SAF for operations.[17]

TABLE 04 | Global annual SAF production volumes

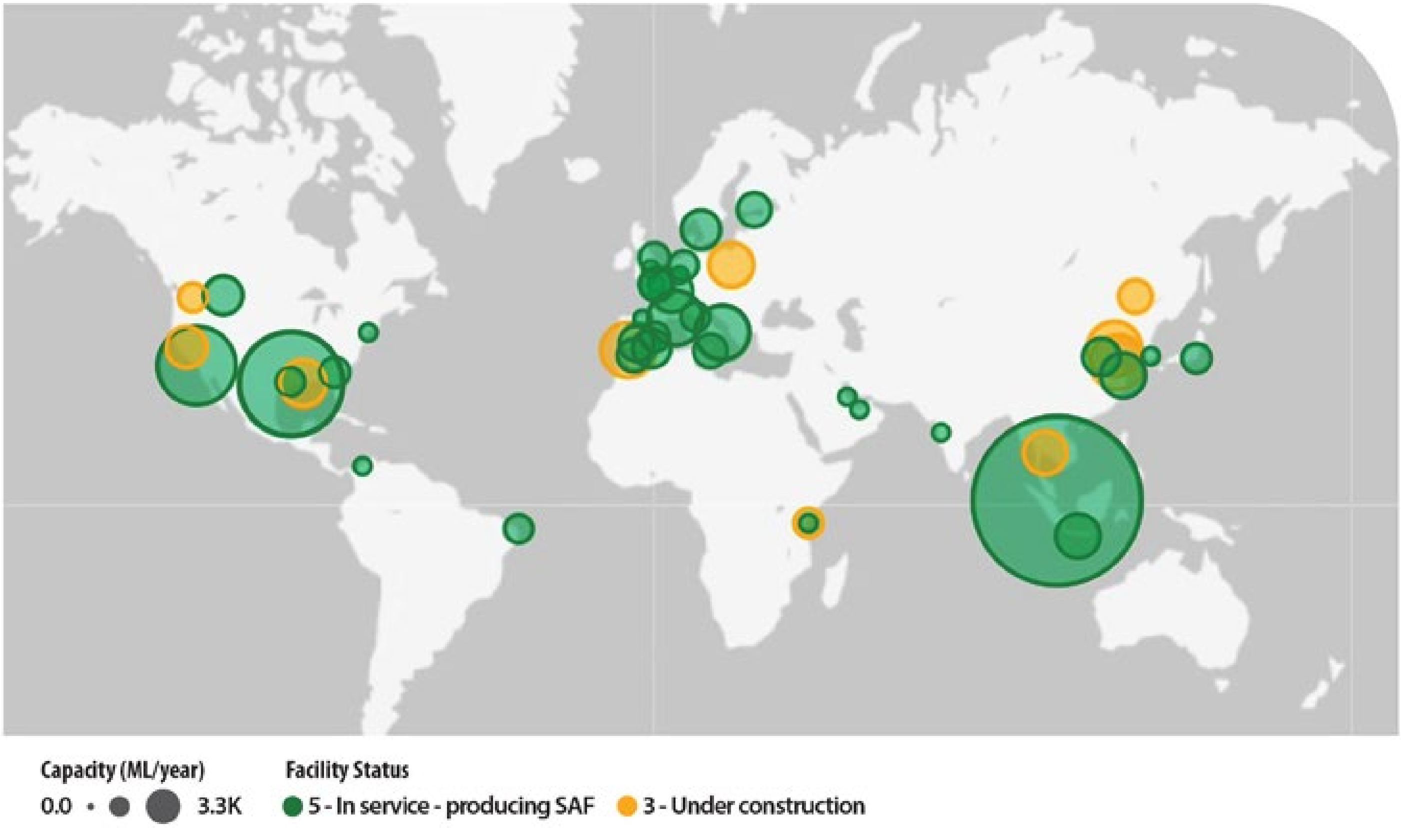
Year	SAF production volumes (in millions of litres)
2021	99.9
2022	300
2023	600
2024	1,300
2025 ***[projected]***	2,700

Source: International Air Transport Association (2024)[18]

17 https://www.icao.int/SAF/SAF-airports

18 https://www.iata.org/en/pressroom/2024-releases/2024-12-10-03/#:~:text=Geneva%20%E2%80%93%20The%20International%20Air%20Transport,of %20global%20renewable%20fuel%20capacity*.

FIGURE 01 | **Total global SAF production capacity in service and under construction (January 2025)**



Source: ICAO tracker of SAF facilities (accessed Jan 2025)[19]

Nevertheless, global SAF volumes for 2024 are still lower than previously forecast, in part because several U.S. facilities have pushed back their production ramp up to the first half of 2025. Moreover, in the broader context of aviation, commercial SAF facilities account for only 0.3% of global jet fuel supply and 11% of global renewable fuel production.[20] The cost of SAF production also remains much higher than conventional jet fuel (typically between 2-8 times higher, depending on the production pathway) and variability in the market price for SAF over time and between regions continues to be significant (see Section 6 on Importing for more details).

In tandem with the adoption of other emissions reduction solutions, IATA projects that production of SAF would need to reach 449 billion litres to meet net-zero by 2050.[21] The largest acceleration would need to happen in the 2030s – ideally as policy support becomes global, potential lower prices lead to better competitiveness with fossil-based kerosene, and credible offsets (e.g., carbon credits) become scarcer.

Carbon Offsetting and Reduction Scheme for International Aviation

Domestic aviation typically falls under national laws and regulations and forms part of a country's nationally determined contributions under the Paris Agreement. In contrast, policies for international aviation are discussed and agreed to at ICAO, the United Nations Agency responsible for aviation. As referenced in

19 https://www.icao.int/SAF/SAF-production-facilities

20 https://www.iata.org/en/pressroom/2024-releases/2024-12-10-03/#:~:text=Geneva%20%E2%80%93%20The%20International%20Air%20Transport,of%20global%20renewable%20fuel%20capacity

21 Deloitte research 2023

above, one of the existing policies to encourage SAF uplift in Canada (and among other ICAO Member States) is participation in ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

CORSIA is the global market-based measure that aims to achieve carbon-neutral growth for international aviation from 2020 onwards. The initiative requires airplane operators with international routes to acquire CO_2 emissions reduction units on the open market from other sectors to offset the emissions growth of international aviation. Operators have the option to reduce offsetting obligations through the use of CORSIA eligible fuels (CEF) that have at least 10% fewer GHG emissions on a lifecycle basis. To produce CEF, fuel producers must be certified by a Sustainability Certification Scheme (SCS) that has been approved by the ICAO Council to perform the certification.

As Canada has adopted CORSIA into regulation, all types of aircraft operators (commercial, business, private) that emit more than 10,000 tonnes of CO_2 emissions on international flights from 2019 to 2035 have to offset growth from the agreed CORSIA baseline. These obligations started in 2024, after a short delay caused by the COVID-19 pandemic. They will become more stringent over time and mandatory for larger ICAO member states in 2027.

SAF Policies in Other Jurisdictions:

With global production still extremely low relative to conventional jet fuel supplies, the SAF capacity that is emerging (largely Asia) is gravitating toward regions with incentives and mandates such as the U.S. and Europe.

Over the last six years, governments worldwide have begun introducing incentives, mandates, and programs with ambitious goals to drive SAF adoption. Regulatory frameworks and incentive programs aimed at fostering the development, deployment, and utilization of SAF exhibit regional diversity. Leading this divergence, the U.S. relies on an approach of rewarding desired behaviour with incentives while the European Union (E.U.) mandates minimum SAF usage and GHG emissions reductions along with individual States also providing some incentives. Additionally, a 2023 revision of the E.U. Emission Trading Scheme (ETS) Directive provides a support mechanism for the use of eligible aviation fuels which is estimated at around €1.6 billion, and set aside from 1 January 2024.[22] Based on current and announced commercial commitments, country-level demands are expected to be concentrated in Europe and the U.S., although regulations have also begun to be introduced in Asia, specifically Singapore.

The Canadian market mainly competes with U.S. producers. Incentives in the U.S. for SAF production have created favourable investment conditions that impact opportunities for potential Canadian SAF producers. Further, the U.S. market has the greatest demand pull on Canadian feedstocks (under current regulations) and competition between airlines in Canada and the U.S. for SAF supply is high due to the close geographical proximity.

22 https://climate.ec.europa.eu/news-your-voice/news/adoption-eu-rules-ets-support-system-accelerate-use-sustainable-aviation-fuels-2025-02-06_en

The following section is a brief overview of the leading jurisdictions that have introduced policies to support SAF production and use. Canada can learn from the experiences of other jurisdictions, as it considers measures to create a domestic SAF market.

- As part of its SAF Grand Challenge, the **U.S.** federal government set an ambitious target to reach 11.3 billion litres of domestic SAF production by 2030. As of September 2024, the U.S. had the second-highest nameplate capacity for SAF production[23] and is leading the world on announced projects, with over 11 billion litres of announced SAF projects scheduled for completion by 2030 (representing USD$44 billion in announced investment).
  - **Federal programs:**
    - At a national level, production of SAF in the U.S. gained substantial support through the passage of the Inflation Reduction Act (IRA) in 2022, with USD$3.3 billion in available tax credits.[24] Beginning in January 2025, and modified under the One Big Beautiful Bill, the Clean Fuel Production Tax Credit (45z) offers tax credits of up to USD$1 per gallon for the production and sale of low emission transportation fuels, including SAF. This credit is available until the end of 2029.
    - The Renewable Fuel Standard (RFS) is the backbone of the U.S. biofuel and SAF industry (SAF typically claims RIN D4 credits). This policy is a mandate on road fuel users and is predominately met using ethanol from maize/corn. The environmental attributes from SAF can be sold to obligated parties as credits, although fossil jet fuel is not itself obligated.
    - Under the Environmental Protection Agency's proposed "Set 2" RFS rule for 2026–2027, renewable fuels produced from foreign feedstocks or imported renewable fuels would generate only 50% of the RIN value compared to those made from domestic feedstocks.
  - **Examples of State level programs:**
    - The California Low Carbon Fuel Standard (LCFS) offers credits for SAF suppliers (opt-in), based on a carbon intensity score. The program tends to provide larger incentives to renewable diesel products than to SAF due to the LCFS' carbon intensity calculations.
    - In addition to some preferential tax rates and its own LCFS, Washington State offers a tax credit for the sale and purchase of alternative jet fuel with a least a 50% reduction in lifecycle emissions, worth between USD$1-2 per gallon (depending on the carbon intensity). There are also credits available for the use of SAF in flights departing from Washington State (claimable only once one or more facilities in the state achieve a production capacity of 75 million litres per year).[25]
    - Oregon's Clean Fuels program sets carbon intensity limits for non-aviation transportation fuels and provides voluntary credits for SAF.
    - Illinois has a Sustainable Aviation Fuel Purchase credit worth up to USD$1.50 per gallon of SAF (with a minimum 50% reduction in lifecycle emissions) sold to or used by air carriers in Illinois.
    - Minnesota has a Sustainable Aviation Fuel Tax Credit for SAF produced or blended in the state or sold for use in flights leaving the State, offering up to USD$1.50 per gallon of SAF (with a minimum 50% reduction in lifecycle emissions).
    - Nebraska has a SAF tax credit which provides a USD$0.75 per gallon tax credit for the production of low-carbon aviation fuel (with a minimum 50% reduction in lifecycle emissions).
    - Montana's Alternative Fuel Production Property Tax Incentives offer property tax abatement to eligible SAF production facilities.

23 https://www.icao.int/SAF/SAF-production-facilities

24 IEA, "Aviation."

25 https://www.nrel.gov/docs/fy24osti/87802.pdf

- The Government of the **United Kingdom** (U.K.) published its Jet Zero Strategy in July 2022, which sets out the actions that will need to be taken to achieve net zero by 2050 in the aviation sector. By 2025, the U.K. has committed to have at least five U.K. SAF plants under construction.
  - Since 2008, the U.K. has had a Renewable Transport Fuel Obligation (RTFO), which applies to entities that supply over 450,000 litres of petrol, diesel, gas oil or renewable fuel, including aviation. In 2024, the U.K. announced a separate SAF mandate, seeking to establish a minimum threshold amount for all jet fuel in flights departing from the U.K. that must be provided by sustainable sources. The mandate is set to start in 2025 at 2% of total U.K. jet fuel demand and will increase on a linear basis to 10% in 2030 and to 22% in 2040. From 2040, the obligation will remain at 22% until there is greater certainty regarding SAF supply.[26] The mandate will phase in a cap on the feedstocks used in the hydro-processed esters and fatty acids (HEFA) process, although not until other types of SAF are also commercially viable. There will also be a separate obligation on power to liquid (PtL) fuels, starting in 2028, which will reach 3.5% of total jet fuel demand in 2040. The obligations of this mandate will be placed on the fuel suppliers.
  - Alongside the mandate, the U.K. Sustainable Aviation Fuel Act 2026 achieved Royal Assent on March 5, 2026, establishing a legal framework for a revenue certainty scheme.
  - Beyond regulatory measures, the U.K.'s Green Fuels, Green Skies Competition provided £15 million for early-stage development of SAF production plants. The U.K. also invests in research and development to explore new technologies and feedstocks for SAF production, as well as grant funding for demonstration and commercial scale projects through its Advanced Fuels Fund. The program has allocated over £135 million for the development of SAF production plants in the U.K.
  - London Heathrow Airport also offers incentives through Heathrow's SAF Incentive Program.[27]

- Within the **E.U.**, France, Italy, Netherlands, Sweden and Spain are regional leaders.[28] With some of the strongest regulatory pressures in the world, demand for SAF is projected to escalate significantly in Europe, reaching 46 million tonnes by 2030.[29]
  - The European Union (E.U.) has adjusted the Emissions Trading System, intending to eliminate free allowances for the aviation sector by 2026. As part of its 'Fit for 55' package, the ReFuel EU Aviation regulations mandate that flights departing from larger European airports must carry a minimum amount of SAF, with binding targets starting at 2% SAF by 2025, rising to 6% by 2030, and eventually reaching 70% in 2050. Within these regulations, there are also specific targets for synthetic fuels. The rules also prevent fuels produced from feed and food crops (e.g., canola), intermediate crops, palm and soy-derived materials, and soap stocks and their derivatives from participating in the program.[30]
  - Within the E.U., individual Member States have enacted their own policies to support SAF development and use.

26 Sustainable aviation fuel initiatives - GOV.UK (www.gov.uk)

27 https://www.heathrow.com/company/about-heathrow/heathrow-2-0-sustainability-strategy/our-carbon-strategy/sustainable-aviation-fuel-saf#:~:text=The%20scheme%20incentivises%20the%20use,swap%20to%20cleaner%20fuels3

28 https://www.icao.int/SAF/SAF-production-facilities

29 https://alternative-fuels-observatory.ec.europa.eu/transport-mode/aviation/general-information-and-context

30 https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/refuel-eu-aviation-handbook.pdf

- **Singapore** is home to the world's largest SAF production facility, Neste's Singapore refinery, which has capacity of up to 1.2 billion litres. It is a major supplier to both U.S and European markets.
  - Starting in 2026, Singapore has announced it plans to require all flights departing the country to use SAF, aiming for a target of 1% in 2026, and raising it to 3-5% by 2030.[31] Rather than enacting a blend mandate, the procurement of this SAF will be funded by levies imposed on air travellers through plane ticket prices, and the Central Aviation Authority of Singapore will procure the greener aviation fuel using the collected levies.[32]
- **China** has around 500 million litres per year of SAF production capacity (over 90% of which is destined for export), with a further 4.8 billion litres of new capacity announced. In addition to exporting SAF, it is also a major global exporter of waste and residue feedstocks, such as used cooking oil. Its domestic policy is still developing. The country launched its first SAF pilot programme in September 2024, whereby twelve commercial flights from Air China, China Eastern and China Southern will use SAF at four airports, with plans to expand in 2025.[33]

Global Partnerships and Measures

Industry Partnerships

As the aviation industry adapts to the emerging SAF market both globally and in Canada, leading stakeholders have come together to collaborate and form alliances to support the widespread adoption and education around the use of SAF. The rationale for this effort varies among stakeholders, including interest in environmental commitment, regulatory compliance, market leadership, cost efficiency in the long term, innovation and competitive advantage, stakeholder pressure, and operational resilience.

Globally, commercial airlines have played a big role in driving progress on SAF through partnerships, offtake agreements, and partnering on research and development. In some cases, this support has helped production facilities obtain the investments required to move forward. For instance, LanzaJet opened the world's first ethanol to SAF production facility in Georgia, U.S., boasting an annual capacity of 37 million litres with funding from the U.S. Department of Energy, a loan from Microsoft's Innovation Fund, and a USD$50 million grant from Breakthrough Energy[34]. LanzaJet's partnership with British Airways, and Nova Pangaea Technologies' on Project Speedbird has secured USD$11.2 million in government funding to drive SAF production. Test flights using SAF have been conducted by Thai Airways, Bombardier, Gulfstream, and Virgin Atlantic, with GE Aerospace making continued progress towards 100% SAF-compatible engines. In 2023, United Airlines and its partners launched an investment vehicle to support start-ups working on SAF research, production and technology, leveraging over USD$200 million in investments[35]. Some Canadian airlines have also initiated investments, including Air Canada's investment with Carbon Engineering, a Canadian company focused on direct air capture technology. Air Transat, a member of the SAF+ International Group network, in partnership with Airbus, Pratt & Whitney, is assessing the feasibility of developing a commercial e-SAF plant in Quebec.

31 https://www.reuters.com/sustainability/singapore-require-departing-flights-use-sustainable-fuel-2026-2024-02-19/

32 https://www.spglobal.com/commodity-insights/en/news-research/latest-news/agriculture/091224-appec-singapores-saf-levy-to-only-apply-to-air-ticket-sales-from-2026

33 https://www.weforum.org/stories/2024/12/could-cooking-oil-from-china-disrupt-civil-aviation-with-sustainable-fuel/

34 https://www.lanzajet.com/freedom-pines

35 https://www.united.com/en/us/fly/company/responsibility/united-airlines-ventures.html

A different subset of these industry partnerships is focused specifically on building market demand, albeit through different strategies. These include:

- **Airline schemes to promote consumer choice:** These programs enable passengers, corporations and cargo customers to contribute to paying the SAF premium through opt-in programs, green fares, or direct purchase of SAF. Some airlines, including KLM / Air France, have extended this type of program to include a ticket price increase that is clearly linked to SAF, with fee increases ranging from 1-12 euros.[36] WestJet and Air Canada both offer opt-in programs, which help to build demand.
- **SAF producer schemes:** These programs enable airlines or corporations to buy SAF directly from producers or retailers – and are typically combined with a book and claim system. Airlines can also choose to buy SAF directly.
- **Joint procurements:** These programs seek to aggregate demand and attempt to offer price certainty by creating larger volume procurements over multiple years. Canada could explore a voluntary procurement partnership program between aviation stakeholders, corporations, and potentially even governments, to purchase SAF or SAF certificates, creating a demand signal while helping Canadian businesses to reduce their Scope 3 emissions. It could also work toward the development of a demand forecast, in collaboration with key industry associations and Canadian airlines, with the aim to send a signal to fuel producers about Canadian airlines' willingness to pay for reliable volumes of SAF.
- **Educational campaigns to promote demand:** Airports and airlines also have a role to play in driving demand by educating passengers and business partners on the environmental and economic benefits of SAF use for Canada. In 2023, United Airlines partnered with Sesame Street on a consumer education campaign to promote the benefits of using SAF, highlighting tools like its carbon footprint estimator and the airline's Sustainable Flight Fund.[37]
- **Feedstock studies:** Feedstock suppliers, fuel suppliers, government, and airlines can also help to generate demand for Canadian SAF and feedstocks by conducting life cycle assessments of anticipated Canadian SAF pathways. Research could offer insight into how best to leverage Canada's advantages to support low-carbon intensity SAF production, including identifying areas in the lifecycle of the fuel that could be improved (see Section 8 on Sustainability Criteria and Accounting for more details).

The following are a few examples of specific international initiatives that have emerged:

- **Sustainable Aviation Buyers Alliance (SABA):** Spearheaded by Environmental Defence Fund (EDF) and RMI, SABA is trying to accelerate the path to net-zero aviation by driving investment in SAF and supporting companies, airlines, and freight customers to achieve their goals. Members include Workday, Microsoft, UPS, and Deloitte.
  - **Goals:** Develop a high-integrity SAF framework to guarantee credible emissions reductions, accelerate and aggregate investment in SAF, build transparent and credible tracking systems, and provide education and policy support.
  - In 2023, SABA coordinated the purchase of over 3 million litres of SAF.
  - In 2024, SABA and its members committed to channel close to $200 million into purchasing SAF certificates – equal to roughly 50 million gallons (or 189 million litres) of SAF.[38]

36 https://www.france24.com/en/live-news/20220110-air-france-klm-adds-biofuel-surcharge-to-plane-tickets

37 https://biodieselmagazine.com/articles/united-launches-consumer-education-campaign-on-saf-2518576

38 Sustainable Aviation Buyers Alliance Announces Historic Agreements to Purchase Sustainable Aviation Fuel Certificates to Grow

- **Eco-Skies Alliance (United Airlines Investment):** A first-of-its-kind program involving leading global corporations working with United Airlines to help power flying in a more sustainable way. Members include Biogen, Visa, and Meta.
  - **Goals:** Work with United to collectively purchase approximately 12.8 million litres of SAF per year.[39]
- **Sustainable Freight Buyer's Alliance (SFBA):** Smart Freight Centre alongside Business for Social Responsibility (BSR), the World Economic Forum and seven multinational shippers founded SFBA to create a powerful decarbonization demand signal and a centralized hub for action initiatives. Members include corporations like Amazon, Nike, P&G and Nestle.
  - **Goals:** Track impacts and progress towards climate goals of each individual corporation, aggregate demand through the Fleet Electrification Coalition, engage in advocacy to communicate relevant policies to members and inform policy makers on gaps in the industry.[40]
- **The Aviation Initiative for Renewable Energy (AIREG):** Founded in Berlin by aviation companies, airports, research institutes, companies in the aviation industry and companies in the provision and processing of raw materials. AIREG focuses on the increased production and use of regenerative aviation fuels in Germany. AIREG has more than 50 members, including Airbus, Boeing, and BP.[41]
  - **Goals:** By 2030, AIREG's goal is to help reach a 10% quota for SAF use, have at least one commercial SAF facility operate in Germany, and construct and operate a PtL research, technology, and demonstration platform in Germany.

Despite the benefits, consistent challenges have been identified with demand-based programs, which can make industry investment in SAF and industry collaboration more difficult, including price transparency, existing limitations on traceability, cost, and a lack of guidance from standardization bodies that enables organizations to use SAF to reduce value chain emissions (i.e., Scope 3 for corporate travelers). Furthermore, there is not yet clear guidance on how to account for SAF purchases on balance sheets in compliance with Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS) accounting methodologies.

Government-Industry Partnerships

Many countries around the world have developed fora to work with aviation industries to share information and collaborate. In 2022, Japan launched a public-private council to promote the introduction of SAF in Japan.[42] The U.K. has the Jet Zero Taskforce, a partnership between industry, academia and government that is focused on decarbonizing the U.K. aviation sector.[43] Canada had the world's first voluntary agreement to reduce GHG emissions from aviation (signed in 2005 with the Air Transport Association of Canada), which was a precursor to the Aviation Climate Action Plan for 2022-2030 and the Sustainable Aviation Task Force. With the rapidly evolving landscape and various decarbonization plans and initiatives taking place across the country, this type of forum can serve as a vital connection point to discuss emerging issues around SAF deployment, share information about current and future policies, initiate research and to continue to work together on how to monitor adoption and communicate the benefits of SAF use including refining the approach to emissions accounting from SAF use under the Aviation Climate Action Plan.

Government and industry can also work together to leverage international events and fora to pursue initiatives that will both attract foreign direct investment in SAF production and accelerate opportunities for Canadian companies in global markets. There may also be new opportunities to explore international initiatives together, including the development of green aviation corridors. Similar to the models developed for green shipping corridors, aviation corridors could constitute agreements between airports and airlines, to establish dedicated routes that prioritize the use of SAF, helping to share the higher cost of SAF and increasing the demand of SAF at a location.

Investment in Clean Fuel Technologies - Accelerating the transition to net zero aviation (flysaba.org)

39 CEVA Logistics, "Eco-Skies Alliance," accessed 2024

40 Smart Freight Centre, "Join as a member," accessed 2024.

41 Aviation Initiative for Renewable Energy in Germany e.V., "aireg members," accessed 2024.

42 https://www.fas.usda.gov/data/japan-japanese-government-and-industry-partner-develop-saf-capacity

43 https://www.gov.uk/government/groups/jet-zero-taskforce

Policy and Industry Interventions Are Shaping the Market

Global policymakers and the aviation industry are pursuing a wide array of strategies to promote the production and adoption of SAF. An overview of SAF policy options and examples of their implementation are provided in Tables 05 and 06.

