# BC-SMART Low Carbon Fuels Consortium

**Decarbonising Long-Distance Transport**

**Newsletter Issue No. 10, September. 2023**

**BC-SMART Decarbonising the Aviation Sector**

## *From the BC-SMART Secretariat*

As reported in previous newsletters, British Columbia (BC), partially through "enabling" policies such as the Province's Low Carbon Fuels Standard (LCFS), is making significant progress in decarbonising its transportation sector. However, when it comes to aviation, the sector's heavy dependence on fuel and the limited extent to which low-carbon-intensive (CI) alternatives, such as "green" electricity and hydrogen, can be used has focused attention on the commercial development of biojet/Sustainable Aviation Fuels (SAF).

Currently, there are limited amounts of SAF available. Its high price and the decarbonisation targets that have been set by organisations such as ICAO (International Civil Aviation Organisation), countries and airlines have highlighted the concern regarding the increased amounts of SAF that will be required. As covered in more detail within this newsletter, 99% of the biojet/SAF that is used today is made from lipid/oleochemical feedstocks. This same feedstock is used to produce bio/renewable diesel, resulting in increased competition for this finite lipid supply. At the same time, "decarbonisation policies" such as the US's Inflation Reduction Act (IRA) have further "complicated" matters by encouraging SAF production in the US, likely at the expense of production in other nations.

However, BC is uniquely positioned to be a decarbonisation leader. It has some clear advantages, such as "green" (hydro) electricity, an innovative forest sector that already produces and sells "sustainable biomass residues" (pellets), and enabling policies (e.g., carbon tax, LCFS, etc.) that have encouraged groups such as BC's two oil refineries to invest in innovative ways to decarbonise their operations and the fuels they produce. Much of the vegetable-derived lipids produced in Canada also pass through the Port of Vancouver. The province also leads the country in the number of EV cars sold and used per capita.

As mentioned earlier, aviation is unique in how much the cost of fuel contributes to the sector's bottom line. There are also limited options regarding how aviation might decarbonise its operations. Although the graph below (Figure 1) summarises how airport and airline efficiencies can reduce the aviation sector's carbon footprint, it is clear that decarbonising the jet fuel that is used will have (by far!) the biggest impact. Vancouver is a major hub, about halfway between Asia, Europe and South America, with the Province of BC also large enough that aviation plays a major role in ensuring provincial connectivity. Consequently, this issue of the BC-SMART newsletter is focused on how we might decarbonise aviation and how the various (perhaps ambitious?) targets that have been set by organisations such as C-SAF, ICAO, etc., might be met.

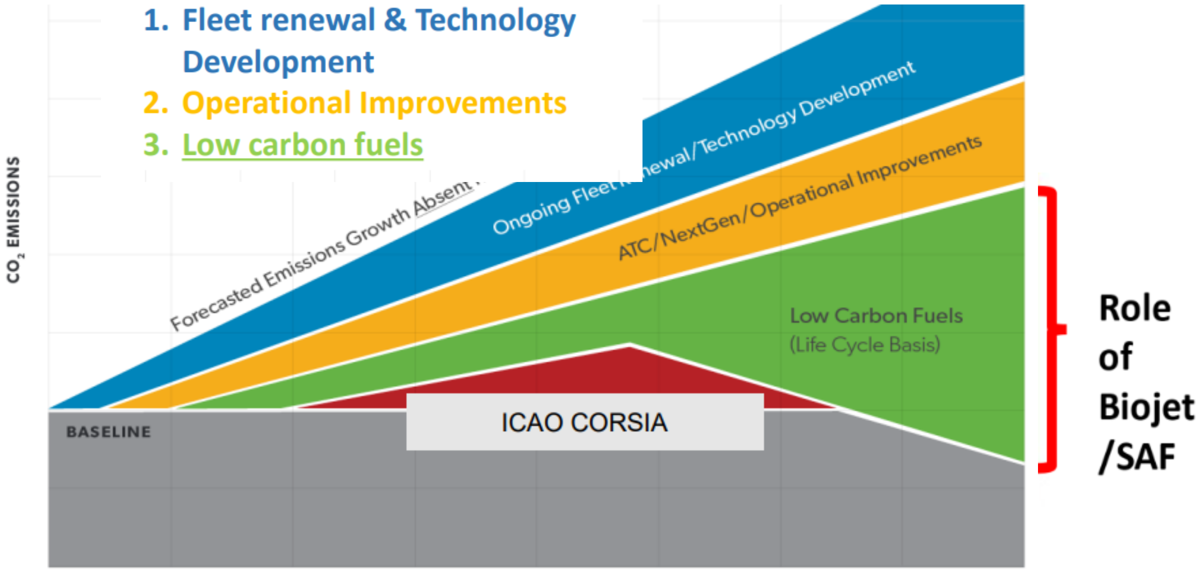

**Figure 1** Measures to reduce aviation-related emissions (ICAO, 2019 [1]; IEA, 2022 [2]).

As always, we appreciate your readership and value your input and feedback. Thank you for reading and participating in the BC-SMART network!