TABLE 05 | Supply-side Global Policy Examples

Type of Policy Intervention	Considerations	Examples
Tax incentive or exemption	✓ Helps close price gap between SAF and jet fuel ✓ Increases SAF production in the jurisdiction ✓ Stimulates sustainable feedstock production and processing ✓ May not guarantee product will be used in jurisdiction	• The expired Sustainable Aviation Fuel Credit in the U.S., which included a USD$1.25 baseline credit for each gallon of SAF produced in aviation, with an additional tax credit of 1 cent for every percentage point of emissions savings above 50%, with an upper tax credit limit of USD$1.75 per gallon.[44] • Under Brazil's National Biodiesel Production and Use Programme, biodiesel producers who acquire raw feedstocks from family farmers can claim tax reduction of up to 68%.[45]
Early-stage innovation funding	✓ Funds and promotes RD&D ✓ Promotes innovation and best practices in SAF supply ✓ Needs to be broad to spur innovation across a variety of solutions	• U.K.'s Green Fuels, Green Skies Competition offers £15 million in grant funding to support early-stage development of SAF plants.[46] • French Carbaero with call for project funding in FEED phase. • SAFFA Fund representing USD$200 million with major lessors like Airbus, AirFrance / KLM, AEG Fuels, and BNP Paribas. • In 2022, Japan awarded ¥114.5 billion of grants to pilot projects developing e-fuel, SAF and other green innovation technologies. This initiative is part of a ¥2-trillion green innovation fund to help companies become carbon neutral by 2050.[47]
Capital funding (grants, low-to-no interest loans)	✓ Supports first-of-a-kind SAF production plants ✓ Supports the scale-up of SAF pathways with higher technology readiness levels (TRLs) ✓ Needs to work in parallel with regular financing models	• The U.S. Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Programme provides loan guarantees of up to USD$250 million to fund the development, construction and retrofitting of commercial biorefineries and biobased product manufacturing facilities.[48] • The U.S. Innovative Energy Loan Guarantee Program offers up to USD$3 billion in loan guarantees for commercial-scale SAF projects.[49]

44 Sustainable aviation fuel credit | Internal Revenue Service (irs.gov)

45 SGS INSPIRE, Biodiesel Policies and Markets: Success Stories Around the World, 2020.

46 UK Department for Transport, "Green Fuels, Green Skies (GFGS) competition: winners,"accessed 2024.

47 Takeo Kumagai, Japan awards Yen 114.5 bil grants for e-fuel, SAF and other green technologies, S&P Global Commodity Insights, 2022.

48 U.S. Department of Agriculture, "Biorefinery, Renewable Chemical, and Biobased Product Manufacturing Assistance Program," accessed 2024.

49 https://www.energy.gov/edf/innovative-energy-and-innovative-supply-chain

Type of Policy Intervention	Considerations	Examples

Contract for difference (CfD)	✓ De-risks first-of-a-kind SAF production plants	• The SDE++ (Stimulation of Sustainable Energy Production and Climate Transition) program in the Netherlands subsidizes companies and non-profit organizations that generate renewable energy and use CO_2-reducing technologies via the CfD mechanism.[50] The subsidy is distributed over a period of 12–15 years with a limit varying from €60–300 per tonne of CO_2 avoided.
		• The U.K. government owned Low Carbon Contracts Company (LCCC), which has proven experience delivering the Contract for Difference scheme in the U.K., will act as the contractual counter-party by signing contracts with SAF suppliers and managing payment flows.
		  • If the market price is lower than the Strike Price: LCCC pays the difference to the producer.
		  • If the market price exceeds the Strike Price: the producer pays the difference to LCCC

Direct subsidies for production	✓ De-risks first-of-a-kind SAF production plants	• The Australian Fuel Security Services Payment pays refiners a production payment during loss-making periods based on the number of litres of fuels (petrol, diesel, jet fuel) they produce.[51]
Fossil fuel levies	✓ Increases the price of fossil fuels, which decreases their usage and increases SAF demand	• The E.U.'s revised Energy Taxation Directive proposes a minimum tax rate of €10.75 per GJ, applicable to traditional aviation fuel used on intra-EU flights, while SAF benefits from a zero minimum rate. The policy will be gradually introduced from 2023, before being fully enacted in 2033.[52]
Consumption credit	✓ Makes up price gap and ensures credit goes to reducing price of SAF	• Illinois offers a consumption tax credit for the use of qualifying SAF on flights departing Illinois airports.

50 IEA, "Stimulation of sustainable energy production and climate transition (SDE++) – Policies," accessed 2024.

51 Australian Government – Department of Climate Change, Energy, the Environment and Water, "Liquid Fuel Security Review," accessed 2024.

52 Thomas Kropp, "Opinion of the European Economic and Social Committee on the proposal for a Regulation of the European Parliament and of the Council on ensuring a level playing field for sustainable air transport, 2022.

TABLE 06 | Demand-side global policy examples

Type of Policy Intervention	Considerations	Examples
CORSIA	✓ Offers a global market-based measure that drives airlines to reduce international emissions, including through SAF use	• From 2021 until 2026 (pilot phase from 2021 to 2023; and first phase from 2024 to 2026), only international flights between States that volunteer to participate in CORSIA are subject to offsetting requirements. • From 2027, all international flights will be subject to offsetting requirements (with some exemptions). • Aircraft operators can reduce their obligations through the use of eligible sustainable aviation fuel that adheres to specific sustainable criteria.
Blending mandate (supplier obligations)	✓ Creates the long-term, predictable demand needed to de-risk production (supplementary measures needed to address cost)	• The European Commission has enacted a SAF blending mandate for fuel supplied to E.U. airports, with minimum shares of SAF gradually increasing from 2% in 2025 to 70% in 2050.[53] • The U.K. obligates the supply of an increasing amount of SAF in the overall U.K. aviation fuel mix. The SAF Mandate starts in 2025 at 2% of total U.K. jet fuel demand, increasing linearly to 10% in 2030 and then to 22% in 2040.[54]
Low-Carbon fuel standards (LCFS)	✓ Sets a fuel carbon intensity reduction ✓ Can create an incentive to supply SAF through available credits, which offers a signal of long-term demand – most effective if the policy is aviation-specific otherwise opt-in credits can be generated by on-road applications, as an example ✓ A sufficient credit price (and price stability) offers greater certainty to prospective SAF project developers	• In the U.S., California, Oregon and Washington all have low carbon fuel standards in place. At present, in all of these jurisdictions, aviation fuels are "opt-in" fuels, meaning that sustainable aviation fuel (SAF) production can be used to generate credits, but the use of traditional jet fuel does not generate deficits.[55]

53 EASA, "Sustainable Aviation Fuels," accessed 2024.

54 https://www.gov.uk/government/collections/sustainable-aviation-fuel-saf-mandate

55 https://rmi.org/how-states-can-use-low-carbon-fuel-standards-to-incentivize-clean-hydrogen-derived-fuels/#:~:text=Aviation%20fuels%20have%20been%20brought,SAF%20uptake%20has%20been%20slow.

Type of Policy Intervention	Considerations	Examples
Domestic carbon pricing or cap-and-trade	✓ Increases the price of fossil fuels, which decreases their usage and increases SAF demand	• Under the E.U. emission trading system, air carriers must surrender carbon allowances from intra-EU flights, each representing one ton of CO_2, equivalent to their emissions reported in the previous year.
Minimum levels of public procurement	✓ Generates stable early demand that helps de-risk and kick-start SAF production	• The Government of the Netherlands participates in KLM's Corporate SAF Programme whereby the premium difference between CJF and the SAF equivalent for their fliers are paid for by the government agencies.[56]
End user collaboration (Voluntary market action)	✓ Creates opportunity to aggregate procurement, providing a more reliable demand signal ✓ Supports information sharing to help end users move forward with procurement	• Sustainable Freight Buyers Alliance (SFBA) establishes a decarbonization demand signal and a centralized hub for collective responsibility and action and acts as a convening centre to aggregate demand and scale solutions. • Sustainable Aviation Buyers Alliance (SABA) accelerates the path to net-zero aviation by driving investment in SAF and supporting companies, airlines, and freight customers. • Aireg, an initiative for aviation fuel based in Germany, is meant to drive the research, production, and usage of SAF across the country.
Voluntary SAF purchase for travelers (Airline initiatives, not national policy)	✓ Bridges the cost differential of procuring SAF ✓ Improves awareness and transparency around SAF	• Swiss International Airlines allows customers to voluntarily purchase a certain amount of SAF to make their flight carbon neutral. • Travelers with Scandinavian Airlines can opt to purchase 20-minute blocks of SAF for USD$10 per block, which in turn earns them bonus points. The amount of SAF purchased will be used to replace the equivalent amount of fossil fuels in the airline's operations as soon as possible.[57]

56 KLM Corporate Sustainable Aviation Fuel Programme - KLM Netherlands

57 Mark Caswell, SAS to give loyalty points to customers purchasing biofuel, Business Traveller, 2021.

SECTION 4

DEVELOPMENT OF A CANADIAN SAF MARKET

Understanding the Key Challenges

During discussions and workshops with fuel producers, air carriers, airports, investors, aerospace manufacturers and other key stakeholders undertaken throughout the development of this SAF Blueprint, three core challenges were identified highlighting why production and use of SAF in Canada has been limited. They are as follows:

The high cost of SAF compared to jet fuel

Procuring SAF can be a competitive, resource-intensive endeavour. From a cost perspective, SAF is approximately 2-8 times more than conventional jet fuel. From a logistical perspective, securing and receiving SAF requires additional time to plan and coordinate with various stakeholders across the supply chain (e.g., fuel producers, distributors, airports, etc.). This additional effort, which can sometimes be lengthy, also contributes to the increased cost of procuring SAF.

There is uncertainty and concern regarding how the cost premium of SAF may be absorbed by the sector and/or passed on to the end users (e.g., through ticket purchase price). Given Canada's user-pay model and that fuel typically accounts for more than 25% of commercial airline operating costs, any significant volume of SAF purchased would be challenging for airlines (particularly smaller ones) to manage. Airlines have indicated that they would not be able to absorb the costs of 10% SAF use on their own and this will result in increases to ticket prices, possibly impacting affordability and decreasing their global competitiveness. Canadian airlines have expressed concern that some customers may look to cross the border in search of alternative, less expensive flights. If the cost of flying in Canada rises, this would be a growing challenge.

Canadian production investment risk

For investors and would-be Canadian SAF producers, there is also uncertainty regarding the opportunity for a return on investment. Despite the fact that SAF produced globally has been taken up by off-take agreements, and that the federal government, several Canadian airlines and associations continue to emphasize their desire to use the low-carbon fuel, producers have expressed the need for a long-term, durable demand signal(s) to help unlock the billions in capital investment required and make the decision to produce in Canada. Investing in new facilities requires significant capital expenditure, including FEED studies, and takes time, which leads to inherent risk. The lack of a viable operating margin that provides an adequate return on capital is a key challenge to producing SAF in Canada.

Demand is not the only consideration. Producers looking to build SAF production capacity typically assess opportunities across various jurisdictions, looking for the most compelling economic prospects and where existing supply chains can be leveraged. In the current environment, would-be producers are attracted to the opportunities presented in the U.S., given their Inflation Reduction Act and state-level incentives. Moreover, U.S. producers can also take advantage of both U.S. production incentives (notably the Clean Fuel Production Credit) and Canadian market credits when selling to Canada. The dynamic helps to support supply into the Canadian market (particularly into B.C.), but puts prospective Canadian producers at a comparative disadvantage when competing for investment.

The type of SAF that could be produced in Canada is also a consideration. Canola is thought to be a leading feedstock for any would-be Canadian SAF producer in the near-term. As described within this report, there are varying sustainability standards and life-cycle accounting methodologies used by ICAO and other jurisdictions. In some instances, such as in the European Union, food crop based SAF is restricted, limiting a producer's export opportunity. This is likely seen as lesser risk as the North American market alone is likely large enough to sustain Canadian production.

Depending on the technology pathway and the operating set-up, renewable diesel (RD) and SAF can be produced in the same facility. The decision to produce either fuel is an economic one and existing policy, regulatory, market conditions and operating costs tend to favour RD production. The production of SAF requires greater volumes of feedstock than when producing RD (e.g., for the HEFA pathway), making it a slightly more carbon–intensive fuel. Furthermore, existing RD facilities may not have the processing units to produce SAF, resulting in added costs to install and operate additional equipment.

Co-processing is seen as a potential means of producing SAF in Canada. However, given the current limit on the volume of renewable content permitted under ASTM International, the business case is not viable. For this reason, industry is seeking to increase the limit to 20-30% which could result in increased production.

Limited available supply

Although new facilities continue to come online around the world, production is limited to a handful of countries (there is currently no sustained commercial production of SAF in Canada). The SAF produced by these suppliers is in high demand.

Currently, SAF production and uptake is driven by markets that either regulate supply or offer targeted SAF production incentives. Most SAF being produced globally is destined for the E.U. (to satisfy ReFuelEU regulations) or the U.S. Canadian airlines that are looking to purchase SAF face the challenge of securing global volumes, but with access to fewer policy supports for SAF adoption and less ability to compete. The scarcity in the global market has also encouraged fuel purchasers to lock up SAF supply over the short- and medium-term in offtake agreements to meet compliance obligations and take advantage of credits, which ultimately impacts the near-term availability and pricing of global imports into Canada. As described by some prospective purchasers, this reality is proving to be very difficult and expensive. While Air Canada and WestJet have had some success in procuring and importing SAF, other smaller carriers are unable to compete and are interested in the opportunities presented through book and claim, which has yet to be widely recognized and adopted.

The Potential of Existing Measures

Consensus from the working sessions, discussions and workshops held with non-government stakeholders to develop the SAF Blueprint is that the current policy landscape in Canada is inadequate to support a domestic SAF market and that Canada will likely continue to struggle to access imports in the near-term. Participants in the initiative identified a need for more SAF-tailored support to ensure Canada has access to SAF. The following is a snapshot of existing policies and measures in place to support the development of SAF in Canada, as well as insights from non-government stakeholders on how they could be optimized over time.

TABLE 07 | Existing Policy and Measures with Details for Canadian SAF Development

Existing policy or measure	Type of policy	Program objectives	Potential support to Canadian SAF market, as heard in the non-government stakeholder workshops
Bioenergy Strategy for Canada	Federal strategy	The 2030 Emission Reduction Plan commits to exploring the feasibility of a Bioenergy Strategy to optimize how Canada uses its agricultural, forestry and municipal waste resources to generate net-zero energy in the medium and long term.	Could provide a forward looking collaborative federal government vision of bioenergy in Canada, including end use for SAF, but will not include funding or specific program development.
Clean Fuel Regulations (CFR)	Regulation	The CFR requires lifecycle carbon intensity reductions from gasoline and diesel produced in and imported into Canada for use in Canada, leading to greenhouse gas emission reductions. The CFR also provides an incentive for the production and import of low-carbon fuels, including SAF. SAF producers face no reduction requirement and only benefit from credit creation and participation within the CFR credit market. As announced by the Prime Minister on September 5 and reiterated in Budget 2025, targeted amendments to the CFR will be carried out to support the domestic low carbon fuel sector while maintaining the Regulations' primary goal of lowering emissions and transitioning to a lower-carbon economy.	Opportunity in a future regulatory review to assess whether further action should be taken with respect to jet fuel / SAF.

Existing policy or measure	Type of policy	Program objectives	Potential support to Canadian SAF market, as heard in the non-government stakeholder workshops
Canada Infrastructure Bank (CIB): Project Finance and FEED initiative	Financial support	The CIB provides customized investment solutions to finance clean fuel production facility construction projects (including SAF). It also provides project acceleration funding to support FEED studies during the development phase.	Continue to provide project finance and FEED financing through acceleration funding.
Accelerated Capital Cost Allowance for Specified Clean Energy Generation and Energy Efficient Equipment	Tax incentive	Provides an accelerated capital cost allowance for specified clean energy generation and energy efficient equipment, such as equipment used to generate electricity and/or heat from renewable energy sources or from waste, or that produces low carbon fuels from waste.	Explore augmenting existing tax incentives to further support SAF production.
Greening Government Strategy and Low Carbon Fuel Procurement	Federal Strategy	The GGS presents the Government of Canada's objectives for greening its operations on the pathway to net-zero GHG. It includes a commitment to purchase at least 20% low-carbon fuels for federal national safety and security (NSSF) air and marine operations by 2030, and to reduce net-emissions intensity by 50% by 2040. This includes purchasing SAF and SAF environmental attributes for air force operations with some funding support from the Low-Carbon Fuel Procurement Program (LCFPP), an initiative to stimulate market development for low carbon aviation and marine fuels in Canada through federal leadership and procurement.	Continue procurement activities to build SAF demand in Canada.

Existing policy or measure	Type of policy	Program objectives	Potential support to Canadian SAF market, as heard in the non-government stakeholder workshops
Strategic Innovation Fund (SIF)	Financial support	Encouraging Canadian businesses to invest in research and development activities that lead to technology transfer and commercialization of new products, processes and services; accelerating the growth and expansion of innovative businesses in Canada; attracting and retaining large-scale investments to Canada; advancing networks of collaboration between the private sector, research institutions and non-profit organizations in key emerging technology sectors and in industrial research, development and commercialization.	SAF projects could be prioritized subject to available funding.
Initiative for Sustainable Technology (INSAT), supported by SIF	Financial support	Augment the essential technologies required for the widespread adoption and certification of alternative aviation fuels. Examples include adapting technologies to permit the use of high-ratio blends of SAF; combustion technologies for hydrogen and other carbon-free fuels; and onboard cryogenic storage systems.	Support adoption of higher blends of SAF and research and development of new technologies.
Various Support for Feedstocks	Program	Agriculture and Agri-Food Canada supports the Canadian agriculture and agri-food sector through initiatives that promote innovation and competitiveness. • AgriInnovate Program • AgriScience Program – Projects • Canadian Agricultural Strategic Priorities Program • Agricultural Climate Solutions Program (closed to applications) • Agricultural Clean Technology Program The Clean Hydrogen investment tax credit (CH-ITC) is a refundable investment tax credit and provides varying levels of support, between 15 and 40 per cent of eligible project costs, based on the carbon intensity of the hydrogen produced. As such, the CH-ITC can create opportunities for the production of low-carbon hydrogen as a feedstock or refining component in the production of SAF.	Consider aligning program objectives with feedstock related actions described in the Blueprint.

Existing policy or measure	Type of policy	Program objectives	Potential support to Canadian SAF market, as heard in the non-government stakeholder workshops
B.C.'s Low Carbon Fuel Standard (LCFS)	Regulation	Supply side market transformation policy incentivizing and requiring the supply of low carbon and/or renewable transportation fuels into B.C. and disincentivizing the supply of fossil derived fuel.	The B.C. LCFS will continue to support the development of the SAF market and maintaining the stackability of the credits has been identified as a positive element to incentivize SAF in B.C.
CORSIA	Global Market Based Measure	CORSIA is a global market-based measure designed to offset CO_2 emissions from the international aviation industry through the purchase and cancelation of emission units by aeroplane operators.	CORSIA will continue to incentivize SAF purchases by airlines up to 2035.

To articulate the opportunity for developing a domestic SAF marketplace, the subsequent sections explore domestic production and import of SAF. As is the case with the Canadian jet fuel market today, a combination of these paths will be necessary to work toward Canada's sustainable aviation goals.

Reaching Canada's SAF Goals

Domestic Production	Importing SAF	Book and Claim & Sustainability Criteria and Accounting
• Comparative assessment of technological pathways suitable for Canada (*approved pathways & a comparative assessment*) • Maximum SAF production scenarios for Canada in 2030, 2040 and 2050 • Potential of Canadian feedstocks	• Considerations for importing neat and blended SAF to Canada • Potential sources of imports: U.S. and wider availability • Key learnings from early Canadian procurement efforts	• Considerations for the exploration of a national Book and Claim framework • Considerations around sustainability criteria and accounting

SECTION 5

Domestic Production

Key Insights

1	Based on feedstock availability and technology readiness, Canada has significant potential for SAF production that could meet some of its domestic SAF needs. However, even in a scenario where the maximum production volume for Canada by 2050 was reached (and all produced SAF was used in Canada), Canada would still rely on imports of SAF (in combination with other decarbonization measures) to reach net-zero in its aviation sector.
2	In general, the costs associated with most SAF production pathways are likely to decline throughout 2040. However, even for the most economical SAF production pathways, it is unlikely that the cost gap between SAF and conventional jet fuel will completely close, and some form of long-term support will be needed to ensure production and use in Canada (in the absence of other measures to require use).
3	For investors and SAF producers that are considering Canada, there is uncertainty regarding the opportunity for return on investment, including the absence of long-term durable demand and the availability of more competitive incentives offered in other jurisdictions. A focus on building concrete demand and a competitive investment environment could help Canada to realize some of its potential for domestic production.

Technological Pathways for Canada

What is the most likely path to SAF production in Canada?

Of the technological 11 pathways approved by ASTM International for SAF production (see Section 1), there are five pathways that could offer potential for significant SAF production in Canada given the availability of feedstocks, technological readiness, and supply chain readiness. Table 08 below displays the current state of the potential to build out each of the five pathways in Canada, including associated opportunities, challenges and announced projects.

There are several pathways which Canada will unlikely be able to deploy at significant scale – for example, the Hydroprocessed Fermented Sugars-Synthesized Iso-paraffin pathway (HFS-SIP), which relies on high carbohydrate feedstocks like sugarcane. Canada produces carbohydrate-rich feedstocks such as corn and wheat that could be used in HFS-SIP production; however, this pathway would be in competition with the sugar fermentation route via ATJ production. Of the two technology pathways, HFS-SIP, with its lower SAF blending limit, faces higher commercialization barriers.

TABLE 08 | Current State of Technological Pathways and Potential for Canadian Production

Technological Pathways	Tech Readiness	Opportunities	Challenges	Recent Developments
Hydro Processed Esters and Fatty Acids (HEFA)	High	• Requires low initial cost for infrastructure compared to other pathways (though it has higher ongoing costs).[58] • Capable of producing significantly higher volumes compared to other pathways due to its technical maturity and commercial readiness. • Canada is a leader in the production of canola oil and soy oil and has established supply chains. • Canadian crops are grown through sustainable means and there are opportunities for Canadian farmers to demonstrate that their crops are being produced at lower carbon intensity values than published benchmarks (e.g., ICAO default canola HEFA value). • Helps create new domestic demand and reduce export related risks for Canadian canola producers while supporting investments in domestic value-added processing. • Fats, oils and greases (FOGs) offer high potential for emissions reduction.	• Concerns around sustainability and optics of using crop-based feedstocks for SAF. • Multiple users of HEFA feedstocks could lead to future competition and increased cost. • Risk that increased future demand from other jurisdictions could affect availability of feedstocks in Canada. • Possible concerns for investing in the HEFA pathway as other pathways emerge (lower-carbon intensity) and become more economical. • Challenge for FOGs (non-crop-based feedstock) include limited availability, cost, variability in quality, risk of fraudulent oil (e.g., palm oil being reported as used cooking oil) and logistical complexities in collection and processing. Even if Canada successfully builds HEFA capacity, SAF production may not be guaranteed as producers with the ability to switch between renewable diesel (RD) might opt for RD over SAF if the market price (in combination with any available credits) remains higher for RD.[59] For more detail, see Section 5 competing uses.	• Though multiple Canadian facilities for renewable diesel production via HEFA have been announced and are under construction, only one currently plans on producing SAF.

58 Air Transport Action Group, Fueling Net Zero, 2021.

59 SAF Whitepaper (2024), Argus Media Group

Technological Pathways	Tech Readiness	Opportunities	Challenges	Recent Developments
Hydro Processed Esters and Fatty Acids (HEFA)	High	• Potential to switch between production of SAF and RD, enhancing financial viability and sustainability of operation in the long term.		
Gasification and Fischer-Tropsch (GFT)	Low to Moderate	• Significant volumes of feedstock are available in Canada (MSW, forest and agricultural residues). • Feedstocks do not compete with food and are lower in cost compared to HEFA feedstocks. • SAF production from MSW could be located near large urban centres such as Toronto, Vancouver, etc., as economies of scale are necessary for financial viability.	• In the near term, high capital costs and technical challenges. • Currently, collection of agri-residue, forestry residue and MSW is insufficient and supply chains for some feedstocks are underdeveloped. • Ramp-up of technology at commercial scale will take time. • Biomass-based GFT facilities have not been able to reach the large scale of coal or natural gas-based processes, which is partly due to the low energy density of the feedstock which makes their long-distance transportation difficult. • Renewable natural gas (RNG) is also competing for MSW biogenic feedstock (see Section 5 on competing uses).	• No announced production in Canada and anywhere else in the world at date of publication. • In the U.S., Sumitomo and Strategic Biofuels announced planned SAF production via GFT by 2029 and by leveraging carbon capture sequestration (CCS).[60] • DG Fuels has secured investment in Japan for a GFT facility.
Alcohol-to-Jet (ATJ)	Low to Moderate	• ICAO's "rule of thumb" suggests that corn ATJ and HEFA from fats, oils, and greases are the most capital-efficient pathways.[61] For corn ATJ, plants are already depreciated and use a very viable feedstock. • There are over a dozen ethanol production facilities in Canada, the majority of which are owned/operated by Canadian firms. Canada is also the biggest market for export of U.S. ethanol.	• Canada currently has a deficit in ethanol production with growing quantities imported for domestic use. • Construction in Canada will depend on several factors, including availability of ethanol for use in aviation. Existing blending mandates for ethanol in gasoline in Canada will ensure ethanol will continue to be required for ground transportation. Over the longer term, high adoption rates for zero-emission vehicles will eventually lead to a reduction in demand for ethanol in ground transportation. • Carbon-intensity benefits from starch-based SAF produced through ATJ are relatively small in comparison to conventional petroleum-based jet fuel (in the absence of additional emissions-reducing measures like carbon capture and storage).	• First pioneer facility is operational (Lanzajet, Freedom Pines) in the U.S.

60 Sumitomo Corporation

61 SAF rules of thumb (icao.int)

Technological Pathways	Tech Readiness	Opportunities	Challenges	Recent Developments
Power-to-Liquids (PtL)	Low	• Considerable opportunity to unlock feedstock potential for very low carbon intensity SAF without requiring biomass feedstocks. • PtL technology can leverage cost reductions developed in GFT or ATJ pathways as there can be some overlap between the technologies. • Potential demand driver for recycling carbon from industrial plants' emissions. • Potential demand driver for further scale-up of solar, wind, and other renewable electricity sources.	• Varying perspectives about the timing/growth of the PtL industry in Canada. In 2030, any PtL volumes will be at pilot scale. • PtL is currently one of the costliest SAF production pathways. Costs may eventually decrease as the technology matures and scales, but the timeline for achieving lower cost production is longer-term and more uncertain than most other technology pathways. • Lack of renewable energy to meet demand, in part due to competing uses for renewable energy among many other industries in Canada (see Section 5 on competing uses). • Cost and high demand for renewable electricity will be a big challenge. It is currently significantly more expensive than HEFA (up to four times more expensive).[62]	• SAF+ International Group has a pilot plant in Montreal, where it has demonstrated its expertise and e-SAF production capabilities. • The E.U.'s ReFuelEU: Aviation includes a sub mandate for increasing levels of PtL-based SAF to be supplied in E.U. airports. • Low-carbon hydrogen is starting to be produced in Quebec.[63]
Co-processing	Moderate to High	• Canada has some of the only co-processing facilities (Parkland and Tidewater) in North America with the proven capability to produce SAF and direct infrastructure to Vancouver International Airport (YVR). • Much lower capital requirements than other pathways as it enables the use of existing refinery infrastructure. It also creates shorter project lead time, i.e., faster access to the market.	• Switching to co-processing SAF can involve some complicated logistics at the refinery level. It is possible to spread out the cost of the switch and the feedstocks if the refinery can produce a large enough batch of SAF. However, the business case to do so requires production of SAF at a higher biogenic percentage than is currently allowed under the ASTM jet fuel standard. • Approval of additional feedstocks could also help to bring down costs. For example, pyrolysis oil (biocrude) not currently recognized as a feedstock for the ASTM jet fuel standard. • To an extent (given co-processing feedstock limits), feedstocks for co-processing compete with dedicated pathways for SAF such as HEFA. Broader expansion of co-processing will require options such as biocrude from woody biomass.	• In December 2024, Parkland announced the production of Canada's first batch of low carbon aviation fuel (nearly 101,000 litres) at its Burnaby Refinery. • Discussions among stakeholders are ongoing at the ASTM International's aviation fuel subcommittee towards a potential increase to co-processing of up to 30% renewable content.

62 Argus Media (2024)

63 SAF+ Consortium, "The first production of SAF sustainable aviation fuel developed in Canada," press release, September 14, 2021.

Standalone and Co-Processing Plants

Most technology pathways referenced in Table 08 operate as standalone plants, typically producing SAF that has up to 100% biogenic content (noting that the MSW-GFT pathway has variable biogenic content based on MSW composition). Some standalone plants leverage existing facilities (e.g., renewable diesel refineries), benefitting from available energy infrastructure and established logistics (and avoiding additional capital costs associated with project development on greenfield sites).

Co-processing plants involve simultaneously processing biogenic feedstocks, such as vegetable oils and waste FOGs, with fossil-based feeds within a conventional petroleum refinery. Co-processing requires facility modifications but necessitates much lower up-front financial investment and market risk than new standalone greenfield sites. The pathway also carries lower investment risk because refineries can switch between co-processing and traditional crude oil processing, depending on market conditions.

However, one of the major global limitations for co-processing is the jet fuel standard's allowable limit of 5% biogenic feedstock (ASTM D1655). In Canada, access to the full B.C. LCFS credits available for SAF requires a higher biogenic content than 5%. Despite the challenge, Parkland's refinery in Burnaby, B.C., and BP's Cherry Point refinery in Washington State have successfully produced co-processed fuel volumes. Unlocking additional and sustained production of co-processed fuel volumes in Canada depends in part on the successful validation of a higher allowable percentage and variety of biogenic content, leading to an update to the ASTM D1655 standard.

In December 2024, Parkland announced it has successfully produced Canada's first batch of co-processed low-carbon aviation fuel at its Burnaby Refinery. Using existing infrastructure, Parkland produced approximately 101,000 litres of the fuel by using non-food grade canola and tallow as core feedstocks. This SAF has been purchased by Air Canada and will be mixed with conventional jet fuel and used at Vancouver International Airport. This initiative demonstrates a complete Canadian value chain, from local development, production, sale to end use.

Canada's Maximum SAF Production Scenario

The purpose of this section is to explore the limits of Canada's potential to produce SAF domestically to support the achievement of Canada's SAF-related goals. The simplified analysis outlines the maximum SAF production potential over time, modelled according to technology pathway, and based exclusively on technology readiness and feedstock availability (considering competing uses as well as imports and exports).

The model is not intended as a comprehensive projection, rather the Maximum SAF Production Scenario was built on feedstock availability and technological readiness. It does not account for all factors and considerations that influence decisions around production, including the costs of production over time, trade dynamics or market price of SAF, competition for feedstocks or fuels (e.g., renewable diesel), or the impact of either existing or new policy measures. In examining the emissions benefit of this scenario, it does not analyze the trade-offs of using Canada's feedstocks to produce SAF relative to other decarbonizing uses, including low-carbon electricity generation or industries.

An overview of the methodology for the maximum SAF production scenario and its assumptions concerning feedstock yield, growth rates, and competing uses appears in Appendix 2. The information behind these assumptions was gathered by Deloitte through working sessions, interviews, and data collection from industry stakeholders on feedstock availability, the anticipated progression of technological readiness of pathways, and competing uses from other fuels. The model assesses the total potential SAF production by technological pathway for 2030, 2040, and 2050.

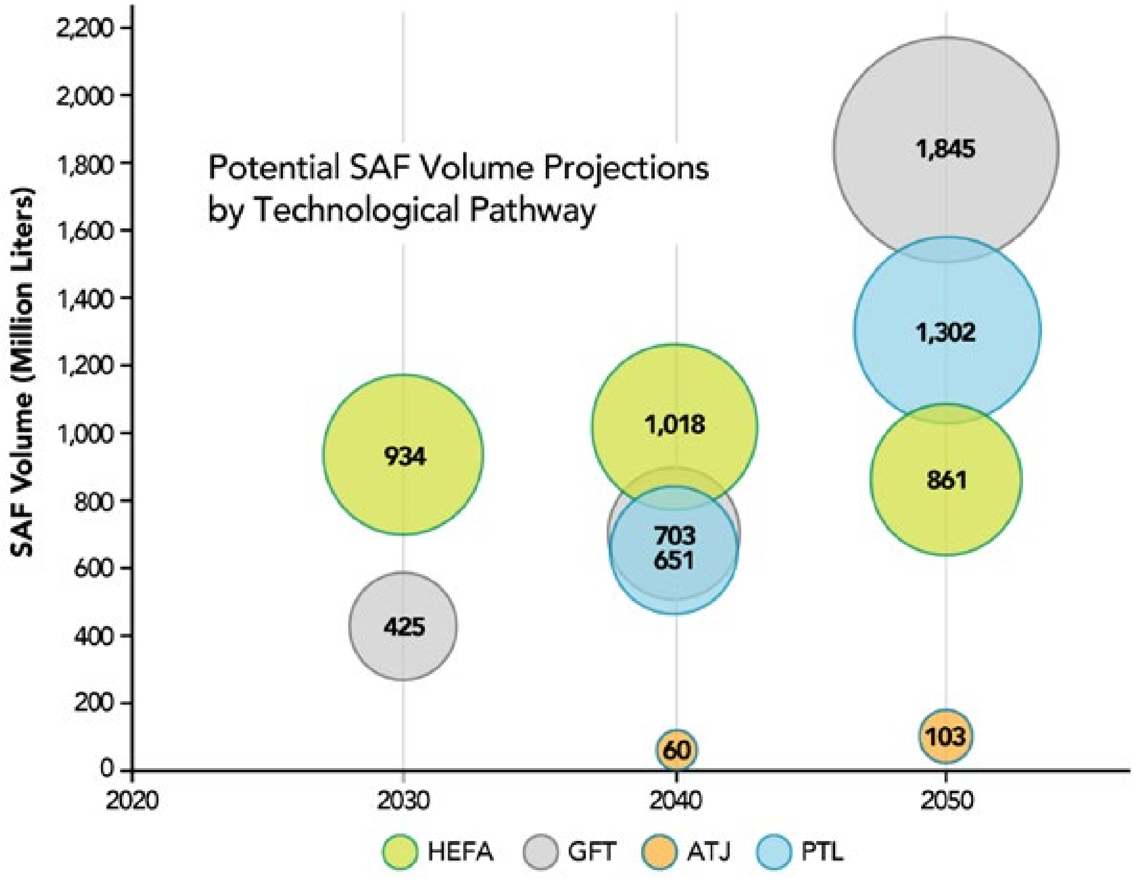
To what extent could Canada's 2030 aspirational goal and 2050 vision be achieved entirely through domestic production?

Ultimately, domestic production alone is an insufficient strategy for meeting Canada's decarbonization goals. Imports maybe needed in the near-term and will be essential in the long-term.

As mentioned, to reach Canada's aspirational goal of 10% SAF use by 2030 and its net-zero by 2050 vision, it is estimated that Canadian airlines will need to uplift approximately 1 billion litres of SAF annually in 2030 and an estimated 8 billion litres of SAF annually in 2050. The maximum SAF production scenario (displayed in Figure 02 below) suggests that, while it is technically possible that Canada could produce up to a maximum of 1.36 billion litres of SAF by 2030, achieving this level of production would necessitate an extreme level of rapid investment and would depend on the build-out of technology pathways which have not yet been proposed for development in Canada in the near-term (i.e., GFT). It also reveals that, even if Canada were to leverage its maximum feedstock and technology potential, it wouldn't reach the 8 billion litres exclusively through domestic production. At its full potential, Canada would likely only produce enough SAF to supply about half of the volumes by 2050.

The scenario underscores the physical limitations of Canada's domestic resources for SAF production – a market with many natural advantages that are conducive to SAF production (e.g., agricultural and forestry residues, and freshwater resources). Its conclusion is that Canada will need to rely on domestic production and imports of SAF. And as indicated in Canada's Aviation Climate Action Plan, the sector will also need to leverage a combination of other decarbonization measures (both in- and out-of-sector) to reach net-zero aircraft emissions.

FIGURE 02 | **Maximum SAF Production Scenario by Technology**



Maximum scenario for 2030

- As it is currently the only fully commercial technology pathway, volumes for 2030 would primarily need to be supplied through the HEFA pathway in Canada using freestanding production and co-processing (noting that more significant co-processed volumes could become available if ASTM blend limits were to be modified). Planned production is not guaranteed and is dependent on additional factors such as the completion of FEED studies, with market conditions that demonstrate a sufficiently compelling business case to move ahead with projects in Canada.
- Reflecting the maturity of the technology and abundant forestry and agricultural residues in Canada, significant volumes of GFT production by 2030 are technically possible. However, with no announced projects in Canada at an advanced stage of readiness in 2024, the likelihood of these volumes appearing is extremely low and would depend heavily on the immediate-term materialization of major new investments (particularly as GFT is known to be a comparatively capital-intensive pathway). Over the subsequent decade, small volumes could eventually be sourced from new advanced hydrothermal liquefaction projects.
- Existing limitations on ethanol availability in Canada (which is mainly imported) suggest no significant volumes of SAF production through ATJ is possible by 2030. Cellulosic ethanol, made via agricultural residues, is not yet commercially viable in Canada, and will be significantly more expensive than corn ethanol.
- The early-stage nature of PtL technology suggests that significant volumes will likely not be available for domestic use by 2030.

Maximum scenario for 2040

- Although there would need to be significant SAF production in Canada via the HEFA pathway, by 2040 other pathways are expected to reach commercially viability. In a maximum SAF production scenario, technological maturity of GFT (and to a lesser extent PtL) potentially even leads to some erosion of market share from HEFA SAF production by 2040. Unlike HEFA, GFT also offers the potential to mitigate concerns related to land use change and competition with food production and can result in lower GHG emissions, a sustainability perception which is expected to drive adoption of the pathway across industry.
- With the expectation that the ATJ pathway will also achieve commercialization in the 2030s, Canada has some potential to domestically produce ethanol to supply domestic SAF production. By the 2040s, if demand for ethanol from ground transportation (for use in renewable fuel mandates) begins to decline with the widespread adoption of electric vehicles, the supply chain issues associated with ethanol may lessen and offer greater scope to scale up the ATJ pathway.
- Beyond 2030, PtL production will likely start to play a more significant role, although the availability of affordable low-carbon electricity and its prioritization for SAF production over decarbonization of other sectors could have a limiting influence on the viability build-out of this pathway, even in a maximum production scenario.

Maximum scenario for 2050

- In a continuation of the trend from 2040, the combination of low feedstock availability for HEFA (oils and fats) and the growing commercial viability of less carbon-intensive production pathways could eventually cause the HEFA production in Canada to plateau and begin to decline by 2050.
- Provided that forestry and agricultural residue supply chains can be scaled accordingly, and that availability of low-carbon electricity continues to grow significantly in Canada by 2050, the GFT and PtL pathways would offer the greatest potential to produce substantial volumes of SAF.

What is the potential for the projected SAF volumes to reduce GHG emissions?

Based on the maximum SAF production scenarios, Table 09 shows ranges of the potential GHG emissions reduction by pathway, modelled using ICAO default life-cycle values. Emerging data on the PtL production pathway suggests that GHG emissions reduction estimates will vary widely. The GHG emissions reduction range of "up to 98%" reflects this uncertainty, with the ideal scenario of up to 98% GHG emissions reduction reflecting clean electrified systems for carbon capture via Direct Air Capture (DAC) technology and electrolysis for low-carbon hydrogen production.

TABLE 09 | Indicative Potential SAF GHG Reduction by Pathway

Pathways	GHG Emission Reduction range (%)*	2030 Potential SAF GHG Reduction (Tonnes of CO_2e)		2040 Potential SAF GHG Reduction (Tonnes of CO_2e)		2050 Potential SAF GHG Reduction (Tonnes of CO_2e)	
		Low	High	Low	High	Low	High
HEFA	18%-84%	401,288	1,982,837	437,281	2,160,682	370,131	1,828,882
GFT	77%- 94%	966,960	1,009,936	1,598,328	1,669,365	4,197,744	4,384,310
ATJ	0-73%	0	0	0	97,075	0	167,859
PtL	up to 98%**	0	0	0	1,646,360	0	3,292,720
Total		**1,368,248**	**2,992,773**	**2,035,609**	**5,573,482**	**4,567,875**	**9,673,771**

** The GHG emission reduction range has been determined based on a baseline life cycle GHG emissions from conventional fossil jet fuel at 89 gCO_2e/MJ (lower heating value). Values are calculated based on the ICAO default life cycle emissions values and feedstocks available in the Canadian context.*

*** PtL quantification methodology has not yet been published under the ICAO CORSIA programme at the time of writing.*

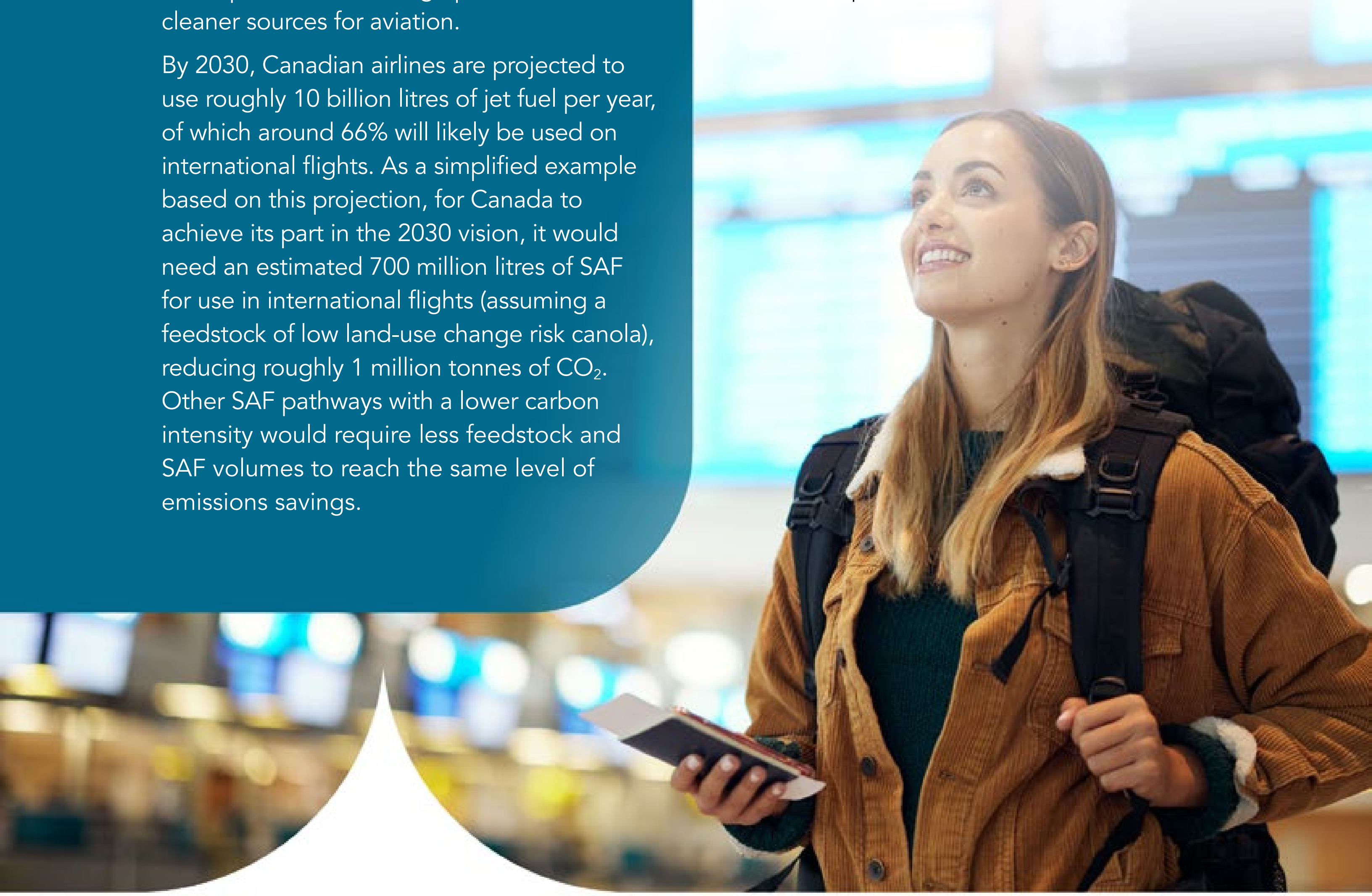
ICAO global framework to reduce CO_2 emissions from international aviation by 5% by 2030

Held in 2023, the Third ICAO Conference on Aviation and Alternative Fuels reviewed the 2050 ICAO vision for SAF, low-carbon aviation fuels and other cleaner energy sources for aviation. Member States, including Canada, agreed to set a goal by 2030 that the jet fuel pool should be 5% less carbon intensive compared to a 2030 scenario of 100% petroleum jet fuel being used. At the 42nd ICAO Assembly in Fall 2025, ICAO Member States endorsed this vision and reiterated the importance of scaling up SAF and other cleaner sources for aviation.

By 2030, Canadian airlines are projected to use roughly 10 billion litres of jet fuel per year, of which around 66% will likely be used on international flights. As a simplified example based on this projection, for Canada to achieve its part in the 2030 vision, it would need an estimated 700 million litres of SAF for use in international flights (assuming a feedstock of low land-use change risk canola), reducing roughly 1 million tonnes of CO_2. Other SAF pathways with a lower carbon intensity would require less feedstock and SAF volumes to reach the same level of emissions savings.

Research and Development to enable longer-term emissions reductions and cost savings

The long-term future of Canadian SAF production and associated emissions savings from its use depends on essential research and cost-saving advancements in SAF production technologies. To contribute to global progress and commercialization along essential production pathways, Canada could examine measures to support additional R&D, to de-risk first-of-a-kind production facilities, and consider the development of the infrastructure necessary to support their widespread use. The Government of Canada has started to make some project-level investments in sustainable aviation, including support delivered through the INSAT program, and should continue to explore opportunities for research and testing that can support higher blend rates of up to 100% SAF (both domestically and in collaboration with international partners).



Feedstocks for Canada

What feedstocks offer the greatest potential to build domestic SAF production?

Supply chain readiness, economic viability and availability of feedstocks, are critical factors in the design and siting of SAF production projects.[64] With the exception of forestry and some large-scale commercial crops such as corn, canola, and soybean, biomass supply chains for bioenergy production are currently underdeveloped in Canada. Waste oils and fats, currently the most widely used feedstocks for SAF production, are relatively low-cost but are increasingly scarce due to growing global demand, the relative ease with which they can be traded over long distances. Used cooking oil and tallow have limited potential for growth as they are by-products of other industries, whereas canola and soy offer reasonable growth potential through increased agricultural yield. In contrast, low-carbon electricity and carbon offers potentially the most abundant feedstock with promising sustainability benefits, but the technology is pre-commercial and investment costs to develop production are high. ICAO's "SAF Rules of Thumb" offer a mechanism to approximate the order for magnitude of some of these production pathways. Table 10 presents a synthesis of specific challenges and opportunities in a Canadian context.[65]

> "Canada has the feedstock, refining expertise, innovation capacity, and domestic airlines to create a world-leading industry that meets its own needs and exports to other jurisdictions. To realize this promise, Canada must mobilize and align the entire ecosystem." – *C-SAF Roadmap*

TABLE 10 | Feedstock landscape in Canada

Feedstock	Production and Regional Profile	Challenges and Opportunities for Canada
Agricultural Residues	There is a significant supply of agricultural residue in Canada. Over 30 million oven-dry tons of agriculture biomass is available in Canada. The main producing regions include the Canadian Prairies (cereal straw), Southern Ontario and Western Quebec (corn stover).	Agriculture-derived residues have limited established supply chains due to the complexity of collection and storage. A lack of standardization of quality and consistency of the feedstock is a known issue. Residues also have low energy density, rendering long-distance transport economically unviable. Competition for feedstocks is likely to increase in the future, as demand for renewable energy and clean fuels grows. Baling or pelleting agricultural residues for biomass power and heating is currently under exploration.

64 C-SAF Roadmap
65 Deloitte Research

Feedstock	Production and Regional Profile	Challenges and Opportunities for Canada
Forest Residues	70 million oven-dry tonnes of forest residues (inclusive of forest and sawmill residues, and urban wood waste) were available in Canada in 2020, although the impacts of COVID-19 and recent closures of pulp and paper mills will have affected available volumes. Trade: Around 90% of wood pellets produced in Canada today are exported. Canada is also one of the world's largest exporters of softwood lumber, with the U.S. being the primary importer.	Collection from forests is expensive due to the complexity of collection, size reduction, transportation, and pre-processing. Additional work is needed to develop supply chains in Canada while retaining the carbon-intensity reduction benefit. While forest residues offer the largest potential source of feedstock that could be used for SAF production, there are other demands for the same feedstock from advanced solid and gaseous biofuels and advanced biochemicals and biomaterials. Demand from export markets for wood pellet production is also growing.
Municipal Solid Waste (MSW)	Approximately 9,385,000 tonnes of MSW are produced in Canada, with about 6,194,000 tonnes containing biogenic content. Most of its located in densely populated regions.	Commercial viability has not been established as extensive pre-processing is required and there are known issues related to sorting and carbon content. There is an upper limit in the non-renewable content of MSW-derived SAF (i.e., MSW-SAF carbon intensity is directly proportional to the non-biogenic carbon from petroleum-derived materials in MSW).
Fats & Oils	As of 2025, Canada had around 14 million tonnes of canola crushing capacity with expansion projects underway in Western Canada which are expected to increase crush capacity.[66] Soybean is also produced in Ontario, Quebec, and Manitoba. For waste fats, there are 14 rendering facilities in Canada which handle over 3 million tonnes of raw materials per year (mainly in the Prairies and Eastern Canada). Trade: More than half of the oilseeds produced in Canada are exported, along with a significant portion of canola and soybean oil. In 2022, Canada was the biggest exporter of tallow globally.[67]	The use of fats and oilseeds in domestic SAF production could reduce Canada's reliance on exporting these commodities, mitigating the volatility associated with less stable export markets. This shift could offer a significant opportunity for Canadian farmers, enhancing their market stability and potential for growth as well as support investments in domestic value-added processing of Canadian-grown oilseeds. The supply chains for both oilseeds and waste fats are mature. The increasing demand for waste and residue oils and fats, such as used cooking oil (UCO) and animal fats, is already leading to a feedstock crunch, with supply constraints expected to persist in the near-term.

66 https://www.canolacouncil.org/about-canola/processing-industry/

67 OEC

Feedstock	Production and Regional Profile	Challenges and Opportunities for Canada
Renewable Energy & Carbon Capture	Renewable energy sources may be used to produce hydrogen via electrolysis, which is a necessary input for SAF production. For more advanced SAF production pathways (PtL), direct air capture will also use significant amounts of clean electricity.	Although capacity is growing in Canada, there are currently significant investment costs associated with low-carbon intensity hydrogen production (though costs could be reduced via government support for renewable energy generation and carbon capture). Demand for renewable electricity to support industrial decarbonization is also high in Canada. Availability will depend on regional circumstances.
Ethanol	Ethanol is made principally from corn and wheat. Some farmers have formed cooperatives to grow crops intended specifically as a feedstock for ethanol production. Trade: There is demand in Canada for ethanol due to federal and some provincial renewable fuel blend mandates. Canada exports small volumes of fuel but also imports significant volumes.[68]	Canada currently relies mainly on imported ethanol to meet its renewable fuels blending mandates (including gasoline). Without additional sources of ethanol production in Canada, in the near-term the use of ethanol for SAF production could result in a feedstock supply crunch. However, over the longer term, impacts may lessen as electric vehicle adoption grows and demand from the road sector decreases.

By 2030, to support significant volumes of SAF production, Canada would most likely need to rely on soybean and canola (which given current trade dynamics can help create new market opportunities in Canada), as both the supply chains and technology are mature. However, there are several challenges associated with these feedstocks. Under ICAO CORSIA (default value), Canadian canola is disadvantaged relative to waste oil and tallow-based SAF (to see the variances of different life cycle assessment methodologies see Section 2). However, pathway applications (actual value) specific to individual projects can demonstrate to ICAO that they are able to achieve lower carbon-intensity than the default values.