*Hana, Susan and Jack*

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[1] https://www.icao.int/Meetings/FutureOfAviation/Documents/2019-01-18%20Aviation%20Innovation%20-%20A4A.pdf

[2] https://www.ieabioenergy.com/wp-content/uploads/2022/10/2-7_Saddler-UBC.pdf

## Summary and Overview

Supporting policies will be critical if we are to decarbonise aviation. Consequently, the inclusion of jet fuel within the BC low carbon fuel standard (LCFS) should play a significant role in promoting the development of SAF by creating a favourable policy environment for its production and consumption. Combined with a volumetric obligation (mandate) for minimum blending of SAF (in 2028), the BC Clean Fuels Act should also provide a framework for BC to become a favoured destination for SAF. Recent policies in the US, such as the IRA and the EU's ReFuelEU mandate, have resulted in significant demand for SAF. Thus, it is hoped that BC's evolving policy environment (such as the LCFS, which will generate credits) will provide a financial incentive for fuel suppliers and help decarbonise BC's (and the world's) aviation sector.

Although aviation is part of the hard-to-(green)-electrify long-distance transport sector, airlines need to reduce their emissions if BC and Canada are to meet their long-term climate goals. While multiple strategies must be implemented (such as more efficient planes, flight routes, etc.), SAF is expected to play the biggest role in reducing emissions. However, the commercialisation of SAF has been slow due to several challenges. These include the lack of supporting policies to bridge the price gap between conventional/fossil-derived jet fuel and SAF, derisking capital investment, etc. For example, new biorefinery construction requires high capital costs and presents a significant risk to investors, while, at the same time, SAF costs 2-5 times more than conventional jet fuel. Currently, the only fully commercial technology is the HEFA process, which produces SAF via the hydrotreatment of fats, oils and greases (FOGs). Partly due to the limited availability of lipid feedstocks, there is an increasing focus on other technologies, such as the gasification of biomass, followed by Fischer-Tropsch synthesis (Fulcrum Bioenergy), alcohol-to-jet (ATJ), etc., with these and other technologies at various stages of commercialisation. However, despite these investments, it is clear that supporting policies will be needed to encourage ongoing SAF development.

The importance of "enabling" policies has been recognised in jurisdictions such as the US, which has implemented the Inflation Reduction Act (IRA) and which can be "stacked" with other biofuel incentives (RINs, LCFS, etc.). In Europe**,** policies such as those outlined in ReFuelEU have defined blending mandates, creating a strong structural demand for SAF. As a result, these national policies are likely to impact Canadian investment in SAF as lipid or biomass feedstocks could be exported from Canada while SAF itself might be more easily imported. Currently, although well-intentioned, the federal Clean Fuel Regulations (CFR) does not provide a strong enough supporting policy framework. At a Provincial level, the proposed amendments to the BC Clean Fuels Act and the inclusion of jet fuel under the low carbon fuel standard should create a more favourable policy environment.

## The increased use of SAF will be essential if the aviation sector is to achieve significant GHG emission reductions.

Aviation contributes to approximately 3% of global CO2e emissions, releasing around 915 million tonnes of CO2e annually. In 2021, the International Air Transport Association (IATA) pledged to achieve net zero carbon emissions by 2050, with ICAO soon making a similar commitment. As outlined by IATA/ICAO, although effective decarbonisation will involve improved aircraft designs, increased engine efficiencies, ground transport enhancements, air traffic control system advancements, etc., SAF will play the major role

if the sector is to meet its 2050 targets. As summarised in Figure 2, IATA has indicated that the increased use of SAF should lead to a reduction of approximately 65% of all emissions by the aviation sector (IATA, 2022). However, as summarised below, determining the carbon intensity (CI) of a fuel is not straightforward.

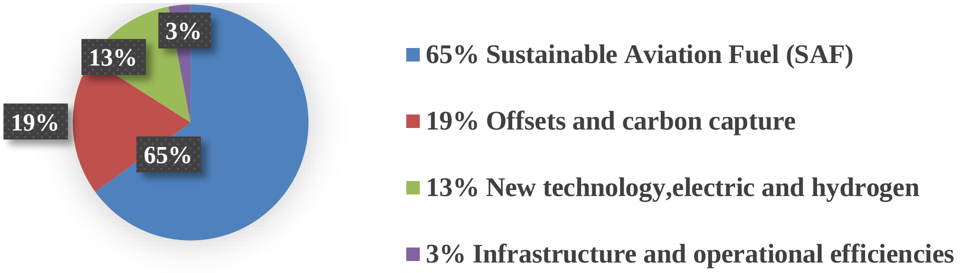

**Figure 2** IATA's strategy to net zero and the projected contribution of SAF.

## How will the carbon intensity (CI) of biojet/ SAF be determined?

The International Civil Aviation Organisation (ICAO) established the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which has developed a life cycle methodology to allow companies to calculate the CI of any biojet/SAF they might produce. However, some US feedstock producers have suggested that the CORSIA LCA scheme does not use the most recent data or incorporate innovative agricultural practices (such as regenerative farming) while substantially overestimating the impact of induced Land Use Changes (iLUC). This would lead to a decrease in the incentive tax credits awarded under the US IRA.