68 StatCan (2024), https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510008101

Over the longer term, other feedstocks could play a more prominent role. Due to their abundance in Canada, forestry and agricultural residues could play a role in supporting Canadian SAF production as supply chains mature and technology readiness develops over time. Improvements in municipal solid waste collection and pre-processing practices could reduce the cost of procurement, thereby increasing its potential use towards SAF production. In Canada, ethanol is made principally from corn and wheat; however, these feedstocks provide reduced carbon-intensity benefits compared to waste or residue. Research into the production of ethanol from non-food sources is rapidly advancing, which in future could make domestically produced ethanol a more attractive feedstock for ATJ. Appendix 3 illustrates the maximum potential SAF feedstock availability in 2030 and 2050.

To ensure Canada's supply chain infrastructure is suitable to support the production, collection, receiving, processing of feedstocks and blending necessary for a SAF marketplace to grow, Canadian stakeholders should work together to ensure there is a clear line of sight on a project pipeline of pilots, demonstrations and commercial projects. This collaboration could ensure Canada is better prepared as the SAF industry in Canada develops and evolves. The development of regional infrastructure and supply chain feasibility studies, as well as activation plans, could also play a role in helping to quantify the opportunity in Canada for governments, but also potential project developers, fuel suppliers and investors. This study could include an assessment of opportunities at high traffic airports, with the aim of eventually establishing regional pilot SAF supply chains.

Competing uses for feedstocks

Building on some of the limitations identified in Table 10, SAF production in Canada could offer many economic and environmental benefits (see Section 1 for more details), but every technology pathway leverages feedstocks that can also be used in the production of other biofuels, bioproducts, and industrial and agricultural processes. These competing uses have an impact on market price, and therefore the business case for SAF production. While it is beyond the scope of this report to undertake a prioritization of Canada's feedstocks on environmental or economic basis, the major competing uses are discussed below.

Circular bioeconomy growth: The market for bio-based products to complement or substitute conventional food and feed waste, products, and energy products is estimated to reach USD $7.7 trillion by 2030. Over 80% of bio-based raw materials are derived from agriculture, with a further 18% from forestry, and around 1% from aquaculture ingredients. This ratio is expected to remain similar during the next years. Currently, 70% of these materials are utilized for food, beverage, and animal feed, while the remaining 30% are used for energy production and products. Within the latter category, biomass usage for construction is expected to almost triple while usage for packaging will more than double.

Renewable diesel: Depending on the technology pathway and the operating set-up, renewable diesel (RD) and SAF can be produced in the same renewable fuel's facility. The decision to produce either fuel is an economic one and existing policy, regulatory, market conditions and operating costs tend to favour RD production. In Canada, low carbon fuel standards and regulations apply to road-based transportation fuels, such as gasoline and diesel. There are no federal or sub-national regulations requiring the use of SAF within Canada's aviation sector, with the exception of B.C. that has volumetric renewable content requirements for jet fuel supplied to B.C. starting at 1% in 2028. Moreover, SAF is also more expensive to produce than RD and requires greater volumes of feedstock (e.g., for the HEFA pathway), making it a slightly more carbon–intensive fuel.

Furthermore, RD facilities may not have the processing units to produce SAF, resulting in added costs to install and operate additional process units needed to produce SAF. Additional economic supports would be needed to overcome the market forces that favour RD production and to realize sustained SAF production in Canada.

Currently, road transportation (particularly for light duty vehicles and transit) has alternative cleaner energies to RD for decarbonization (e.g., electrification, hydrogen fuel cells), whereas aviation is heavily reliant on the deployment of SAF to achieve in-sector emissions reductions. In the medium term, competition for ethanol, forest and agricultural residue feedstocks, and hydrogen, will mean the policy and regulatory context for road (particularly medium- and heavy-duty vehicles) and aviation decarbonization will continue to be interlinked.

Industrial competition: Beyond feedstocks used to produce RD, other industries also use lignocellulosic feedstocks, such as wood residues and cereal straw, including wood pellet production, heat, and power generation and animal bedding. Another input into SAF production, renewable electricity is also needed to decarbonize not just industrial sectors, but residential as well. In Ontario alone, electricity demand is anticipated to grow 75% by 2050, driven not only by greater demand for electrification (e.g., space heating, electric vehicles, etc.) but by growth in the industrial sector and data centres.[69]

Agriculture competition: Some ATJ and GFT SAF production pathways depend on feedstocks that are currently in high demand by the sugar industry (corn grain) and/or the dairy industry (agricultural residues). One European and U.S.-based study suggests the diversion of significant volumes of corn oil, corn grain, and agricultural residues for SAF production would have significant economic impacts, whereas the use of camelina, soy, carinata, and rapeseed oil, tallow, palm fatty acid distillate, and used cooking oil for SAF production would have more minor impacts.[70] The high relative cost of many food-based feedstocks, coupled with European Union regulations that place limits on the use of SAF produced from feed and food crop-based feedstocks (see Section 3 above for further details), has increased interest in the commercialization of technology pathways that use non-food biomass.[71]

International competition: In addition to competition among Canadian industries for available feedstocks, some feedstocks are also international market forces, notably the incentives for SAF production in the U.S. (see Section 3 above for further details). The anticipated growth of the U.S. market over the next several decades has the potential to significantly impact availability of Canadian feedstocks for domestic production. Waste oils and fats are particularly sought after for export, as they are high energy density feedstocks that are conducive to long-distance transportation and the associated carbon-intensity is relatively low. Further analysis of imports and exports of Canadian feedstocks appears in Section 6.

Economics of SAF production in Canada

Despite Canada's natural advantages, large-scale domestic SAF production capacity has been slow to materialize. Interviews with stakeholders from across the value chain suggest there continue to be major challenges and uncertainties regarding the opportunity for a return on investment in SAF projects in Canada and globally.

Although some technology pathways are fairly optimized (e.g., HEFA), SAF refineries are still complex facilities to develop and operate. Large-scale production necessitates multi-billion-dollar investment and is often associated with long project lead-times, which can increase the risk of delays and cost-overruns relative to other investments in energy transition. Moreover, global market prices for SAF (and some feedstocks as well) are vulnerable to fluctuations. For earlier-stage technology pathways that can utilize very low-carbon feedstocks (e.g., PTL), investment carries a higher degree of technological risk. Investment dollars for any pathway are more likely to gravitate to jurisdictions that have a stable, long-term policy environment, existing supply chains, and mechanisms in place to address some of these associated risks.

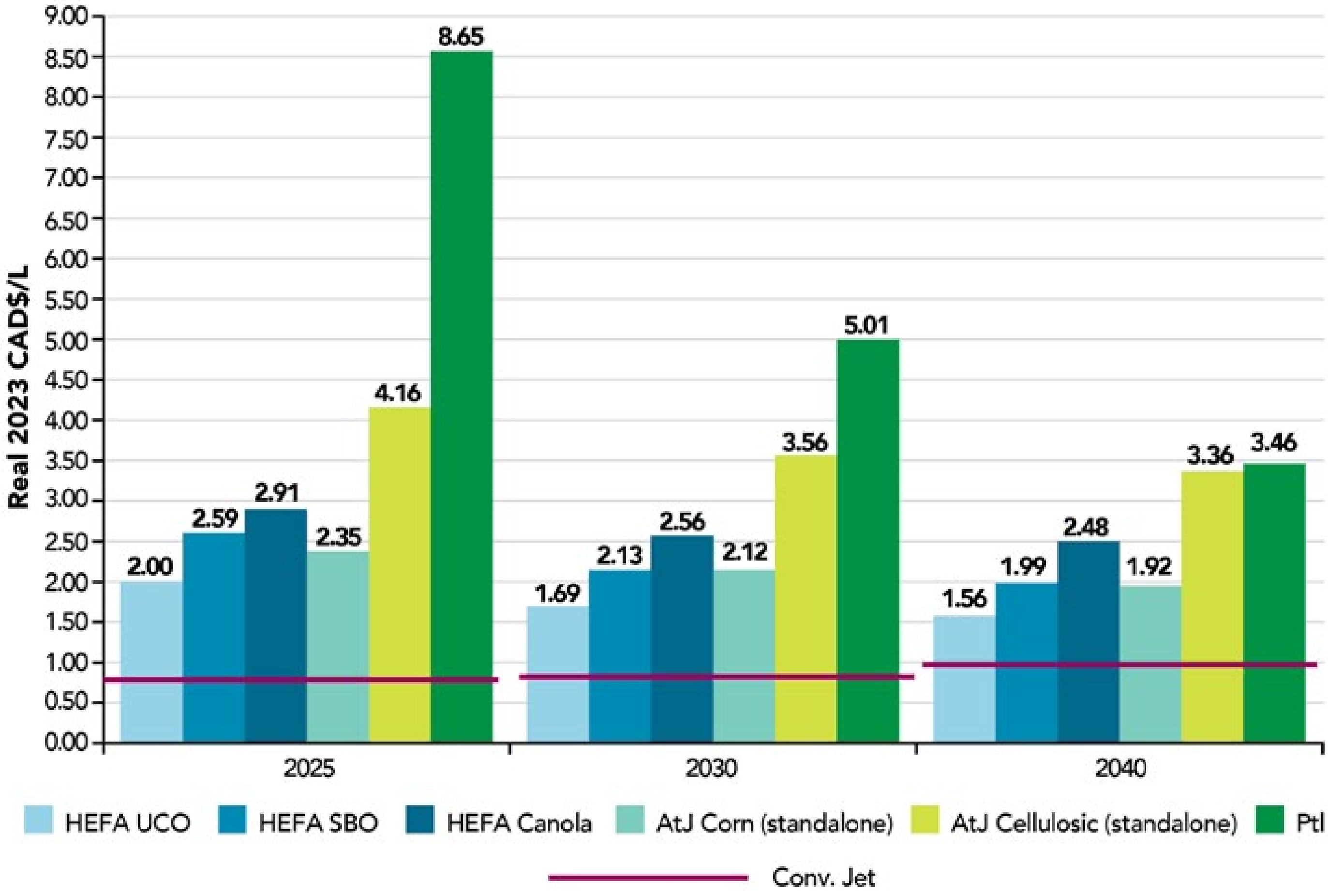
69 IESO, 2024: https://www.ieso.ca/Corporate-IESO/Media/News-Releases/2024/10/Electricity-Demand-in-Ontario-to-Grow-by-75-per-cent-by-2050

70 Capgemini, Identifying Sustainable Pathways for SAF Production, 2023.

71 IRENA, Reaching zero with renewables: Biojet fuels, 2021.

In general, the costs associated with most SAF production pathways are likely to decline throughout 2040 (as technologies mature and domestic industry gains experience in constructing and operating refineries). However, even for the most economical SAF production pathways, it is unlikely that the cost gap between SAF and conventional jet fuel will completely close and long-term policy supports may be necessary to ensure competitiveness of SAF production.[72]
For example, production costs for HEFA-based pathways using soybean and canola feedstocks are expected to fall slightly but will likely remain CAD$1.25-1.65 per litre above the wholesale cost of conventional jet fuel in 2040. Per litre cost reductions below this level for HEFA are unlikely as the technology is already mature and feedstock prices make up a very significant proportion of production costs. More advanced SAF pathways such as PtL, are more likely to experience significant cost reductions overtime as the technology matures but may require even longer-term policy support to achieve cost parity with conventional jet fuel.[73] A projection of feedstock production costs for most SAF pathways is modelled in Figure 03 for 2025, 2030 and 2040.

FIGURE 03 | Projected SAF Production Costs

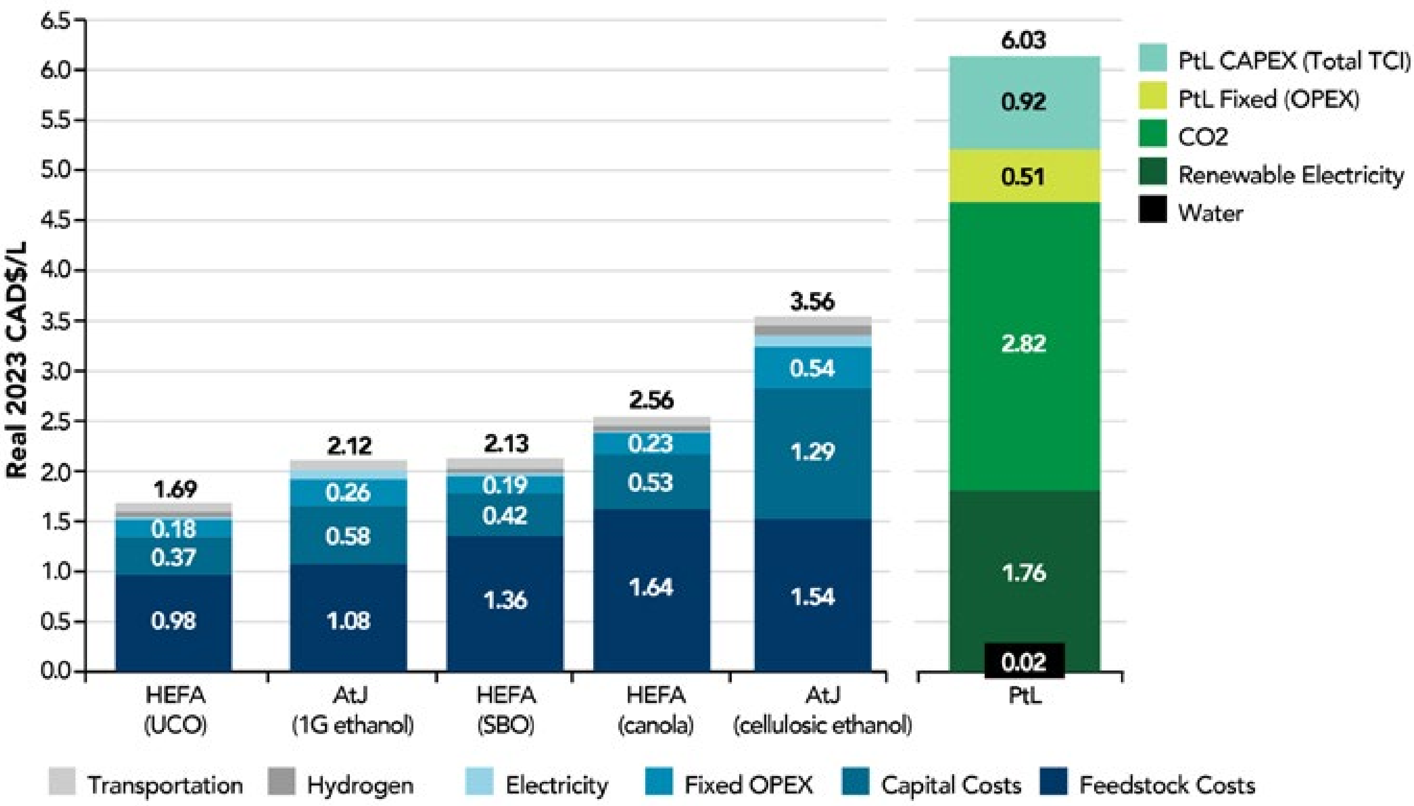


Source: Argus Media (2024)

72 SAF Whitepaper (2024), Argus Media Group
73 SAF Whitepaper (2024), Argus Media Group

In examining SAF production costs for 2030 in greater depth, Figure 04 below offers a cost breakdown by input for several SAF production pathways[74]. It is noted these figures are based on 2023 data and structural shifts to the supply/demand dynamics for UCO / soybean oil / canola oil have changed since then. Across all pathways, feedstock costs (including hydrogen for PtL) account for the largest cost component of SAF production – which is indicative of the value passed on to agriculture and other feedstock suppliers. For HEFA-based pathways capital costs account for 20-25%, as these are relatively straightforward designs, and the technology is fairly mature[75]. Other pathways like ATJ and PtL are much more capital-intensive on a per litre basis. Operating expenses, such as labour and routine maintenance, are the third largest cost component in SAF production. When producers seek to validate a business case for SAF production, proponents must have a sufficient positive forward outlook that the operating margin will exceed production costs and provide a reasonable return on capital employed to reach a positive final investment decision. Production costs are also location-dependent and may be impacted based on the proximity of SAF refineries to feedstocks as well as regional electricity pricing (noting that the values that appear in Figure 04 are based on a North American average price of electricity). As illustrated in Figure 04, feedstock costs are a major component of the final market price of SAF (in particular HEFA SAF), and the difference in the price of feedstock will continue to have an impact on the price of SAF.

FIGURE 04 | Projected 2030 Production Cost Breakdown

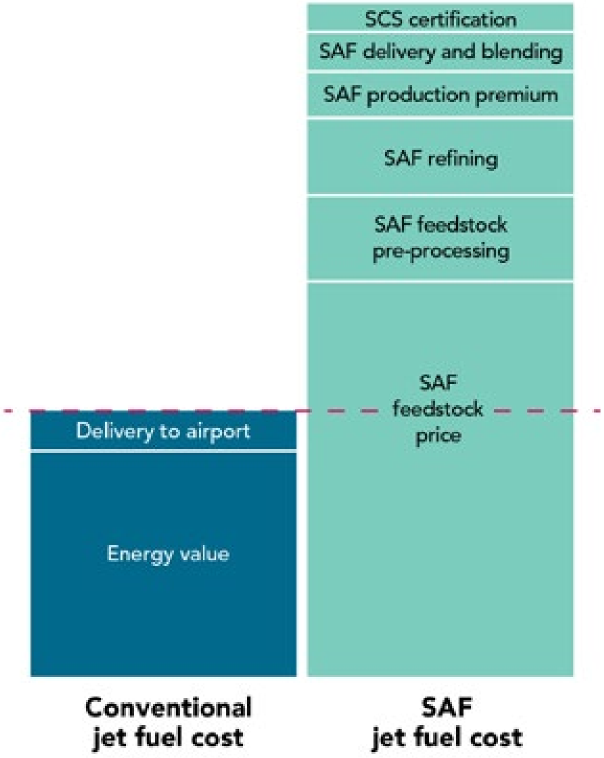


Source: Argus Media (2024)

74 SAF Whitepaper (2024), Argus Media Group

75 Argus Media (2024)

FIGURE 05 | **Projected 2030 Production Cost Breakdown (activities perspective)**



Source: Deloitte (2024)

While there is minimal available data on SAF produced in Canada to date, there are specific regional opportunities and trade-offs that may influence how future SAF production emerges. SAF production by Canadian refiners in the Prairies region could enjoy proximity to feedstocks but would likely need to rely on more expensive rail transport to bring their SAF to market. Beyond the natural advantages of each region, critical elements in the supply chain also have to be online to support production investment, which limits options to site facilities in Canada. Existing refinery capacity in Quebec and Ontario might experience higher feedstock transportation costs (depending on their feedstocks), but could benefit from lower electricity prices and proximity to major airports. Alberta-based refineries could benefit from lower natural gas prices (at the expense of their CI score) and have access to pipeline infrastructure to the B.C. West Coast, but have a slight feedstock cost disadvantage. SAF Refineries in B.C. may have higher feedstock costs but would also benefit from existing market incentives, proximity to a major SAF market and access to the U.S. West Coast SAF markets via marine movements.[76]

To site facilities in Canada, producers need a viable margin and long-term durable demand, noting that the sustained policy signals are needed to make an attractive business case for investment. Where the regional market demand is not sufficient to justify investment, producers could benefit from managing risk in other ways – for example, through measures that directly support production or access to national /global demand through book and claim systems. Other jurisdictions (in particular in the U.S.) have strong production incentives available to domestic refiners (see Section 3 above). This privileges refiners in other jurisdictions who are also able to take advantage of existing incentives for fuel suppliers in Canada (see Section 6 below for further details).

Although the Canadian SAF market is emerging at a slower pace than other jurisdictions with more favourable investment climates, there is progress. Through their procurement efforts, Canadian aviation operators are increasingly working to show that demand for SAF in Canada is growing and have demonstrated an interest in partnership opportunities domestically and abroad. The combination of the federal CFR and B.C.'s LCFS helps create potential for an attractive market for SAF refiners to produce and sell into B.C. However, outside of B.C., there are fewer supports available to cover the elevated costs of SAF production.

76 Argus Media (2024)

SECTION 6

Importing SAF

Key Insights

1	Although significant new capacity continues to be announced and is expected to ramp up globally, production today is limited to just a handful of countries. Exporting producers are primarily selling to the U.S. and Europe, where significant demand and pricing arbitrage has been generated by SAF regulations and incentives. The scarcity has also encouraged fuel purchasers to lock up SAF supply over the short- and medium-term in offtake agreements to meet compliance obligations, which ultimately impacts the near-term availability and pricing of global imports into Canada.
2	Canada could continue to take advantage of volumes available from Asia and leverage the geographical proximity to import SAF from the U.S. (pending any negative trade policies). Airlines' sustained willingness to pay for these volumes will be highly dependent on the creation of a competitive environment for SAF use in Canada and ensuring efficient logistics.
3	With respect to supply chains, Canada may encounter some minor challenges accessing pre-blended SAF from the U.S. Although some neat SAF has been imported and blended in Canada to accommodate the import of large volumes of neat SAF, Canada may need additional blending infrastructure that adheres to international standards to ensure proper handling and delivery of a usable product to consumers.

As established in Section 5 on Domestic Production, significant volumes of SAF will need to be imported to decarbonize the aviation sector, regardless as to whether or not Canada establishes domestic SAF production. The availability of sufficient SAF production capacity in exporting countries, the willingness to pay for SAF among end-users in Canada, and the establishment of reliable supply chains will ultimately dictate Canada's success in importing SAF over the long term. Similar to conventional jet fuel, there are also supply risks for purchasers that choose to import SAF into Canada, including vulnerability to supply chain disruptions, quality control issues, and geopolitical factors (e.g., maintaining energy supply chains).

Recognizing there are annual fluctuations, approximately 30% of Canada's jet fuel consumption is sourced from imports (totalling around 1.5 billion litres in 2022).[77]

Given the forecasted demand increase for jet fuel and Canada's import position and with no new refining capacity on the horizon, development of Canadian domiciled SAF production will not only benefit Canada's economy but will also help to ensure Canada's energy security. As displayed in Figure 06, conventional fuel arrives in Canada via pipeline, rail, trucks and marine shipping depending on the location. Elements of Canada's existing infrastructure for conventional jet fuel can be leveraged for SAF into Canada, although there are minor challenges that add complexity. Under regulations set by the Federal Energy Regulatory Commission, neat SAF (SAF not blended with jet fuel) cannot travel from the U.S. by pipeline, meaning it will need to either be blended first or brought into Canada via another mode of transportation. However, while SAF quantities remain limited, the fuel will likely be transported by truck, rail or marine shipping routes.

77 Statistics Canada, "Production, domestic consumption, and imports of kerosene-type jet fuel." accessed 2024.

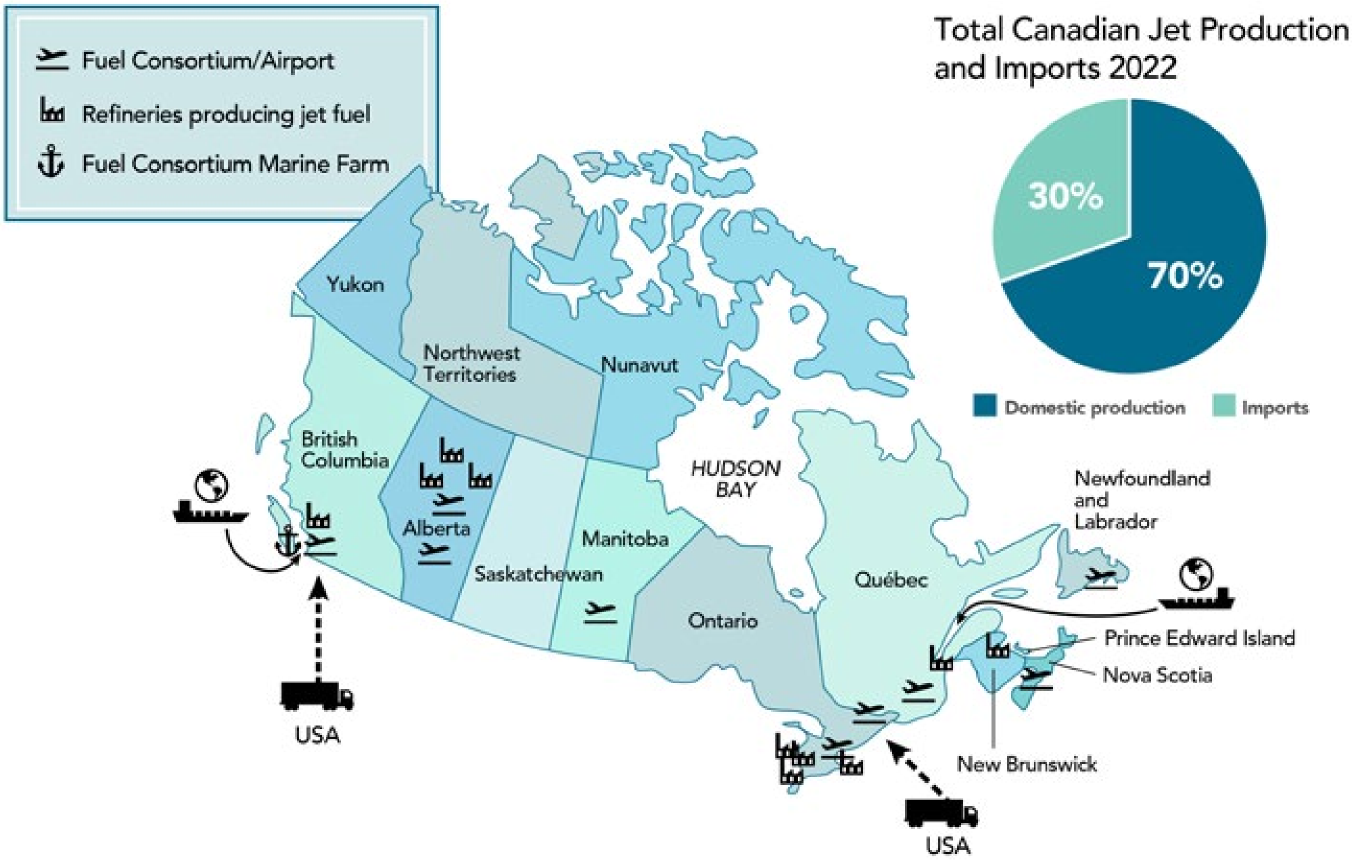
Storage and distribution infrastructure may require some modification or specialized equipment to handle and store SAF. Although not an immediate issue, additional blending capacity may eventually be required, particularly if Canadian purchasers wish to regularly import large volumes of neat SAF (recognizing that some neat volumes of SAF have already been imported and blended in Canada).

Pre-blended and Neat SAF

In accordance with current aviation fuel specifications containing synthesized hydrocarbons (ASTM D7566), neat SAF (or as defined by industry, Synthetic Blending Component (SBC)) must be blended with conventional jet fuel (Jet A or A-1), which is then approved for use in an aircraft.

In the absence of blending infrastructure, the only means of uplifting SAF in Canada is if it is pre-blended. For instance, Neste's 2024 agreement with Air Canada to supply SAF into Vancouver was delivered as pre-blended volumes.

FIGURE 06 | **Conventional Canadian jet fuel production and import pathways (2022)**



Clear guidelines for handling SAF and robust certification, monitoring and evaluation systems are required, especially regarding imports. Aviation fuel used in Canada must be certified to the national standard CAN/CGSB-3.23 - Aviation turbine fuel. CGSB-3.23 applies to two grades of kerosene-type aviation turbine fuel (grades JET A and JET A-1) and includes specifications for conventional hydrocarbons, synthetic hydrocarbons (neat SAF or synthetic blending component), naturally occurring non-hydrocarbons and certain approved additives. Synthetic hydrocarbons are only permitted in jet fuel in a blend with conventional hydrocarbons in accordance with ASTM D7566. Once the synthetic component has been confirmed to meet all requirements of the relevant Annex of ASTM D7566, it shall be blended with conventional blending components or jet fuel conforming to this standard. Once certified, any subsequent testing of the finished batch of fuel shall be done solely against the requirements of CAN/CGSB-3.23. One minor challenge for Canada in importing pre-blended SAF from the U.S. is ensuring the SAF blend meets Jet A-1 specification. The U.S. primarily consumes Jet A fuel, while the rest of the world, including Canada (for the most part), uses Jet A-1.[78] The main difference between the two fuels is that Jet A has a freezing point of minus 40 degrees Celsius, while Jet A-1's freezing point is minus 47 degrees Celsius.[79] Some fuel suppliers have indicated they can produce to Jet A-1 specification in the U.S.; however, in general Jet-A1 is less in-demand in local markets and this specification creates some additional complexity for Canadian purchasers during the procurement process. Exceptions can be made for changing grades, but these are done by the market collectively and could include obtaining exemptions or modifications to regulations by the authority having jurisdiction.

78/79 Civil Aviation Fuel | Jet Fuel Specifications | Shell Global

Conversely, importing neat SAF from other jurisdictions necessitates access to blending infrastructure in Canada that meets international standards. As supply chains mature and SAF becomes available in greater volumes globally, additional investment in these facilities becomes more likely (assuming a strong demand signal emerges in Canada). If blend ratios (currently limited to 50%) increase or even reach 100%, the demands on existing fuel delivery, storage, and hydrant systems may change over time (as fuels qualification work continues to advance). Since fuel demand in Canada is highly concentrated around a small number of airports, dedicated SAF infrastructure is likely to materialize around high-traffic airports first. There are opportunities to leverage Canada's existing jet fuel supply chain infrastructure to transport SAF, but suppliers and purchasers that choose to import neat SAF into Canada need access to blending facilities, ideally at a location that is near a source of bulk conventional jet fuel. Several options are available for purchasers:

- **Blending at a fuel terminal:** Transporting neat SAF to a fuel terminal via infrastructure dedicated for SAF (ship, rail, truck, or pipeline). For smaller volumes, trucks would be suitable, but this shift to more efficient modes could be necessary for higher volumes. Offloading platforms for trucks, trains, or water vessels will be required to accept neat SAF, as well as tanks to store and blend it.
  - Advantages: Terminals have experience in handling fuels, biofuels and required certifications.
  - Disadvantages: Requires SAF-specific fuel supply infrastructure at fuel terminal.
- **Blending at a refinery:** Transporting neat SAF to an existing refinery to be blended with conventional jet fuel.
  - Advantages: Refineries have expertise in handling different hydrocarbon products, including biofuels and required certifications, as well as greater capacity to handle fuel quality issues. When SAF is produced or co-processed at an existing petroleum refinery, the upgrade to the infrastructure and certification of the fuel occurs at the refinery and no further supply chain changes are required.
  - Disadvantages: Blending at refineries is only suitable for large quantities, depending on the refinery and source of neat SAF (e.g., if third party), requires SAF-specific fuel supply infrastructure, although it is highly likely that existing infrastructure can be repurposed. The large quantities are required, in part, since the blending facility would have to be cleaned and dedicated to SAF use for a period of time when it is being blended. This could lead to potential market limitations based on acceptance of neat SAF sources.
- **Blending at or near the airport:** This option includes bringing neat SAF to or near an airport fuel storage facility to blend. This idea is explored in greater depth in Appendix 6.
  - Advantages: Blending at or near airports can minimize logistics and handling events which can contribute to lower overall costs.
  - Disadvantages: Depending on the airport and region, access to land in the right location is needed to construct a blending facility and storage. Blending with conventional fuel requires trained personnel and specific facilities. Specific processes and equipment are needed to deal with any off-specification product and to get it back to specifications. If such facility is separate (i.e., Pearson rail offload fuel system) but still viewed as part of the airport fuel system, handling SAF at those locations would be difficult until updated SAF handling requirements or waivers are adopted by industry. Product quality liabilities would need to be dealt with prudently.
  - Fuel infrastructure management is complex and a one-size-fits-all model should not be pursued. Rather, an evaluation of existing infrastructure and blending opportunities is more likely to happen

on a case-by-case basis. Nevertheless, as the SAF market develops, consideration should be given to ensuring that Canadian supply chains offer some access to SAF blending for new entrants into the market to facilitate imports of SAF into Canada. Where an acute need is identified, this approach could be explored as a public-private partnership model to facilitate this kind of broader access. The most probable source of imported volumes of SAF for Canada would be the U.S. As mentioned in Section 3 above, in 2021 the U.S. federal government set an ambitious target to reach 3 billion gallons (11.3 billion litres) of domestic SAF production by 2030. As of August 2024, the U.S. had produced 16.5 million gallons (62.5 million litres) of SAF across two operational plants. As of 2024, there are dozens of announced SAF projects at varying stages of project development in the U.S., with a cumulative nameplate capacity of 3.48 billion gallons (13 billion litres) by 2030, although the U.S. Department of Energy estimates that possible delays, cancellations or shifts in production to prioritize renewable diesel might result in only 53% of this capacity coming online by 2030.

Notably, in 2024, the U.S. also used 62 million gallons (234 million litres) in its domestic aviation industry, easily outstripping its domestic production capacity and more than doubling its consumption of SAF from 2023.[80] Most of this consumption in 2024 was met through imports, primarily sourced from Neste's refinery in Singapore.[81]

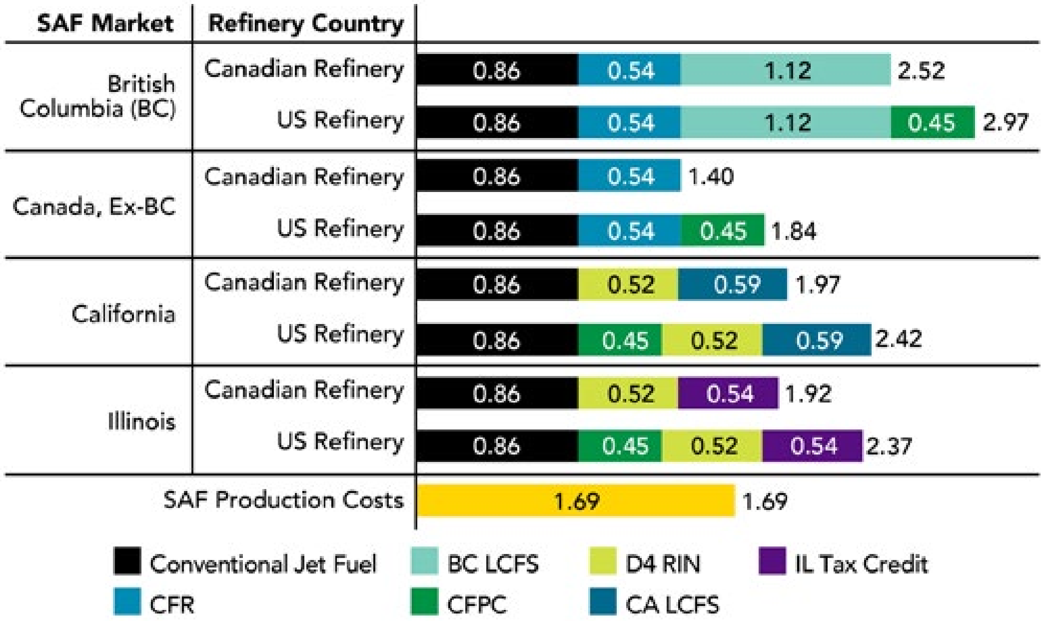
Notwithstanding uncertainties concerning how quickly announced projects could be realized, as well as how much U.S. SAF may be available for export, Canada may access imports from the U.S. According to a 2024 study by Argus Media, which modelled a few different North American markets in 2030 (see Figure 07), B.C. in theory could offer some of the most attractive incentives in North America for U.S-based or Canada-based suppliers looking to sell SAF, due to the incentives available under the combination of the B.C. Low Carbon Fuel Standard and the Clean Fuel Regulations. In this scenario, U.S. suppliers would benefit from both the Canadian incentives as well as access the U.S. IRA production incentives (the Clean Fuels Production Credit), when selling into the B.C. and Canadian markets. Across all models, however, the credit stacks available in Canadian jurisdictions outside of B.C. were universally less competitive than B.C., California, or Illinois. Although not reflective of actual regional market prices (which can be volatile and depend on a number of other major factors, including certainty around maintaining a high credit price; the market price for alternative products that refiners can produce from the same feedstocks, such as renewable diesel; access to feedstocks; and, competing for supply in a market dominated by existing supply agreements), the illustration provides some indication of how existing instruments in Canada could help to support local production and help bring SAF into B.C.[82] The figure below also underscores the reality that predictable long-term policy would be needed to ensure a domestic SAF market.

80 https://www.energy.gov/articles/us-department-energy-releases-new-report-pathways-commercial-liftoff-sustainable-aviation

81 https://www.spglobal.com/commodity-insights/en/news-research/latest-news/agriculture/122424-commodities-2025-saf-on-the-rise-yet-political-landscape-raises-concerns (accessed Jan 1, 2025)

82 Argus Media group (2024)

FIGURE 07 | Simplified comparison of available credit stacks in different North American markets for SAF produced with used cooking oil (UCO) in 2030



Source: Argus Media (2024)

Note: Pricing has and will continue to shift. The data referenced above references a snapshot in time. For more up-to-date information on upstream agricultural feedstock prices and Canadian principal field crops, refer to Statistics Canada and Agriculture and Agri-Food Canada's websites. And for B.C.'s LCFS credit market information, visit their website.

Geographically, Canada's proximity to the U.S. (relative to markets in Asia or Europe) reduces supply chain complexity and emissions associated with fuel transport. In 2024, the U.S. Department of Energy mapped announced projects that are expected to come online revealing several emerging regional clusters. The location of these announced facilities correlates strongly with states that have low-carbon fuel standards or SAF policies, existing refinery infrastructure, or robust feedstock supply (primarily in the Midwest). According to an analysis by Argus Media, among these clusters, the most likely U.S. supply route to emerge for Canada would be soy-based HEFA volumes from the U.S. Gulf Coast, driven by policy supports available in B.C. (with movement facilitated by vessels not under the Jones Act). Tallow-based HEFA volumes from the U.S. Mountain region may also be available to Western Canadian markets, although end users in these regions would compete for supply with end users that are able to access the strong SAF consumption tax credits in Illinois. Other regional sources, including the Pacific Northwest and the Upper Midwest, would be more likely to sell to California, Illinois, Washington or Minnesota markets.[83]

Despite the incentives and policy drivers that presently support SAF investment in the U.S., SAF is still a nascent global market that depends on long-term investment and policy support. Interviews with Canadian industry stakeholders reveal several concerns with the prospect of reliably importing U.S.-produced SAF into Canada:

- **Political uncertainty:** With the shift in the political landscape following the 2024 U.S. presidential election, there is uncertainty associated with the longevity of biofuel and hydrogen policies in the U.S. The lack of clarity and the upcoming expiration of existing programs may deter U.S. producers from committing resources to SAF production, at least in the near-term.[84]

83 Argus Media (2024): SAF Whitepaper

84 https://www.spglobal.com/commodity-insights/en/news-research/latest-news/agriculture/122424-commodities-2025-saf-on-the-rise-yet-political-landscape-raises-concerns

- The International Council on Clean Transportation (ICCT) indicates that without additional policy support in the U.S., there is limited ability for the U.S. to reach SAF targets identified in the SAF Grand Challenge.[85]
- **Offtake agreements to support new projects:** Complicating the availability of supply from the U.S. (and other jurisdictions) is the prevalence of existing offtake agreements, whereby airlines agree to purchase specified amounts of SAF, if a set of conditions are met (e.g., availability at a certain price). An analysis from the U.S. Department of Energy of publicly announced offtake agreements suggests that half of contracts globally are one-year contracts, many of which price SAF below cost and at parity with Jet-A fuel to attract airline buyers. Although rarer, longer term (>10 years) and higher volume agreements tend to be more effective at providing the cash flow guarantee to attract investors and derisk projects. One example of a longer-term offtake agreement helping to advance project development is LanzaJet, which recently opened a SAF production facility in the State of Georgia that could produce 10 million gallons of SAF with offtake agreements in place that account for the facility's production for the next 10 years. However, multiple established and prospective U.S. SAF producers have indicated that the conditions included in some offtake agreements (e.g., purchases dependent on specific pricing or policy related changes) is minimizing this benefit and leading to continued reluctance from investors.
- **Competition for existing supply:** Until committed demand materializes, the global SAF market will remain a seller's market with constrained supply, leaving established producers with the ability to select agreements that have beneficial terms. One of these conditions can be that they will continue to rely on delivery to clients in proximity to production facilities, including regional and local airports to reduce transport and delivery overhead, and locations with minimal additional logistics issues (e.g., blending).

Wider Global Availability of SAF for import into Canada

Outside of the U.S., Asia and Europe are the emerging regional centres of global SAF production, with most of the new announced capacity to be built as standalone refineries.[86] Section 3 Global Perspectives: Current State of SAF offers an overview of the different policies and approaches that leading jurisdictions are pursuing to support the development of domestic production and use.

From a demand perspective, outside of the U.S., Europe's demand for SAF is helping to drive the emergence of a global market. Estimates from global aviation and aerospace industry stakeholders suggest that the European Union ReFuelEU SAF mandate alone could require 3.58 billion tonnes of SAF, and that the U.K. mandate could require 1.2 billion tonnes.[87] Other commitments and policies in Norway, Brazil, Türkiye, the United Arab Emirates, Japan, and India may also contribute to demand. Globally the SAF ecosystem (airlines, operators, and corporate partners) currently has around $45 billion in forward purchase agreements for SAF, an increase from $6 billion prior to COVID-19. International demand signals are helping to grow the global market, but with limited global production and ambitious global commitments, fuel purchasers globally are increasingly competing for scarce available volumes.

From a supply perspective, as of November 2024, there were 37 dedicated SAF production facilities globally, producing roughly 600 million litres of SAF. The next wave of facilities (expected to enter service between 2024 and 2026) could add 2.9 billion litres per year in new production, located in China, Poland, Spain, Thailand (Bangkok) and United States (California and Washington).[88] Nevertheless, signed offtake agreements significantly surpass the total available SAF volume produced globally. For context, in 2022, there were agreements in place for SAF totalling over 21 billion litres – an indication that much of the new supply may not be available for import to Canada.

85 ICCT. "SAF Grand Challenge White Paper" November 2023

86 ATAG, ACI, CANSO, IATA, IBAC, and ICCAIA (2023). CAAF/3-WP34: State of the SAF Industry: An Industry View. Working Paper submitted to the Third Conference on Aviation and Alternative Fuels (CAAF/3).

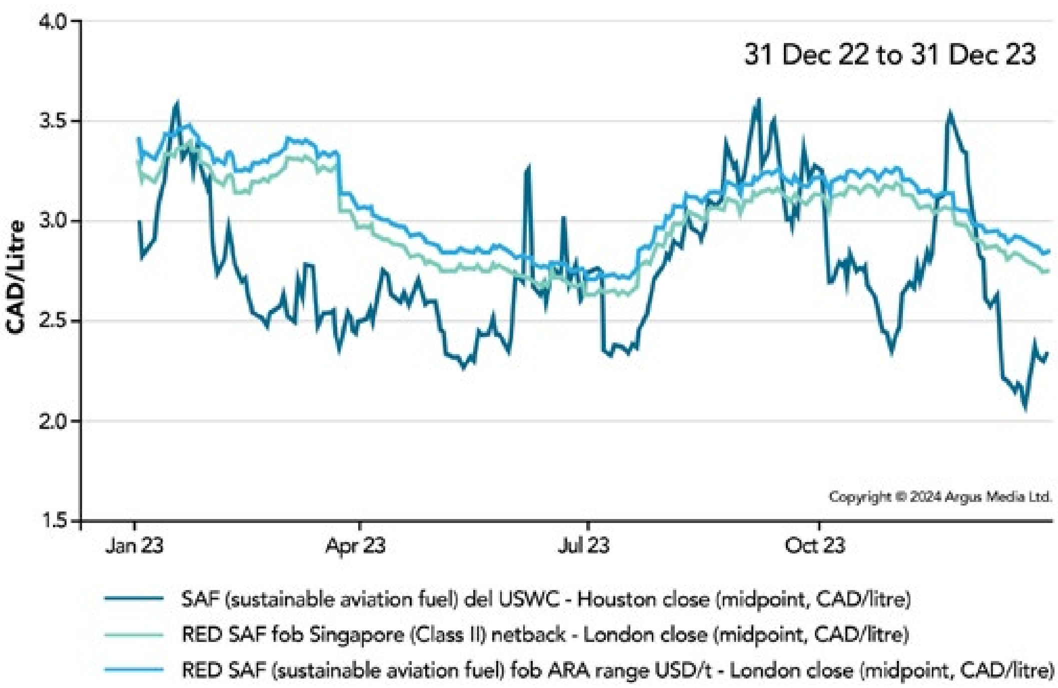
87 https://www.icao.int/sites/default/files/Meetings/CAAF3/Documents/CAAF.3.WP.034.2.en.pdf

88 ICAO, "ICAO Tracker of SAF facilities", 2024

In the more medium term, ICAO provided four SAF production projection scenarios to 2030 that estimate SAF quantities based on an assessment of project maturity and feasibility from announcements made before January 2023. The 2030 SAF projection ranges from 3.059 million tonnes (low scenario) to 16.973 million tonnes (high+ scenario), with most of the production concentrated in North America and Asia. These scenarios include a feasibility assessment targeting variables such as success rate of facilities, facilities which have reached final investment decisions, and facilities which have announced specific plans to allocate production output to SAF, amongst others.[89]

The APAC (Asia Pacific) region has significant variation in terms of the availability of feedstocks and the cost of production. In countries with abundant biomass resources, such as Indonesia and Malaysia, producing SAF from both virgin and waste oils and fats are likely to be more cost-effective than other pathways. APAC also relies heavily on the Major O&G suppliers to drive SAF production and regulations upwards. Countries with limited biomass resources may have to rely on imported feedstocks or advanced production pathways (i.e., ATJ), which could increase production costs.[90] Outside of the recent volumes supplied to the U.S. (from Singapore) in 2024, Asian SAF producers have typically focused on supplying the E.U. market, using premium feedstocks that will meet stringent E.U. requirements. As a result of these regulations, SAF prices in Northwest Europe have often been higher than delivered SAF prices on the U.S. West Coast (see Figure 08 below). As long as the relative price imbalance for SAF across the West Coast, Singapore, and Northwest Europe persists, Asian refiners will likely continue to provide opportunistic supplies to North America to relieve imbalances, but their more structural supply route would be to continue to sell into Europe and capture higher SAF prices.[91] In November 2024, Neste and Air Canada agreed on the supply of 60,000 tons (77.6 million litres) of unblended neat Neste MY Sustainable Aviation Fuel for use on flights from Vancouver International Airport. It marked the first imports of Neste SAF from Singapore into Canada.

FIGURE 08 | **Regional SAF prices (2023)**



Source: Argus Media (2024)

89 ATAG, ACI, CANSO, IATA, IBAC, and ICCAIA (2023). CAAF/3-WP34: State of the SAF Industry: An Industry View. Working Paper submitted to the Third Conference on Aviation and Alternative Fuels (CAAF/3).

90 Deloitte Research

91 Argus Media (2024)

Observations from Canadian SAF Procurements

Despite challenges with a nascent global market for SAF, Canadian air carriers are starting to gain experience with SAF procurement and logistics. Over the last several years, Canadian airlines WestJet and Air Canada have both purchased and imported SAF volumes into Canada for use in their operations. In 2024, the Government of Canada's Low Carbon Fuels Procurement Program announced that deliveries of SAF into Vancouver International Airport would begin in 2025 for use (through book and claim) in Canada's operations at Cold Lake. Canadian fuel suppliers have also used facilities in B.C. to blend neat SAF with Jet A-1 for delivery into Vancouver International Airport. Interviews with stakeholders about these successful procurements, as well as broader experiences in working to integrate SAF into business operations, reveal several key considerations about the prospect of future imports into Canada:

Pricing and competitiveness challenges:

- Experiences with SAF purchased through Book and Claim in B.C. suggest the average cost premium of SAF was 2-3 times the cost of conventional jet fuel.
- Canadian airlines' experiences with SAF purchases in 2023 suggested that SAF pricing is also higher (up to 8 times higher) than the current market price for CORSIA offsets (both of which are currently in limited supply).[92] Airlines that are working to meet ambitious decarbonization commitments are opting to pursue both, even with the higher cost of SAF.
- While some airlines have successfully procured SAF, they have expressed significant concern about the entire industry's capacity to absorb the additional costs associated with reaching and maintaining 10% SAF use at the current market price. IATA estimates that in North America, aircraft fuel accounts for around 26% of total airline operating costs, which represents the single largest operating expense.[93] Airlines have expressed concern that certain cost-recovery options for large-scale SAF procurement (e.g., increasing ticket prices) poses a significant risk to competitiveness against both airlines that do not purchase SAF and airlines that have access to SAF consumption incentives. Airlines indicated a preference for measures that contribute to cost-recovery and/or support availability of SAF at a lower cost in the local marketplace (e.g., the B.C. LCFS).
- Beyond the challenges directly associated with the production price of SAF, for new fuel purchasers, the experience of seeking scarce volumes of SAF on the international market can sometimes be lengthy, including complicated logistics and a reliance on third parties, which can add further time and cost to the procurement process. Given the length of time it can take to negotiate an agreement with a producer and arrange the necessary logistics, the price of SAF may have fluctuated, impacting either a purchaser's volume order or budget.

Specifications, Blending and Availability of SAF:

- Even with end-user requests that are unrestrictive with regard to sustainability, volume, and timing requirements, there are very limited volumes available for imports or from domestic production, particularly before 2028.
- Request for Proposals (RFPs) did not incite action from facilities (e.g., no new facilities were willing to submit proposals based on the request).
- North American SAF refiners are optimizing product placement based on the policy support mechanisms available to them across jurisdictions. The combination of the federal CFR and B.C.'s LCFS creates an attractive market for SAF refiners looking to export to Canada, and multiple suppliers have had their alternative jet fuel carbon intensities approved under the B.C. LCFS.[94]
- SAF fuel blends for the defense sector must meet NATO fuel specifications, which may impose additional testing and logistical requirements on suppliers.
- Some suppliers (and some airlines) expressed a preference for blended fuel, citing the fact that they do not have access to blending facilities in Canada. Nevertheless, some fuel suppliers have imported neat SAF for blending (and later use) in Canada.

92 S&P Global. "Demand for CORSIA carbon credits unlikely to match supply until 2030: Abatable" 2024

93 https://www.iata.org/en/publications/newsletters/iata-knowledge-hub/unveiling-the-biggest-airline-costs/#:~:text=Airline%20Cost%20Items%20Breakdown,to%2025.5%25%20in%20North%20America.

94 B.C. LCFS - https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/rlcf012_approved_carbon_intensities_current_nov2024_v3.pdf

Sustainability requirements, including CORSIA certification:

- When procuring SAF, airlines that fly internationally (and which need to meet an international aviation emissions reduction obligation) will likely need to seek fuel that meets CORSIA sustainability requirements, as well as any local sustainability requirements for fuels in the receiving jurisdiction (e.g., B.C. LCFS). CORSIA requires a high level of transparency and traceability to guarantee fuel sustainability characteristics, and each point in the SAF supply chain is required to have been certified towards CORSIA requirements for Economic Operators and meet CORSIA Sustainability Criteria, as applicable. Airlines ensure that the SAF they procure is eligible for use in CORSIA through sustainability documentation associated with the procured fuel.[95]
- With many new and continuously evolving regulatory requirements, both vendors and airline fuel procurement teams reported the challenge of lengthy administrative processes and maintaining familiarity with multiple jurisdictional requirements – potentially deterring further interest in supplying SAF in Canada. It is important that all levels of government in Canada work together to consider how existing and potential incentives could be stacked and how to avoid misalignment of policies across regions.

SECTION 7

The Role of Book and Claim

Key Insights

1	Exploration of a consistent framework and guidance to scale the use of book and claim systems in Canada can support SAF production and availability and better enable regional collaboration in meeting SAF goals and reducing emissions. Where feasible, aligning with international SAF accounting and sustainability standards like those provided by CORSIA can minimize administrative and financial burden across the value-chain.
2	As part of the exploration of a book and claim system, it is important to ensure that all stakeholders have a common understanding of the interactions between international, national and provincial policies relevant to SAF purchase, blending and use to identify how the environmental attributes of SAF can be claimed and attributed while avoiding double counting. Consideration should be given to understanding how best to enable both aviation operators and end users (e.g., air travel and freight users) to purchase SAF environmental attributes or certificates, helping to mobilize additional demand.

95 ICAO (2023). "CORSIA Approved Sustainability Certification Schemes." 2nd edition, 2023 June 16. CORSIA Eligible Fuels (icao.int)

Book and claim is an important mechanism supporting the consolidation of demand and scale up of SAF production where physical supply is limited. Book and claim systems allow entities to claim the environmental benefits of using SAF without necessarily having to physically source the fuel and take delivery and use it. More specifically, book and claim models 'de-couple' specific environmental attributes (e.g., lifecycle GHG emissions) from a physical product and track and transfer them separately from the physical product via a dedicated accounting system (or registry). Environmental attributes are de-coupled and entered (booked) in the accounting system when a quantity of a sustainable product is added to an agreed-upon point in a supply chain (e.g., a litre of SAF added to an airport's fuel system). They can then be claimed by (or assigned to) an end-user to reduce the emissions associated with their use of the equivalent quantity of the conventional product.

For example, the Roundtable on Sustainable Biomaterials (RSB) has developed the RSB Book and Claim Manual and RSB Book and Claim System to support the voluntary use of book and claim for the hard-to-abate sectors of aviation and shipping. It provides the following overview:

> *Book and claim is a chain-of-custody model in which the administrative record flow does not necessarily connect to the physical flow of a product throughout the supply chain (Source: ISO 22095:2020). In other words, book and claim means that organizations can obtain and claim the sustainability attributes of a product without having to take physical custody of that same product and without needing the buyer and the seller to be connected by a physical supply chain – as is the case with other chain-of-custody models such as 'mass balance'. Book and claim transactions must be tracked and validated through the use of an independent registry. (Source: [RSB-PRO-20-001-002] – Version 3.0 – RSB Book & Claim Manual, Page 1, Link:* *https://rsb.org/wp-content/uploads/2023/04/rsb-pro-20-002-rsb-procedure-for-book-and-claim-4.2.pdf.*

Accounting frameworks, like book and claim systems, can facilitate the allocation of the environmental benefits of a given volume of SAF across different users in the aviation sector. For example, an aircraft operator could claim the direct (Scope 1) emissions reduction value of SAF for it's operations and an air service user (such as an air traveller) could claim the related indirect (Scope 3) emissions reductions from the use of SAF by an air operator.

These systems are important as they will help to consolidate demand and enable SAF benefits to be distributed geographically, even when production is limited to a few locations. They can also facilitate the use of tradable SAF certificates that represent the environmental benefits of producing and using SAF instead of conventional jet fuel. Book and claim systems can strengthen existing SAF markets, as well as create markets for SAF that can help incentivize new production capacity in locations beyond the major airport hubs. They can also help reduce or avoid unnecessary transport of SAF and feedstocks, minimizing cost and the associated incremental lifecycle emissions.

There are also geographic considerations for the use of book and claim to support the achievement of Canada's SAF goals. Generally, only SAF that is uplifted in Canada and attributed towards domestic flights will count towards Canada's national greenhouse gas emissions targets and both imported and domestically produced SAF would need to be physically situated within Canada before its environmental attributes could be decoupled and booked into the system. A well-designed system would allow airlines to claim emission reduction benefits from eligible fuels across national boundaries, given the global scope of their operations.

An effective SAF book and claim system could enable Canadian airlines, governments, and corporations to benefit from and claim SAF's environmental attributes, even if it is not yet physically available in their region. This would support the development of the demand market in Canada by allowing for the environmental benefits of SAF to be claimed by SAF users across the compliance and voluntary market value chain (e.g., fuel producers and supplies, aviation operators, aviation service end-users), thereby reducing costs and increasing efficiencies.

Multiple book and claim systems, including registries, are being established by different organizations to allow for the registration of SAF certificates by fuel producers and to record the transfer of sustainability attributes to airlines or corporations. Each of these systems include a registry to implement the book and claim system rules so that claims are consistent, transparent and avoid double counting. Some registries limit participants to specific stakeholders, while other registries are open to any parties. However, there is considerable variety in how each system is implementing book and claim, and there is not a common consensus around some key issues such as, accounting for credits created under compliance systems and the use of SAF by aviation end-users to reduce Scope 3 emissions.

Various international organizations are working to enhance understanding and improve the alignment of these systems. For example:

- The Council on Sustainable Aviation Fuel (CoSAFA) is an association of global aviation sector associations whose objective is to build government and consumer confidence in SAF through transparent environmental attribute documentation and a smooth transfer of information encompassing the SAF life-cycle. They are working to improve the integrity and reduce the friction in SAF transactions by establishing a common set of fair operating rules that will enable SAF market growth in a global economy. CoSAFA has published a "Methodology of SAF Environmental Attribute Transactions," a system of procedures for the accounting and auditing of global book and claim programs.
- ICAO's Third ICAO Conference on Aviation and Alternative Fuels (CAAF/3) emerged with an agreement to explore the book and claim concept, including undertaking a study of fuel accounting systems for international aviation to better understand these systems and to identify areas for further investigation. The work will identify what role, if any, ICAO could have in supporting these systems to facilitate access to the environmental benefits of SAF and other aviation cleaner energies.[96]

96 https://www.icao.int/sites/default/files/sp-files/environmental-protection/GFAAF/Documents/ICAO-Global-Framework-on-Aviation-Cleaner-Energies_24Nov2023.pdf

The following is an overview of leading global book and claim systems for SAF that are currently in place:

FIGURE 09 | **Overview of selected global book and claim systems**

RSB

Live since 2021, this registry spans the aviation industry across the United States with plans to expand to the shipping sector in the short-term.

Scope

- RSB created a Book & Claim System that allows for the de-coupling of specific attributes from the physical product.

Key Approach

- The RSB Book and Claim system consists of a manual and registry. A manual is the procedure for the rules to register, trade and retire credits in the registry. While the registry is the database that stores book and claim transaction information.
- In order to be eligible for certification under the RSB Book and Claim system, producers must demonstrate compliance with a set of sustainability criteria that cover environmental, social, and economic aspects of production.
- This system was created to enable purchase of the benefits of SAF without physical ownership.

Key Insights

- Supports sustainable production.
- Globally recognized.

Limitations

RMI

The SAFc Registry Guide is being built with Energy Web to provide transparency and consistency to the SAF certificate market.

Scope

- SAFc is an extension to the RSB Book and Claim system. The registry allows producers of SAF to register fuel and generate certificates that can be sold to airlines, airports, and other organizations to reduce their carbon footprint.

Key Approach

- A SAFc can be issued in the Registry if the corresponding SAF volume is owned by an RSB trader-certified entity, and if it the supply chain follows a sustainability certification scheme (SCS) held by RSB or the ISCC system.
- Issued units can be transferred, held and retired by the account holders in the Registry.
- The rulebook specifies how SAFc can be issued, transferred, and retired in an independently governed registry.

Key Insights

- Supports sustainable production.
- Globally recognized.

Limitations

- Currently focused in the United States but has identified a system through which independent book and claim systems can be certified to enable alignment with the SAFc registry.

CADO SAF Registry (founded by IATA)

Developed to facilitate the recording, accounting, and reporting of SAF transactions. The system was launched in 2025.

Scope

- The System facilitates SAF transactions linked to regulatory (including but not limited to CORSIA and E.U. ETS) and voluntary frameworks.

Key Approach

- Based on industry best practices and a manual that explains the registry design and procedures
- Interoperable with other SAF registries to prevent any type of double-counting or double-issuance
- Could function as a SAF clearing-house to ensure the emissions reduction retirement from a specific batch of SAF is only surrendered once
- Designed to be SAF technology agnostic for any types of SAF that meet internationally recognized sustainability standards
- Backed by accounting principles to maintain the integrity of emissions reduction claims associated with SAF.

Key Insights

- Supports sustainable production, intends to be globally recognized, support regulatory and voluntary SAF frameworks.

Limitations

- The key principle of the system is to be agnostic and neutral while offering the transparency needed for any system stakeholder to take decisions based on the data available to the user.

Avelia

Partnership between Shell, Accenture, GBT and EnergyWeb.

Scope

- A blockchain powered book and claim solution that provides a fully traceable certificate system enabling the purchase of the environmental attributes of SAF.

Key Approach

- Requires producers to be certified – once certified they are issued a certificate and can sell credits through the Avelia book and claim system
- The requirements for certification include sustainability requirements defined by Avelia
- The buyers can then purchase credits that represent the benefits of low carbon fuel that are verified through the certification process

Key Insights

- Supports sustainable production
- Currently focused in North America.

Limitations

- Trying to limit double efforts across the field can potentially be included as an extension to the RSB book and claim system.

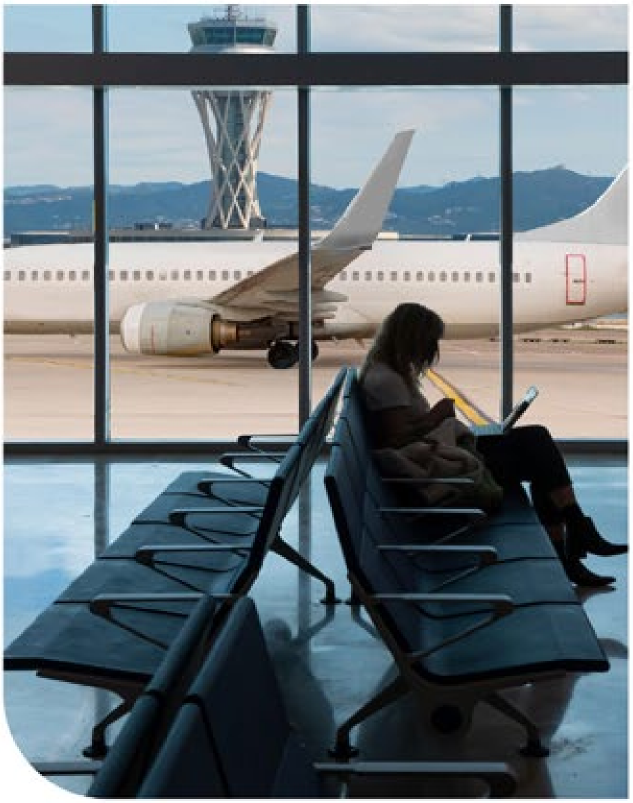
Exploring a National Book and Claim Approach

Additional work is needed to explore and enhance the use of book and claim in Canada, ensuring that transparent, credible systems are in place that meet the needs of all potential participants (fuel producers and suppliers, aviation operators, aviation end-users). This could include the adoption of an existing book and claim system, developing a new national book and claim system, or, a set of consistent principles and criteria for book and claim systems in Canada. An effective book and claim system would include the following elements:[97]

- An electronic data system (e.g. a registry) that can register, track and assign or retire SAF environmental attributes from the voluntary (non-regulatory) market.
- Compatibility with internationally developed book and claim systems (e.g., airlines and private end-users are using multiple systems).
- Include third-party auditing and verification to limited assurance level in accordance with relevant guidelines (e.g. ISO 14064 International Standard for GHG Emissions Inventories and Verification), and relevant security and data standards.
- Include tracking and criteria for SAF sustainability (e.g., CORSIA criteria).
- Is operated or endorsed by a trusted entity or certification body (e.g., trusted not-for-profit or government).
- Capable of tracking SAF use and emissions for both domestic and international flights.
- Capable of providing SAF life cycle carbon intensity values using multiple LCA methodologies (e.g. CORSIA, Canadian Clean Fuel Regulations, B.C. LCFS).
- Capable of tracking and allocating environmental attributes for both aviation operators (Scope 1) and aviation end-users such as air travellers (Scope 3).

Book and claim systems are still at early stages of development globally but are scaling up rapidly. Various aviation stakeholders are just beginning to explore and develop / pilot book and claim systems, each with its own set of rules for regulating the integrity of the system and for minimizing the risk of double counting.

In exploring the potential for a national book and claim system in Canada, it will be important to clarify how SAF purchase, blending and use within Canada or by Canadian airlines will interact with blending mandates, production incentives and other regulations (e.g., Clean Fuel Regulations, B.C. LCFS, CORSIA, etc.). According to IATA and RSB, a book and claim system should allow stacking of incentives for SAF while permitting its use towards regulatory obligations, like CORSIA. However, the RSB manual indicates that this can be regulated or prohibited in some national policies. As such it will be important to clarify the interaction between international, national, and provincial regulations and policies to identify how the environmental attributes of SAF can be claimed and attributed and when it is permissible to stack claims for a given volume of SAF under different systems.



97 This draws from CoSAFA's draft Methodology of SAF Environmental Attribute Transactions and research conducted by the Government of Canada's Low-carbon Fuel Procurement Program.

SECTION 8

Sustainability Criteria & Accounting

Key Insights

1	Variances between CORSIA, national and subnational methodologies are creating an administrative burden on many parts of the value chain that need to certify SAF for regulatory or voluntary market compliance in order to claim benefits of SAF use. SAF certified under regulatory markets such as CORSIA or E.U. RED may be possible to be used in voluntary markets, so long as the certified SAF meets the voluntary market's requirements. More comparative analyses are needed to understand and clarify the similarities and differences between methodologies, and potentially streamline the use of different methodologies, particularly for airlines that operate across multiple jurisdictions.
2	Conducting life cycle assessments (LCA) of anticipated Canadian SAF pathways could help Canada to better understand how to leverage its advantages to support low-carbon intensity SAF production, including identifying areas in the life cycle of the fuel that have a high GHG footprint and could be improved. Potential investors and SAF end-users capitalize on this knowledge, particularly in a global environment where sustainability requirements have economic implications and might become more stringent over time.
3	Canada's canola and forestry industries are available to be utilized for SAF production. These Canadian industries also benefit from recognition under existing sustainability certification schemes, but it must be determined whether these certification schemes can be recognized and/or repurposed for use in CORSIA (only RSB, ISCC, and ClassNK are recognized to date by ICAO CORSIA) to meet international aviation standards. Other feedstocks, such as agricultural residues that are not yet broadly being certified, and may require additional integration and infrastructure in the feedstock production part of the supply chain, to ensure processes are in place for certification.

Accurate carbon accounting across the entire supply chain is critical to ensure that fuel purchasers have confidence in the integrity of the SAF they are buying and to allow a SAF industry to develop that also incents the development of SAFs with lower CIs that are typically more costly to produce. The commonly used approach for carbon accounting is via a life cycle assessment (LCA) of the fuel to determine the fuel product's life cycle GHG emissions, otherwise termed carbon intensity (CI). The system boundary for the LCA of a fuel product, if based on a full life cycle (i.e., well-to-wake for jet fuel), encompasses the feedstock production and collection, fuel production process, and the transportation steps for both feedstock and fuel across the supply chain, up to delivery of the fuel to the aircraft at the airport and combustion of the fuel. SAF produced from biogenic feedstocks such as crops and residues from farming or forestry are valued for their biogenic carbon content and are treated appropriately in LCA carbon accounting (i.e., carbon emissions from combusting SAF are negated by the carbon taken in during plant growth). By accounting for all these processes and steps in the life cycle, the fuel product's CI can provide an equivalent comparison basis with other fuels.

At the international level, Canada is committed to implementing ICAO's CORSIA and CORSIA requires the use of specified LCA methodologies and approaches. Under this initiative, aeroplane operators can reduce their offsetting obligations on international flights through the use of SAF or lower carbon aviation fuels (together referred to as CORSIA Eligible Fuels). Work is ongoing at ICAO to update and add new SAF pathways with default lifecycle values, and to address any methodological refinements or shortcomings, as they arise.

At a federal and provincial level, LCA methodologies such as the ones prescribed in the Clean Fuel Regulations (CFR), and in provincial low carbon fuel regulations would be used for regulatory compliance, for assessing production incentive eligibility and calculating emissions reductions, essentially creating multiple systems of regulatory compliance and incentives. The use of multiple LCA methodologies create an administrative burden on many parts of the value chain as they work to identify and certify the SAF batches, potentially increasing risks of double counting of emissions and emissions reductions. For example:

- The CFR uses the LCA methodology developed by ECCC, including the Fuel LCA Model based on the OpenLCA software platform as the tool for calculating life cycle carbon intensity of fuels.
- B.C.'s Low Carbon Fuel Standard (LCFS) uses the LCA methodology prescribed in the LCFS along with GHGenius as the prescribed tool for determining the life cycle carbon intensity of fuels regulated in the B.C. LCFS.
- In the U.S., an LCA method specific for use in the Renewable Fuel Standard is used by the Environmental Protection Agency (EPA). Publicly available LCA models in the U.S. include Argonne National Laboratory's (ANL) R&D GREET model, the CA-GREET model used in California's Low Carbon Fuel Standard, and the 40BSAF-GREET and 45ZCF-GREET models based on R&D GREET and configured for use in the IRA SAF and clean fuel production tax credit calculation. Previously, the R&D GREET model was simply the ANL-GREET model and was renamed to distinguish the version used for tax credit purposes.

Under the current systems of compliance for SAF claims, separate life cycle analyses would be required, with the recognition that there will likely be differences in LCA outcomes from one compliance system to another for the same physical unit of SAF. ICAO's CORSIA programme provides benchmark or representative CI values for various SAF pathways based upon its LCA methodology. CORSIA also provides the option for claiming a lower CI for a SAF pathway based on evidence provided that indicates improvements from the assumptions used in calculating the default SAF pathway's CI. Under the Clean Fuel Regulations, ECCC has published eight approved CIs for low-carbon-intensity fuel that is suitable for use in aviation. In 2024, several fuel suppliers had the CI values for their alternative jet fuel approved under the B.C. LCFS.[98]

Beyond LCA requirements, the comprehensive sustainability certification and supply chain auditing requirements for CORSIA eligibility adds a layer of complexity for compliance in fuel claims in international aviation. Similar requirements are in place under the CFR's Land Use and Biodiversity safeguards for all low-carbon fuel, including SAF supplied to Canada that create CFR credits. These additional sustainability and auditing requirements might require further outreach and education to increase the willingness and participation from stakeholders in SAF supply chains. Ultimately, while these sustainability and auditing requirements add to the administrative efforts of the process, they provide the needed independent assurance on the emissions reduction and sustainability claims from the use of SAF, promoting its broader use.

Sustainability Under CORSIA and Carbon Intensity of CORSIA Eligible Fuels

CORSIA was established as a market-based measure enabling the purchase and cancellation of emission units by aeroplane operators (e.g., airlines) to complement measures such as technological, operational, and navigational improvements. At the time that CORSIA was being developed as a market-based measure to aid in aviation decarbonization, SAF had not been fully commercialized; however, it was recognized that SAF should also be an alternative means to meeting emissions reduction obligations under CORSIA. In 2014, ICAO established the Alternative Fuels Task Force, which began exploring the production of SAF and the concepts of LCA, land use change effects, and other technical elements. All of this foundational work led to the present-day sustainability criteria, certification requirements, and life cycle emissions approach for assessing the benefits of CORSIA Eligible Fuels (CEF), including processes for monitoring, reporting, and verification of SAF being used in international aviation [for details on Monitoring, Reporting and Verification (MRV) and the CO_2 Estimation and Reporting Tool (CERT) see Appendix 4].

98 https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/rlcf012_approved_carbon_intensities_current_nov2024_v3.pdf

The first and foremost CORSIA sustainability criterion is that CEF must achieve net GHG emissions reductions of at least 10% compared to the baseline of conventional jet fuel on a life cycle basis (89 gCO_2e/MJ). CORSIA provides default values (which are representative of benchmark life cycle emissions values) for combinations of feedstock and feedstock conversion technology, which are termed SAF pathways. These default values can be claimed by aeroplane operators using the associated SAF pathway, upon an independent third-party certification by an ICAO-approved Sustainability Certification Scheme (SCS). However, in some instances, the SAF pathway is not accurately captured by its associated default value GHG emissions. As a more attractive alternative to using default values, ICAO's CEF documentation includes a detailed life cycle methodology to allow SAF supply chain entities (i.e., economic operators) to submit documentation that supports the calculation of a lower life cycle emissions value for a SAF pathway being certified (if the SAF pathway has a corresponding published default value). See Tables 11 and 12 below for more detailed information on default values.

In addition to the minimum GHG reduction requirement, the sustainability criteria for CEFs also safeguards high biogenic carbon stock ecosystems such as primary forest, wetlands, peat lands, coral reefs, and other ecosystems, including ecosystems protected for their biodiversity.

The current comprehensive sustainability criteria are required for CEF produced starting from the first phase of CORSIA on 1 January 2024, and address the following additional sustainability themes: water, soil, air, conservation (biodiversity), waste and chemicals, human and labour rights, land use rights and land use, water use rights, local and social development, and food security. CORSIA's principles of sustainability are detailed in Appendix 4.

Default carbon intensity values for SAF pathways and CORSIA life cycle methodology

As mentioned in the previous section, CORSIA established default life cycle emissions values for eligible fuels that may be used by an airplane operator to claim emissions reductions from the use of CORSIA eligible fuels within a CORSIA compliance cycle (three calendar years). These default values were developed based on the Argonne National Laboratory's GREET model and the EU Joint Research Center's E3 database for the core life cycle emissions component, complemented by land use change models including Purdue University's GTAP-BIO model and the International Institute for Applied Systems Analysis' GLOBIOM model. The ICAO default carbon intensity values are representative values based on the state of knowledge of the feedstock and fuel conversion technology pathways assessed thus far by ICAO. For example, the global rapeseed/canola oilseed HEFA pathway is aggregated from U.S., E.U., and Canadian rapeseed/canola production data.[99] For specific assumptions and specifications used in developing the default values, the ICAO CORSIA Supporting Document "CORSIA Eligible Fuels – Life Cycle Assessment Methodology" provides comprehensive information. Note that ICAO uses energy allocation throughout the life cycle and the functional unit is defined in terms of lower heating value while Canada generally uses higher heating value of fuels. An overview of the default carbon intensity values for feedstocks and pathways relevant to Canada is provided in Table 11 below, noting that the relevant methodologies for claiming PtL SAF life cycle emissions reduction are currently being developed at ICAO.

99 https://www.icao.int/sites/default/files/environmental-protection/CORSIA/Documents/SCS-Evaluation/CORSIA_Supporting_Document_CORSIA-Eligible-Fuels_LCA_Methodology_V6.pdf

TABLE 11 | CORSIA Default CI Values for select feedstocks and pathways relevant to Canada.

	Region	Feedstock	Core Lca Value (gCO_2e/MJ)	ILUC VALUE (gCO_2e/MJ)	Carbon Intensity Value LCEF (gCO_2e/MJ)
GFT	Global	Agricultural residues	7.7	0	7.7
	Global	Forestry residues	8.3	0	8.3
	Global	MSW – 0% non-biogenic carbon (NBC)	5.2	0	5.2
	Global	MSW – NBC as a %	NBC*170.5 + 5.2	0	NBC*170.5 + 5.2
HEFA	Global	Tallow	22.5	0	22.5
	Global	Used cooking oil	13.9	0	13.9
	Global	Corn oil	17.2	0	17.2
	USA	Soybean oilseed	40.4	24.5	64.9
	Global	Soybean oilseed	40.4	25.8	66.2
	Global	Rapeseed/Canola oilseed	47.4	26.0	73.4
ATJ	USA	Corn grain	65.7	25.1	90.8
	Global	Corn grain	65.7	34.9	100.6
	Global	Agricultural residues (standalone*)	39.7	0	39.7
	Global	Agricultural residues (integrated*)	24.6	0	24.6
	Global	Forestry residues (standalone*)	40.0	0	40.0
	Global	Forestry residues (integrated*)	24.9	0	24.9

**Standalone conversion design – pathway utilizes a facility to produce fuel from an intermediate product (e.g., ethanol/isobutanol) that is not co-located with the facility that produces the intermediate product from the fuel feedstock. Integrated conversion design – pathway utilizes a co-located facility where heat is integrated between the systems to produce the fuel and intermediate products (e.g., ethanol/isobutanol) from the fuel feedstock to minimize energy requirements.*

Although the above default global CI values are available for use under CORSIA, there are some regional CI values including for the USA, E.U., and Brazil (see Table 12 below). The difference is due to unique data and assumptions which can reflect regional differences (e.g., crop yield). There are no default CI values unique to Canada.

TABLE 12 | CORSIA Default Carbon Intensity Values for Select Feedstocks and Regions (in gCO_2e/MJ)

Region/Country	Feedstock	Core LCA Value (gCO_2e/MJ)	ILUC VALUE (gCO_2e/MJ)	Carbon Intensity Value LCEF (gCO_2e/MJ)
USA	Soybean Oilseed	40.4	24.5	64.9
Brazil	Soybean Oilseed	40.4	27	67.4
Global	Soybean Oilseed	40.4	25.8	66.2
EU	Rapeseed/ Canola Oilseed	47.4	24.1	71.5
Global	Rapeseed/ Canola Oilseed	47.4	26	73.4

Although the CORSIA LCA methodology can be used (in place of a default value) to calculate the actual carbon intensity of a pathway, the actual CI can only change the CORE LCA value under CORSIA and not the ILUC value. As shown in Table 12 above, ILUC values can contribute substantially to the SAF CI or LCEF value (gCO_2e/MJ). Agricultural practices for crop-based SAF pathways that can provide evidence of low risk for land use change could qualify for zero ILUC value if independent validation can prove that it satisfies the CORSIA Low LUC Risk methodology (refer to the ICAO CORSIA Eligible Fuel document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values"). Such practices include crop yield increases, use of marginal or degraded lands, and other agricultural practices.

Sustainability certification

ICAO reviews and approves Sustainability Certification Schemes (SCS) that opt to provide CORSIA CEF certification which involves certifying CEF producers and other entities in the supply chain for compliance with ICAO requirements for economic operators and CEF sustainability criteria. CORSIA-approved SCSs are currently limited to RSB, ISCC, and ClassNK.
Each entity in the supply chain, up to and including the CEF blender, must be certified by the SCS to CORSIA eligibility requirements. These requirements include (but are not limited to) those related to ensuring CEF sustainability and that economic operators calculate actual life cycle emissions values (if default values are not applied) using the CORSIA LCA methodology as prescribed. Certification audits are carried out by independent certification bodies that work with CORSIA-approved SCS and are accredited under relevant ISO standards for third-party conformity assessment bodies.

Sustainability information for each batch of CEF must be tracked on a step-by-step basis through the supply chain as described in Figure 10 below, with sustainability declarations generated for each step. The integrity of the certification system is maintained through annual audits of the certified entities, regular monitoring and review of the certification system, transparency elements of the certification system, documented complaint procedures, and many other SCS requirements that promote integrity of the system. These systems and activities are crucial for ensuring the integrity of sustainability claims, accurate carbon accounting, and compliance with ICAO's CORSIA requirements.

After the blending point, supply chain entities are not required under CORSIA to be certified by the SCS and the aeroplane operator takes responsibility for tracking the CEF, through third-party verification bodies that are obligated under CORSIA.

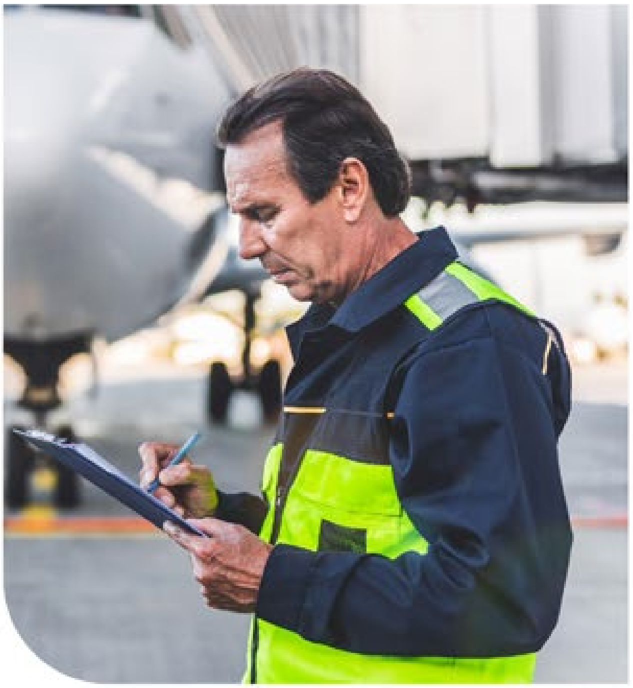
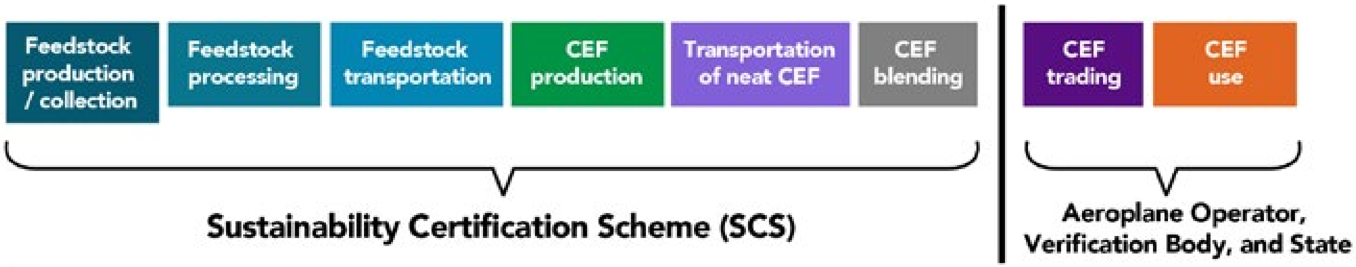


FIGURE 10 | CORSIA Eligible Fuel (CEF) Supply Chain Monitoring, Reporting, and Verification Responsibilities



Key Features:

The Sustainability Certification Schemes (SCS) certification scope under CORSIA goes up to the CEF blender, although life cycle emissions values go through to the CEF combustion using estimated or default life cycle emissions values for downstream transportation.

Once the CEF is produced and blended, the Aeroplane Operator takes the responsibility of tracking the CEF through the CORSIA Monitoring, Reporting and Verification process. The State to which the Aeroplane Operator is attributed has the prerogative of overseeing the data submitted by the Aeroplane Operator for compliance with CORSIA provisions.

Comparing Carbon Intensity Determination (LCA methodologies) Under Different Schemes (B.C. LCFS, CFR, CORSIA, EU RED, CA LCFS, US IRA 40B SAF Credit)

LCA models are designed for different purposes and variations may therefore exist in estimates of GHG emissions reductions. Various factors may influence this, including assumptions, input data, treatment of coproducts, etc. Pereira et al. indicates that agricultural practices, coproduct credits from surplus electricity and approaches to indirect land use change were the major drivers of differences in outcomes for the fuels and models that were investigated (EU RED (BioGrace), GHGenius, and US GREET).[100]

A comparison of the main relevant LCA models is shown in the Table below, indicating substantial differences.

TABLE 13 | Comparison of the Main Relevant LCA Models

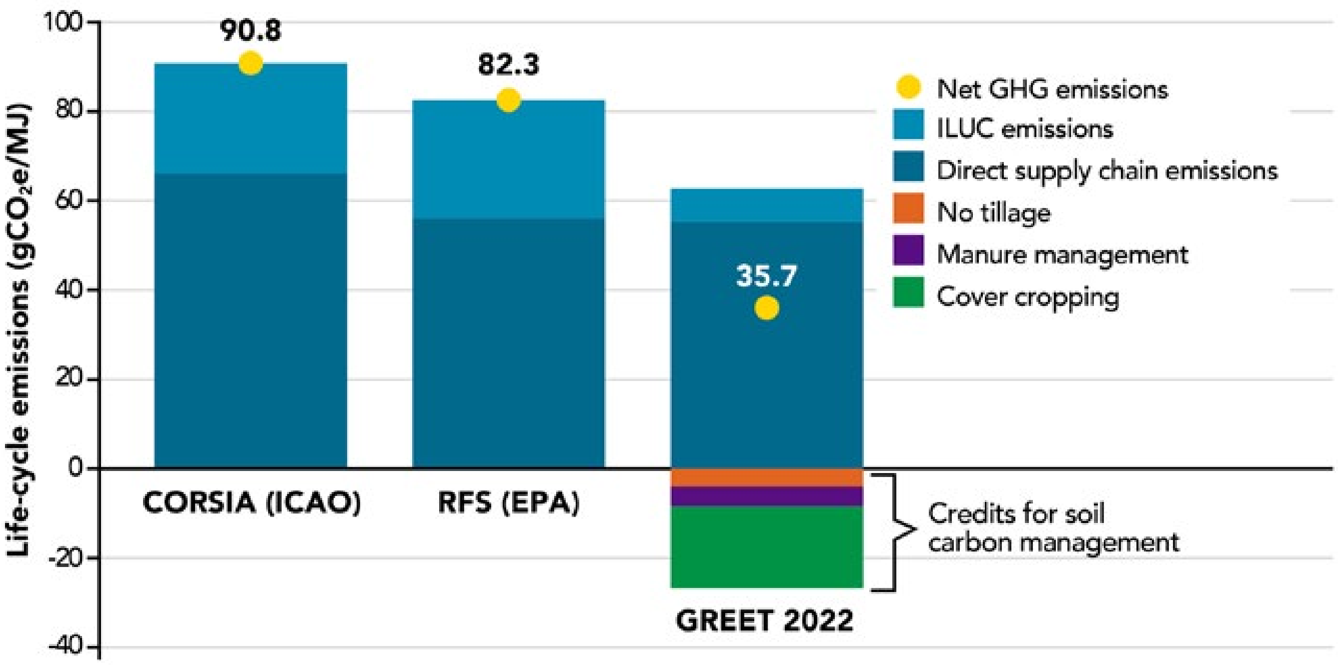
	B.C. LCFS (GHGenius)	Canada CFR	CORSIA	EU RED (BioGrace)	US GREET
Co-product allocation	Substitution / Displacement	Energy	Energy	Energy	Substitution / Displacement
Long term emissions amortization period (years)	20	N/A	25	20	30
Induced Land Use Change (ILUC)	Optional, both direct and indirect emissions can be determined. Larger market impacts not included	No, but high ILUC feedstocks identified as per the Land Use and Biodiversity criteria	Yes, both direct and indirect	No, but high ILUC feedstocks identified	Yes
Induced land use change (ILUC) model	N/A	N/A	GTAP-BIO & GLOBIOM	N/A	CCLUB
Jet fuel baseline (gCO_2e/MJ)	88.83 (higher heating value)	N/A	89 (lower heating value)	N/A	87

Carbon Calculator for Land Use Change from Biofuels (CCLUB); Global Trade Analysis Project (GTAP-BIO) model with extension for biofuel production impacts; Global Biosphere Management Model (GLOBIOM)

100 Pereira et al., "Comparison of biofuel life-cycle GHG emissions assessment tools: The case studies of ethanol produced from sugarcane, corn, and wheat" (2019)

As an illustrative example of how the use of different methodologies can affect the LCA, the impact of the differences in the CORSIA, US RFS, and the GREET 2022 model on the carbon intensity of corn ethanol-to-jet is shown in Figure 11 below. Agricultural practices such as no tillage, manure management and cover cropping increase soil organic carbon and contribute negative values that lead to reducing the overall carbon intensity under GREET. Under CORSIA, certain agricultural practices have also been identified that enable a crop based SAF pathway to provide evidence of low risk for land use change. Upon independent validation, the SAF pathway can qualify for zero ILUC GHG emissions (see Section 5 "Low Land Use Change Risk Practices" in the ICAO CORSIA Eligible Fuel document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values"). At the time of writing, specific, project-based improvements in soil organic carbon attributed to the production of specific crops are not considered in ICAO's LCA Methodology (for a more detailed analysis of the difference between the DOE Argonne GREET Method and ICAO Method for Corn Ethanol to Jet SAF Carbon Accounting, see Appendix 5).

FIGURE 11 | Life Cycle Emissions Estimates for Corn Ethanol-to-Jet[101]



101 Jane O'Malley and Nikita Pavlenko, Drawbacks of adopting a "similar" LCA methodology for U.S. sustainable aviation fuel (SAF), International Council on Clean Transportation, 2023.

Compliance of Canadian Feedstocks with CORSIA Sustainability Criteria and Comparison of Carbon Intensity Under Various Systems

General sustainability of Canadian feedstocks with respect to CORSIA Sustainability Criteria Certification

Sustainability certification has been widely used in Canada for various crops and biomass resources. According to the Canadian Canola Growers Association, Canadian canola is qualified to be certified as sustainable by ISCC under the EU Renewable Energy Directive and this certification could be extended to sustainability certification needed for SAF used in international aviation. Sustainability of other types of crops, such as soybean, wheat, and corn, which can potentially be used for SAF production, must be individually assessed. Guidance for assessing compliance with CORSIA sustainability criteria has been published by ICAO to ensure uniform application of environmental sustainability criteria.[102] Third-party certification is required for all feedstocks. This may limit the pool of eligible feedstock, including for SAF production, which could potentially increase the costs if farmers have more accessible markets (beyond SAF) and the SAF supply chain requires them to take proactive action for eligibility, along with associated costs, administrative burden, and verification risk. Farmers will need to be aware that their crops are destined for SAF production at the point of harvest or earlier. However, this is not well aligned with the current bulk handling system for major SAF feedstocks like canola and soy, where feedstock is aggregated from various sources and sold to diverse end uses.

It should be noted that, under the CFR, Canada's existing national laws and regulatory frameworks for agricultural feedstocks have been formally recognized by ECCC as sufficient to meet its Land-Use and Biodiversity (LUB) criteria. As a result, Canadian farmers and the agricultural feedstocks they grow for biofuel production are considered compliant with these criteria at a national level. (Note: low-carbon intensity fuel supply chains must still provide declarations and conduct material balancing to ensure full traceability to comply with requirements related to credit creation.)

Canada's forest sector uses multiple sustainability certifications. According to NRCan, approximately three-quarters of Canada's managed Crown Forest land is certified to at least one independent third-party certification standard (note that they have not applied for recognition under the CFR). Three types of forest management certifications are used:

- the Sustainable Forestry Initiative (SFI)
- the Forest Stewardship Council (FSC)
- the Canadian Standards Association (CSA)[103]

Despite the extensive state of certification in Canada with respect to forestry activities, sustainability for production of SAF will be independently required under the CORSIA standard, which might limit domestic supply for CORSIA eligible fuel. Whether the current certification standards used in Canada will comply with CORSIA standards will have to be assessed in order for any SAF produced from these resources to be eligible under CORSIA. Several schemes in Canada are recognized by RSB and ISCC, but it will have to be verified whether FSC, SFI, PEFC (Programme for the Endorsement of Forest Certification) and CSA are included. The Sustainable Biomass Program (SBP) is a certification system designed to ensure that biomass used for energy production is sourced from sustainable and legally compliant sources. It is recognized and accepted under EU RED and accepted by ISCC and RSB. However, current certification schemes in the Canadian forest sector certify harvesting for purposes of lumber and paper and pulp production and does not include collection of forestry residues. Although FSC and SFI certifications were not originally intended for the certification of residues, residues from a

102 https://www.icao.int/sites/default/files/environmental-protection/CORSIA/Documents/CORSIA%20Eligible%20Fuels/Guidance-on-Sustainability-Themes-4-8.pdf

103 Natural Resources Canada, "Forest management certification in Canada," accessed 2024.

certified forest area can be included provided that the supply chain actors are also chain-of-custody certified. RSB has published specific guidelines for assessing the sustainability of woody biomass and this includes specific definitions for forest residues which should be further assessed.[104] For example, the 2021 iteration of this document states that RSB does not consider "low quality roundwood from a final harvest, i.e., size or quality of the material is not sufficient to be accepted by a sawmill, are not considered forestry residues and not eligible for RSB certification (for energy purposes)". Roundwood, that is unsuitable for a sawmill, would likely be directed to another type of forest product manufacturing facility, such as pulp and paper, before being chipped and utilized for SAF production. ISCC has also published guidelines for sustainability of forest biomass.[105]

An in-depth analysis of current certification and specific sustainability guidelines from CORSIA, RSB and ISCC will need to be carried out to guide SAF supply chain entities (e.g., feedstock producer, fuel producer, fuel blenders) in ensuring sustainability compliance, including an assessment by RSB/ISCC on the eligibility of established Canadian sustainability schemes. Despite these hurdles, Canada's forest sector appears well-equipped to produce SAF from a sustainability perspective. Canada is home to 40% of the world's sustainably certified forests, demonstrating its commitment to sustainable forestry practices.[106]

Carbon intensity of Canadian feedstock for biofuel production

The emissions reductions under CORSIA will likely be lower than under the CFR for the same physical unit of SAF because of ILUC GHG emissions considered under ICAO CORSIA (see Figure 11 in the section above), while the CFR has developed land use and biodiversity criteria to determine a feedstock's eligibility. One investigation on the carbon intensity of canola-derived jet fuel across eight regions in Canada, determined that life cycle GHG emissions had estimated levels ranging from 44 to 48 g CO_2e/MJ[107], which is almost identical to the CORSIA CORE default life cycle emissions values. These results exclude land use change and land management changes effects; when these effects are included, the life cycle emissions are calculated as ranging from 16-58 g CO_2e/MJ (note that the study did not consider indirect or market-mediated land use change effects). The GREET 2016 model was used in this work which explains the similarities with the ICAO CORSIA CORE life cycle emissions. The investigation also compared the same scenarios using GHGenius 4.03a which showed life cycle GHG emissions for canola-derived jet fuel are estimated to range from 33 to 38 g CO_2e/MJ for the eight regions (11 to 43 gCO_2e/MJ with land use and land management change effects), demonstrating that GHGenius delivers 5-15 g CO_2e/MJ fewer emissions than GREET 2016.

According to a Canola Council of Canada comparison study (unpublished), different models provide the following emissions reductions for canola feedstock (excluding ILUC):

TABLE 14 | Emissions reduction of Canola feedstock for different models

Model	Emission reduction
BC LCFS	93%
EU RED	74%
US RFS	66%
CA LCFS	47%

This can be compared with the CORSIA CORE LCA value which provides a 47% reduction in GHG emissions (noting that CORSIA calculations used the GREET 2019 model). The greatest emissions reductions are under the BC LCFS which uses the GHGenius model based on a coproduct allocation using substitution/displacement, rather than energy allocation. This has a significant impact with respect to oilseed crops where the coproduct meal (used for animal feed) reduces the life cycle GHG emissions of the canola oil fraction of the oilseed, which is the component that is converted to SAF.

104 RSB, RSB requirements for woody biomass, 2024.

105 ISCC, ISCC EU 202-4 Forest Biomass – ISCC Principles 2 – 6, 2023.

106 Susan van Dyk, Canadian aviation sector launches new initiative to accelerate national sustainable fuels production, GreenAir News, 2022.

107 Obnamia et al., Regional variations in life cycle GHG emissions of canola-derived jet fuel produced in western Canada, 2020 (DOI: 10.1111/gcbb.12735)

Analysis and Key Insights on Standards and Certifications

CORSIA default carbon intensities create a one-size fits all solution, which has certain advantages and limitations. The underlying data for calculating carbon intensity, such as sources of electricity and heating, may have a significant impact and local conditions may not reflect this. Even where regional defaults are provided, they may not reflect actual conditions. However, actual CI values can be calculated using the CORSIA LCA methodology to reflect actual conditions and attain benefits if such conditions lead to lower carbon intensity than the ICAO default value. Some aspects may be absent from the CORSIA methodology, such as accounting for modified agricultural practices that increase soil carbon and should be addressed at the ICAO level to better represent actual practices.

Most of the canola produced in Canada is eligible to be sustainably certified under ISCC and may likely be able to meet CORSIA sustainability standards. The majority of Canada's managed crown land is third-party certified. However, these certifications are based on production of lumber and pulp, and they do not cover the removal of forest residues. Whether these sustainability standards are recognized under ISCC or RSB would need to be determined to ensure that SAF produced from such feedstocks will be CORSIA eligible fuel. Wood pellet producers use the Sustainable Biomass Program (SBP) certification and, as it is approved under EU RED, is also recognized under ISCC and RSB.

Variances between CORSIA, national and subnational methodologies distort the SAF market and are creating an administrative burden on many parts of the value chain that need to identify and certify SAF or are looking to comply or claim benefits of SAF use. More is needed to understand and clarify the similarities and differences between methodologies, particularly for airlines that operate in these jurisdictions. More is also needed to understand and clarify the similarities and differences between methodologies in Canada and in other jurisdictions, particularly for airlines that operate across these jurisdictions.

To support a compelling business case for investment in domestic SAF production, the LCA on potential Canadian SAF pathways (e.g., HEFA from canola, GFT from forest residues, ATJ from corn- or wheat-based ethanol) could be calculated and compared across

jurisdictions that have independent LCA methodologies. This can offer information on high-value opportunities for SAF production, with a focus on maximizing GHG emissions reductions, which can significantly influence the design of projects and encourage investment (as lower CI values can leads to higher credits, which can be more valuable to producers and end-users). From a regulatory standpoint, such a comparison can clarify the advantages being offered by LCA approaches in other jurisdictions and aid in any refinements of Canada's LCA methodologies over time (e.g., improved accuracy, decreased administrative burden).

These comparisons are also important as they can determine whether promising Canadian feedstock/ technology pathways can meet the current CORSIA standard, as well as aid in identifying areas in the life cycle that could be improved to qualify under CORSIA (e.g., farming practices, electricity source, heating source), or to present an LCA for a fuel pathway that performs better than the default values through the actual value approach. Ideally, the exercise would be undertaken for different provinces, to consider key geographical differences such as feedstock yield, sources of heating and electricity, transportation distance to processing facilities, etc. Where feedstocks are certified under a sustainability scheme, it must be determined whether these certification schemes are recognized under CORSIA and will meet CORSIA standards. The analysis could offer insight into the specific regions that could achieve the lowest CI for a given feedstock and technology pathway, allowing potential investors and SAF end-users to capitalize on this knowledge, particularly in a global environment where sustainability requirements might become more stringent over time.

Summary of Key Insights on the Development of a SAF Marketplace: Future Scenarios and Opportunities

2026-2030:

- In B.C., regulation will require the use of at least 1% of jet fuel starting in 2028, increasing to 2% in 2029, and 3% in 2030.
- HEFA will be the dominant global pathway for SAF production and has the most potential facilities in FEED stage in Canada. The availability and creation of a cross-value chain for SAF focused on waste fats and oils (vegetable and oilseed) will be required for this to be successful.
- During this timeframe, Canadian air carriers will likely continue to pursue opportunities to import SAF and uplift from international airports, where possible. It is expected that the majority of available SAF will come from the U.S. and Asia (i.e., Singapore and China), but should an international book and claim mechanism be formed, the prospect of acquiring SAF from other regions could significantly increase.
- Changing policy landscape could influence the near-term availability of SAF internationally and alter the current outlook.
- Depending on the timing for the ASTM International qualification process to expand blending limits, co-processed jet fuel may be available by the end of the decade. It is expected that by 2030, ASTM will enable higher biogenic content for co-processing, which will provide air carriers with additional lower-carbon fuel alternatives.
- In combination of the various opportunities to acquire SAF (domestic production, importation, etc.), Canada may have access to enough fuel to reach its aspirational goal. However, if no private and/or public sector actions are taken to establish a SAF marketplace in Canada, it is likely that domestic production will not materialize by 2030, and Canada will continue to rely on importing marginal volumes from established international capacity.

2030 and beyond:

- This timeframe will likely be characterized by a noticeable growth and evolution of SAF production into lower carbon intensity pathways, though HEFA is still expected to be dominating production. In the coming decades, other pathways will begin to emerge globally, increasing supply but alongside increasing demand.
- As this happens SAF production through HEFA has the potential to level off given that the feedstocks for HEFA have several alternative uses. Canada could see the growth of other technologies such as GFT and PTL hitting the market. Demand will likely start to materialize more consistently for these other pathways as supply chains materialize and SAF becomes more cost competitive. ATJ/Ethanol – may be opportunities to import from Brazil and U.S.
- The potential to both import and domestically produce ethanol, and the expectation of commercial viability in the 2030s, enable the ATJ pathway to contribute greater SAF volumes from 2040 onwards. If domestic production via ATJ has scaled up, importing more ethanol, and having the right frameworks in place to allocate the ethanol to SAF production will unlock considerable volumes of SAF beyond what was forecasted.
- The potential for PtL to deliver significant reductions to the climate impact of aviation would continue to encourage investments into the development of this pathway. Canada would be particularly well positioned to become a pioneer in PtL, as it has significant access to renewable energy (hydro, solar, and wind) that can become available for low-carbon hydrogen projects across the country.

SECTION 9

Blueprint's Findings: A Way Forward - Potential actions to consider in helping reach the 2030 aspirational goal and net-zero by 2050

Governments and industry stakeholders across Canada have begun taking action to unlock the potential of SAF; however, the pace and scale of action would need to accelerate to reach Canada's 2030 aspirational goal and 2050 SAF projections. To build a SAF market in Canada, all levels of government, and industry should work together to overcome the impeding core challenges described in this report.

The following are the Blueprint's findings, intended to offer insight into potential actions to ensure availability and access to SAF in the immediate term. They also point to the need to focus on elements that would help extend beyond 2030 to diversify Canada's SAF market and scale new technologies, with a view to achieving net-zero emissions by 2050. These findings are intended for consideration by both government and non-government stakeholders across the value chain, which would help to secure sufficient availability and access to SAF in Canada.

TABLE 15 | Pillars of Actions to Help Achieve the 2030 Aspirational Goal

Pillar 1: Strategic Partnerships

Strategically use existing and new partnerships (domestic and international) to explore opportunities that support SAF production, importation, and use.

To help address: high cost / investment risk / limited supply

- Continue to collaborate through the Sustainable Aviation Task Force, across multiple levels of government, and non-government stakeholders, industry sectors and the public through Canada's Aviation Climate Action Plan. Members should prioritize discussions on deployment, with a view to sharing knowledge, insight, best practices, and lessons learned.
- Work with all levels of government to consider how existing and potential incentives could be stacked and to avoid misalignment of policies across regions.
- Leverage international events and fora to pursue initiatives that will both attract direct foreign investment in SAF production and accelerate opportunities for Canadian companies in global markets.
- Liaise with airports, airlines, and aircraft manufacturers, as well as governments and other actors across the value chain, to explore opportunities for collaboration, including the formation of green aviation corridors.

Pillar 2: De-Risk Investment

Explore opportunities to establish programs, long-term policies, and business models to encourage industry and governments to invest in growing a SAF market. Governments at all levels, as well as industry stakeholders, will have a role to play in de-risking SAF.

To help address: high cost / investment risk / limited supply

- Consider long-term policies that could help de-risk the private sector investment needed to establish SAF production and distribution infrastructure and create SAF demand certainty.
- Assess opportunities to provide support for domestic production, importation, and/or SAF use, specifically to help address the price premium for SAF.
- Find opportunities to consolidate existing Canadian demand.
    - Develop a Canadian demand forecast in collaboration with key industry associations and Canadian airlines.

Pillar 3: Build Supply Chains and Establish Supporting Infrastructure

Investigate options to help accelerate the development of regional supply chains, including for lower-carbon feedstocks, to unlock future SAF pathways that will be needed beyond 2030 and ensure preparedness and ability to handle and blend SAF volumes produced domestically or imported.

To help address: investment risk / limited supply

- Develop an evergreen project pipeline with pilots, demonstrations, and first commercial projects to identify where infrastructure is required as the market evolves.
- Develop regional infrastructure and supply chain feasibility studies and activation plans (including types of feedstocks, location of local SAF production facilities with feedstock available, locations to receive, blend and integrate SAF into conventional fuel supply chain, etc.).
    - Assess opportunities at high traffic airports (i.e., Vancouver, Toronto, Calgary, Montreal, Edmonton) to establish regional pilot SAF supply chains.
    - Explore public-private-partnerships to build blending facilities.
- Regional stakeholders could lead action-oriented strategies to identify and address barriers to unlocking the regional supply chains of feedstocks deemed high potential for Canada (e.g., agriculture and forest residues), with a focus on collection and delivery logistics.

Pillar 4: Codes and Standards

Consider updating existing—and developing new—codes and standards to enable and accelerate SAF uptake and remove barriers to deployment, domestically and internationally.

To help address: investment risk / limited supply

- Conduct a gap assessment of relevant fuel specifications to confirm there are clear guidelines for SAF storage, handling, and dispensing standards.
- Examine measures to support organizations that wish to contribute to the expansion of ASTM International's co-processing blending limits and approved feedstocks for SAF.
- Through ICAO and other international fora, continue to advocate the sustainability and life-cycle carbon intensity of Canadian feedstocks.

Pillar 5: Accelerate Technology Development and Innovation

Investigate opportunities for further R&D, developing research priorities, and ensuring collaboration between domestic and international stakeholders to ensure Canada maintains its competitive edge and global leadership.

To help address: investment risk / limited supply

- Continue to support research and development to enable the build-out of existing and new SAF pathways, both domestically and with international partners.
- Explore opportunities for support through the ASTM International process of increasing SAF Blend rates to reach 100%, where possible.
- Examine measures to de-risk first-of-a-kind production facilities, support the commercialization of new technologies, and understand future infrastructure requirements.

Pillar 6: Emissions Accounting and Book and Claim

Consider participating in the development of a domestic and/or international book and claim mechanism, recognized by government and international partners, to further increase demand and equitable access to SAF.

To help address: high cost / investment risk / limited supply

- Conduct additional comparative analyses to understand and clarify the similarities and differences between emissions accounting methodologies and potentially streamline the use of different methodologies.
- Compile life cycle assessment studies of anticipated Canadian SAF pathways under different regulatory regimes to help Canada to better leverage its advantages to support low-carbon intensity SAF production, including identifying areas in the lifecycle of the fuel that have a high GHG footprint and could be improved.
- Explore a consistent framework and guidance for the use of book and claim systems in Canada for domestic and international flights, noting the need of its recognition under global standards like GHG Protocol.
  - It is important to clarify the interaction between international, national and provincial policies relevant to SAF purchase, blending and use to identify how the environmental attributes of SAF can be claimed and attributed to domestic and international flights while avoiding double counting.
  - Consider how best to enable end users (e.g., organizations) to purchase SAF environmental attributes or certificates and help to grow the market for SAF.

Pillar 7: Education and Awareness

Promote and ensure individuals, organizations, governments, and communities are aware of the opportunities and benefits of SAF to the Canadian economy and environment.

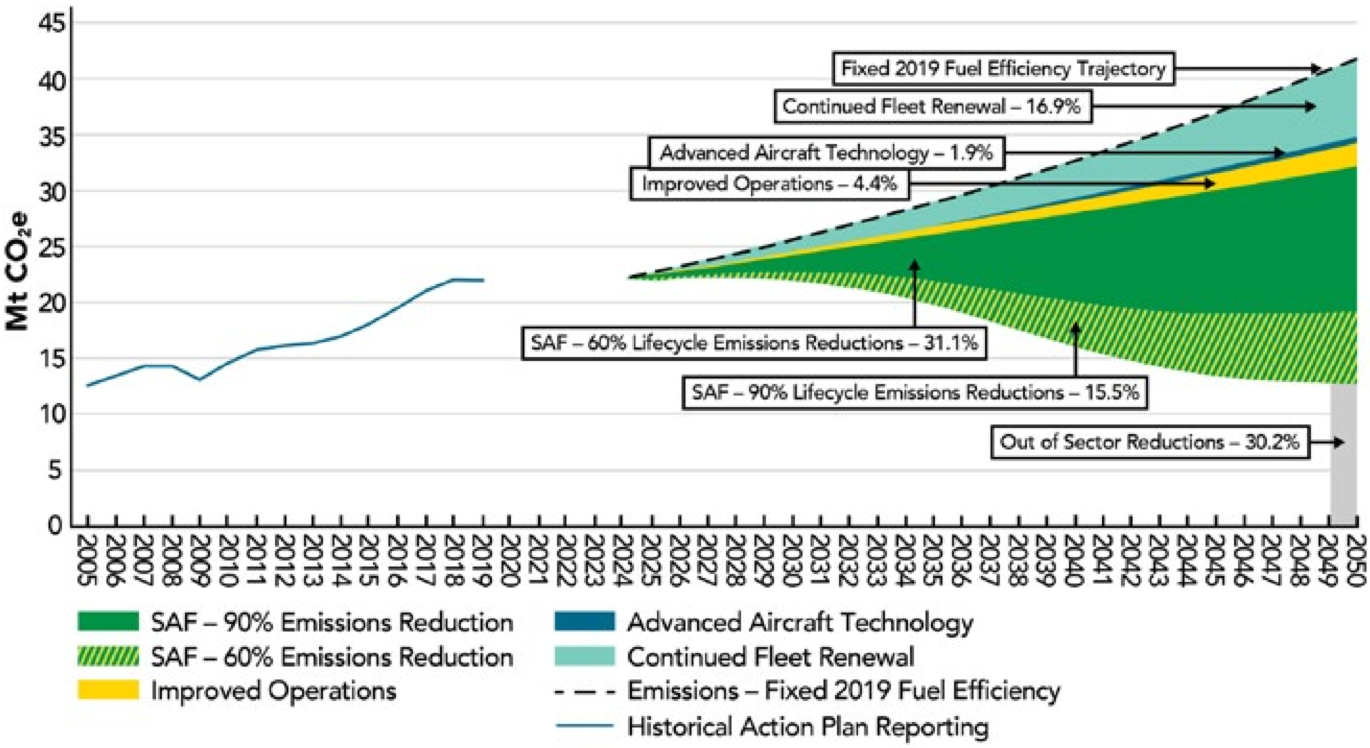
To help address: high cost / investment risk / limited supply

- Pursue opportunities to educate passengers and business partners on the benefits of SAF use from both environmental and economic perspectives.
- Develop publicly-accessible cost calculators for assessing the cost of SAF and its impact on aviation service costs.
- Continue to enable corporations and cargo customers to contribute to paying the SAF premium through opt-in programs.
- Continue to publish studies and highlight current and future efforts to advance SAF in Canada.

APPENDICES

Appendix 1:

2050 Canadian Aircraft Emissions Forecast - A Vision to Net Zero



Source: Canada's Aviation Climate Action Plan (2022-2030)

Appendix 2:

Maximum SAF Production Scenario Framework (Deloitte)

The Maximum SAF Production Scenario is built exclusively on feedstock availability and technological readiness of each pathway. The contributing information is outlined in Figure 12 below. Conversion rates from the International Civil Aviation Organization, Concawe and Deloitte on the yield per feedstock (appearing in Table 16 below) were leveraged to determine the volume of SAF in the maximum production scenario.

FIGURE 12 | Inputs and outputs to the Maximum SAF Production Scenario Framework

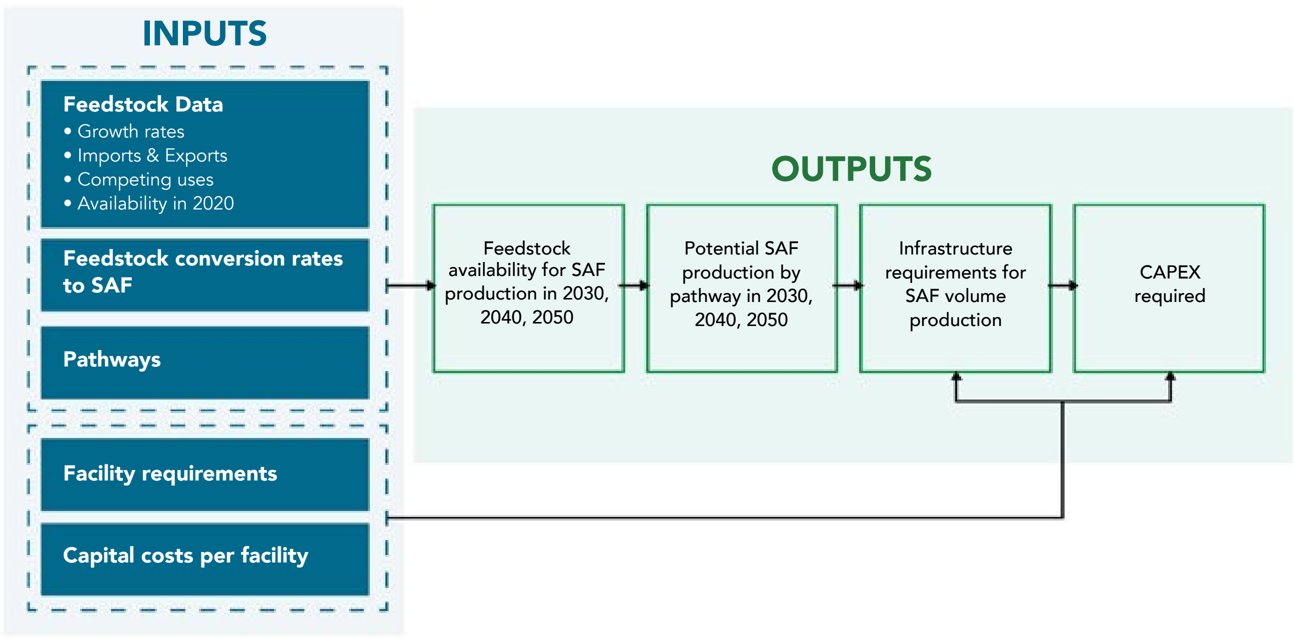


TABLE 16 | Total Yield per Feedstock and Technology[108]

Feedstock	Technology	Yield (distillate/feedstock)
Canola Oil	HEFA	83%[109]
Soybean Oil	HEFA	83%[110]
FOGs	HEFA	71%[111]
Agricultural Residue	GFT	8%[112]
Forestry Residue	GFT	14%[113]

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109 SAF Rule of Thumb
110 SAF Rule of Thumb
111 Deloitte Analysis
112 SAF Rule of Thumb
113 SAF Rule of Thumb

Feedstock	Technology	Yield (distillate/feedstock)
Municipal Waste	GFT	23%[114]
Ethanol	ATJ	60%[115]
Hydrogen	PLT	184%[116]

To support this simplified analysis, growth rates for feedstock categories were applied to 2020 actual volumes to identify volumes for 2030, 2040, and 2050. These volumes were then adjusted to account for current trade flows (export and import) and competing uses, resulting in a maximum volume that could be utilized for SAF production. In some instances, proxies or substitutes were leveraged due to data limitations particularly for non-crop-based feedstock. To project 2030, 2040, and 2050 growth rates of feedstock, a multiplier on feedstock availability trends and technological readiness was added. Table 17 displays the growth rates that were used:

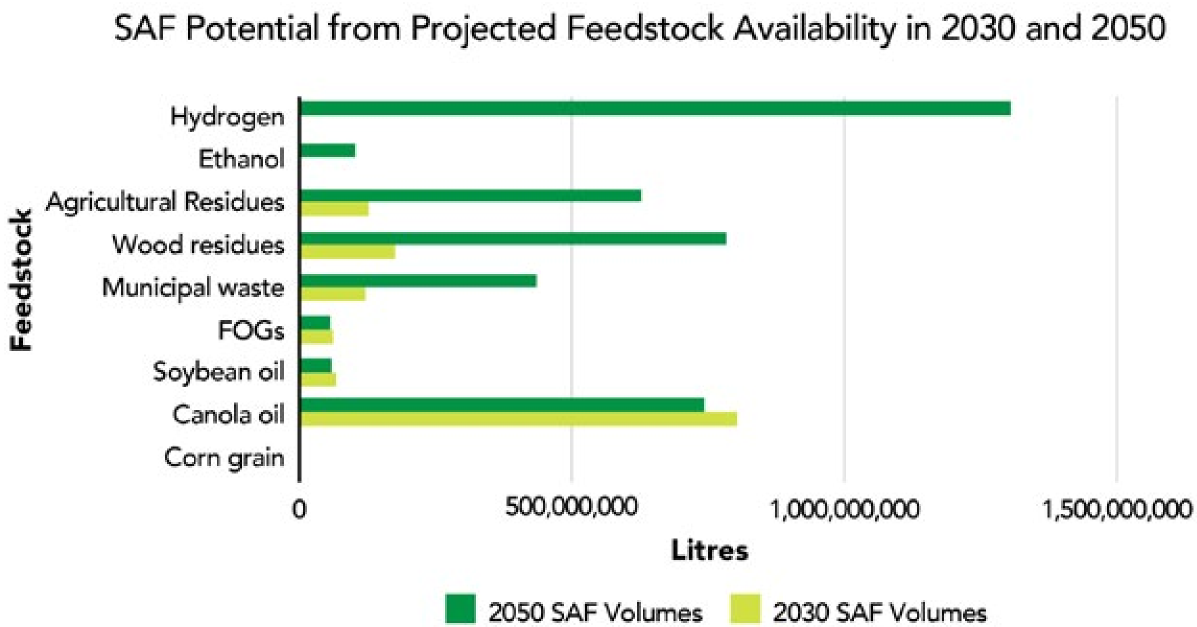
TABLE 17 | Growth rates for feedstock for SAF volume projections

Pathway	Feedstock	Proxy or Substitute	Annual growth rate 2020-2030 (%) of domestic production of feedstock
HEFA	Canola Oil	N/A	3.3%[117]
	Soy Oil	N/A	0.4%[118]
	Other FOGs	Animal Fats Used Cooking oil	1.1%[119]
GFT	Municipal solid waste (MSW)	N/A	1.1%[120]
	Forestry Biomass	Lumber	2.0%[121]
	Agricultural residues	Crop Production	2.9%[122]
ATJ	Corn grain	N/A	0.4%[123]
	Ethanol	N/A	2.8%[124]
PtL	Hydrogen	N/A	0%[125]

114 Deloitte Analysis
115 SAF Rule of Thumb
116 Concawe
117 Agri Canada Medium Term Outlook, 2023
118 Agri Canada Medium Term Outlook, 2030
119 Population Growth Rates
120 Population Growth Rates
121 Natural Resources Canada, 2024
122 Deloitte Analysis
123 Agri Canada Medium Term Outlook, 2023
124 Agri Canada Medium Term Outlook, 2023
125 Deloitte Analysis

Appendix 3:

Maximum Feedstock Availability for SAF Production in 2030 and 2050 (based on Maximum SAF Production Scenario only)



Source: Deloitte Research

Appendix 4:

CORSIA accounting overview and CORSIA sustainability principles

The CORSIA Monitoring, Reporting and Verification (MRV) system is assigned to collect information on international aviation CO_2 emissions on an annual basis and compare emissions against the baseline emissions. Fuel use on each flight is monitored and CO_2 emissions are calculated, and reporting of CO_2 emissions is carried out between aeroplane operators, States, and ICAO. CORSIA's CO_2 Estimation and Reporting Tool (CERT) is an ICAO tool to help aeroplane operators estimate and report their international aviation emissions based on the assumption that all fuel used is conventional fuel.

Under CORSIA, an aeroplane operator can claim the reduction of its CO_2 offsetting requirements with CORSIA eligible fuels (CEF). At the end of each CORSIA compliance period, the State will deduct the verified emissions reductions from the use of CEF from the total annual offsetting requirements for the three-year period to calculate an operator's total final CO_2 offsetting requirements (in tons) which must be met through the purchase and cancelation of offsets.

CORSIA Sustainability Principles are as follows: CORSIA SAF should generate lower carbon emissions on a life cycle basis.

1. CORSIA SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock.
2. Emissions reductions attributed to CORSIA SAF should be permanent.
3. Production of CORSIA SAF should maintain or enhance water quality and availability.
4. Production of CORSIA SAF should maintain or enhance soil health.
5. Production of CORSIA SAF should minimize negative effects on air quality.
6. Production of CORSIA SAF should maintain biodiversity, conservation value, and ecosystem services.
7. Production of CORSIA SAF should promote responsible management of waste and use of chemicals.
8. Production of CORSIA SAF should respect human and Labour rights.
9. Production of CORSIA SAF should respect land rights and land use rights including indigenous and/or customary rights.
10. Production of CORSIA SAF should respect prior formal or customary water use rights.
11. Production of CORSIA SAF should contribute to social and economic development in regions of poverty.
12. Production of CORSIA SAF should promote food security in food insecure regions.

Appendix 5:

Comparison of ICAO and GREET LCA methodologies for SAF carbon accounting using corn ethanol-to-jet pathway as an example

Ethanol-to-jet lifecycle stage	Data/Information Source for DOE Argonne GREET LCA Methodology (March 2023)	Data/Information Source for ICAO CORSIA LCA Methodology (June 2019)
1. Core Life Cycle Assessment GHG Emission According to ICAO, "core" life cycle GHG emissions (sometimes referred to as "direct" or "attributional" emissions) include emissions linked to "the full supply chain of SAF production and use." ICAO says its core life cycle emission analysis includes all emissions related to: • Feedstock cultivation. • Feedstock harvest, collection, recovery. • Feedstock processing and extraction. • Feedstock transport to fuel production facilities. • Feedstock-to-fuel conversion processes. • Fuel transportation and distribution; and • Fuel combustion in aircraft engine.	The DOE Argonne GREET model is updated annually to reflect changes and improvements in activities linked to core emissions. The latest DOE Argonne GREET model was released in March 2023 and uses a database with mostly 2022-era crop and fuel production data.	The ICAO CORSIA default life cycle emissions for corn grain ethanol-to-jet fuel pathway relies on two sources for its "core life cycle emissions" estimate. ICAO averages the "core life cycle emissions" estimates from 1) a 2014 paper by Staples et al., and 2) the pathway as modelled by the European Union's Joint Research Center (JRC). **1.** The Staples et al. paper used the 2012 version of the DOE Argonne GREET model, which relied on a database of 2008-2011 era feedstock and fuel processing data. **2.** JRC relied on a 2017 paper by Edwards et al., which utilizes a variety of data sources from 2006-2012 for European (non-U.S.) corn ethanol production factors.
2. Land Use Changes Economic models are used to simulate potential future direct and indirect "land use changes" (considered together as induced land use change or ILUC), that could hypothetically result from expanded demand for crop-based biofuels. These models generate results (i.e., estimates of the amount of land converted) based on theoretical scenarios of biofuels expansion, along with assumptions about future crop prices, crop yields, biofuel conversion rates, demand responses, and other factors.	Via the CCLUB module, the DOE Argonne GREET model is integrated and linked with Purdue University's GTAP-BIO model (a computable general equilibrium, or CTE, model) for the purposes of estimating potential land use changes from various biofuel expansion scenarios ("shocks"). The current version of GREET is linked to the latest version of GTAP-BIO.	The ICAO CORSIA default life cycle emissions method for ILUC emissions is a two-step process whereby land use change is first estimated, followed by translation of the changes in land use into ILUC emissions. For estimating land use change, ICAO's CORSIA relies on two sources related to corn ethanol expansion: 1) GTAP-BIO, and 2) GLOBIOM, a European economic model. **1.** GTAP-BIO in ICAO CORSIA uses a 2011 global database for land cover and economic data. **2.** GLOBIOM uses a global land cover data set from 2000.

Ethanol-to-jet lifecycle stage	Data/Information Source for DOE Argonne GREET LCA Methodology (March 2023)	Data/Information Source for ICAO CORSIA LCA Methodology (June 2019)
3. Emissions from Land Use Changes After economic models are used to estimate potential land use changes from various biofuel expansion scenarios, "emissions factors" are assigned to the different land types that are predicted to be converted.	The DOE Argonne GREET model primarily relies on the Carbon Calculator for Land Use Change from Biofuel Production (CCLUB) module to assign emissions factors to land use changes estimated by GTAP. The CCLUB module was developed by scientists at Northwestern University, Argonne National Lab, and the University of Illinois system. The CCLUB model was last updated in October 2021. CCLUB draws from Colorado State University's CENTURY model. The GREET model also allows users to instead use the emissions factors from the AEZ-EF developed by U.C. Berkeley and CARB in 2014 in lieu of CCLUB.	ICAO's CORSIA method for ILUC emissions uses land use change emission factors from two different sources: 1) emissions factors from the "Agro-Ecological Zone Emissions Factor" model (AEZ-EF) are applied to land use change results from the GTAP-BIO model, and 2) emissions factors from the GLOBIOM model are applied to land use change results from the GLOBIOM model. The AEZ EF model was developed by U.C. Berkeley and CARB in 2014 and relies on data on carbon emissions from various land types published in the 2006-2014 timeframe. The AEZ-EF model has not been updated since 2014.
4. Time Horizon After total land use change emissions are estimated in steps 2 and 3, they are amortized across a "time horizon" to develop an annual average.	The GREET-GTAP-CCLUB framework uses a 30-year time horizon, consistent with U.S. EPA, CARB, and other organizations. IPCC typically uses a 100-year time horizon for GHG emissions accounting.	The ICAO CORSIA method for ILUC emissions uses a 25-year time horizon, which compresses emissions into a shorter timeframe, resulting in higher annual emissions estimates. ICAO's published default ILUC emissions values are determined via two methods: the first method is identical to the core life cycle emissions approach and takes the midpoint of the two ILUC model's output (after step 4 amortization) when the difference is up to 10% of the fossil baseline (i.e., 8.9 gCO_2e/MJ). When the difference between the two ILUC models exceeds 8.9 gCO_2e/MJ, the default ILUC emissions value is taken from the lower value plus an adjustment factor of 4.45 gCO_2e/MJ.

Table adapted from Renewable Fuels Association (2023) and includes Transport Canada ICAO-specific edits for improved clarity.

Appendix 6:

Case study: Blending neat SAF at or near an airport

Blending facilities at or near airports

The following is a summary of a 2024 study, led by FSM Management Group, which explores the option to develop blending infrastructure at or near airports to facilitate the use of neat SAF. Finding appropriate locations to build SAF blending facilities could prove challenging. High-traffic airports that have adjacent space available could offer a suitable location that has the benefit of minimizing fuel transportation costs.

Presently, SAF handling guidelines prevent SAF blending in an airport fuel system; meaning that, in order to facilitate blending at airports, a separate SAF blending facility would need to be constructed. In the short term, temporary or smaller equipment could be used to handle SAF blending, such as truck or rail transloading or repurposing existing fuel infrastructure. Alternatively, small-scale self-contained tank systems could be integrated into the jet fuel supply chains, while larger SAF Blending Facilities are installed to react to the market development of SAF. Ideally, the facility would be designed to adapt to evolving quality and handling standards as well as to be easily integrated into the overall airport fuel systems. To ensure that different fuel purchasers and end-users can access the facility (thereby facilitating the use of SAF in Canada), industry and government could work together to identify innovative ownership and financing options.

Over the longer term, as the aviation sector is expected to move toward 100% SAF blend use, such facilities could be designed to be re-used or integrated into the airport fuel system.

Infrastructure requirements for blending SAF

The estimate for a SAF Blending Facility incorporates all equipment and infrastructure required to safely operate SAF blending including:

- A fuel system (storage tanks, unloading and loading facilities, pumps, filters, secondary containment, mixing capability)
- Civil works (i.e., water, wastewater system) and approximate space requirements (i.e., land)
- Land, acquired through either leasing or purchase

As the market develops, short-term blending options could be implemented such as repurposing unused fuel storage infrastructure, using transloading operations, and adding smaller tanks in existing fuel storage systems to handle blended SAF. In the medium term, feasibility and quality control studies should be conducted to improve SAF handling efficiency, reduce liability issues, and launch development plan studies to secure land and appropriate funding. Site-specific factors will also need to be considered, such as the availability of land, operational liability, enabling enhanced access to fuel infrastructure, and the ownership of potential facilities.

Cost Estimates of Blending Infrastructure for Large Airports

The report by FSM Management group assessed two scenarios for an isolated SAF Blending Facility for each airport in the study:

- A Base Case Scenario where the facility is located near the Airport Fuel System but isolated, receives SBC and conventional jet fuel via tanker truck, can handle two (2) different SBCs. The SAF Blend once certified is delivered to Airport Fuel System via tanker truck.
- An Alternate Case, where the SAF Facility is connected to Airport Fuel System via a short distance pipeline for receipt of jet fuel into the SAF Facility and transfer of certified SAF Blend back to Airport Fuel System.

The range of potential costs for the base case facility was estimated to be from CDN$17.4 to CDN$72.2 million, and the range for the alternate case facility was from CDN$15.2 to CDN$46.5 million. For the larger airports, there was a significant cost benefit to the alternate case due to more efficient transfer infrastructure. A 30% contingency was built into the budget given the high level of uncertainty surrounding availability of land and other civil works that might be required. The increased cost estimate is largely due to strict quality controls. For instance, connecting the SAF Blending Facility to the main Airport Fuel System through a pipeline eliminates the need for tanks, which reduces infrastructure costs and also eliminates the expenses associated with maintaining and operating those tanks.

A blending facility could be developed in Canada in as little as two years. Criteria for selecting the best location to receive and/or blend SAF include the quantity of SAF required, the location of SAF production facilities, and space for blending and storing infrastructure. Load-offload racks, storage tanks, blending system, pipeline connections, testing facility and administration offices will be required to support the blending facility, although there may be opportunities to leverage existing petroleum infrastructure.