CORSIA offers standardised international methodologies for measuring the CI of jet/ biojet/ SAF, hoping to foster global collaboration in reducing aviation's carbon footprint. Although the US GREET LCA model has a similar methodology to CORSIA, the GREET model estimates lower iLUC emissions, incorporates "climate-smart" agriculture practices and uses a more updated database. Consequently, it typically results in lower CI values as compared to the CORSIA scheme. Some US feedstock producers have claimed this makes GREET a more desirable tool as it fosters more significant tax credit allocations within the biofuel industry (see more here).

In the US, different versions of the GREET LCA model are used by California, Oregon and Washington States to incorporate more regional-specific data and, consequently, "tailor" their fuel regulations with greater precision. However, the CORSIA model is gaining more international traction, particularly in regions that lack localised data, and it continues to evolve to try to incorporate broader sustainability criteria over and above the CI of the fuel.

Currently, in BC, the GHGenius LCA model is used to calculate the CI of fuels that are regulated by BC's LCFS. At a national level, the Environment and Climate Change Canada (ECCC) LCA model should provide more of a "federal oversight" by incorporating more pertinent data while leveraging many external databases.

As mentioned, various organisations and countries have established 2030/2050 decarbonisation targets for aviation, with SAF expected to play a major role. The CORSIA framework can provide an international benchmark where the CI of SAF might be assessed. However, the use of comparable LCA models, such as GREET, has emphasised that the "devil is in the details" and that when *well-to-wing* comparisons are made, factors such as land use assumptions, model boundaries, default values, etc., can each have a significant influence on the CI values that are reported. Groups such as IEA's Bioenergy Task 39 and the US DoE are "grappling" with these challenges, with the goal of finding an acceptable compromise regarding how the CI of SAF might be determined.

As indicated below (Table 1), although "green" electrification and "green" hydrogen will contribute to net zero aviation, the suitability of these technologies for many aircraft and use over long distances will be very limited. It is also well documented that the majority of aviation emissions are due to long-haul passenger flights, where increased SAF use is the only real alternative.

**Table 1** An overview of where low- and zero-carbon energy might be deployed in commercial aviation (ATAG, Waypoint 2050).

| Flight | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| **Commuter**<br>9-50 seats<br><60 minutes flights<br><1% of industry $CO_2$ | SAF | | Electric and/or SAF | Electric and/or SAF | Electric and/or SAF | Electric and/or SAF | Electric and/or SAF |
| **Regional**<br>50-100 seats<br>30-90 minutes flights<br>3% of industry $CO_2$ | SAF | SAF | Electric or hydrogen fuel cell and/or SAF | Electric or hydrogen fuel cell and/or SAF | Electric or hydrogen fuel cell and/or SAF | Electric or hydrogen fuel cell and/or SAF | Electric or hydrogen fuel cell and/or SAF |
| **Short haul**<br>100-150 seats<br>45-120 minutes flights<br>24% of industry $CO_2$ | SAF | SAF | SAF | SAF | Electric or hydrogen combustion and/or SAF | Electric or hydrogen combustion and/or SAF | Electric or hydrogen combustion and/or SAF |
| **Medium haul**<br>100-250 seats<br>60-150 minutes flights<br>43% of industry $CO_2$ | SAF | SAF | SAF | SAF | SAF | SAF | SAF potentially some hydrogen |
| **Long haul**<br>250+ seats<br>150+ minutes flights<br>30% of industry $CO_2$ | SAF | SAF | SAF | SAF | SAF | SAF | SAF |

A major challenge for electric aircraft is the low energy density of batteries, which is about 40 times less than the same weight of jet fuel[3]. As shown in **Table 1**, electric or hydrogen-powered airplanes will only be used for short flights, and even then, not likely before 2040. Similarly, although hydrogen can be used as a low-CI fuel, it must be compressed or stored as a cryogenic liquid with safe storage and safe fueling critical steps. As most of the world's hydrogen is currently produced via steam reforming of natural gas, the carbon intensity (CI) of the hydrogen needs to be ensured if real climate benefits are to be achieved. While most of BC's electricity is green (hydro), and it can be used to make hydrogen via electrolysis, this "green" hydrogen is likely to be much more expensive than hydrogen derived from natural gas.

As will be covered in more detail at the end of the newsletter, policy has and will play a key role in decarbonising transport. For example, British Columbia's LCFS has encouraged BC's two oil refineries to both decarbonise their operations and the fuels they produce. Tidewater Renewables, located in Prince George, BC, will soon be running its standalone facility, which will primarily produce renewable diesel, but with the potential to "pull off" a SAF component. In parallel, and as discussed in more detail below, the Vancouver-based Parkland refinery is now routinely co-processing lipids with the potential to co-process less costly, more available and lower-CI biocrudes in the future.

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[3] https://www.cnn.com/travel/article/electric-aircraft/index.html

## *Co-processing at an oil refinery is one way of increasing lower-carbon-intensity jet fuel production*

Sustainable Aviation Fuels (SAF) have predominantly been produced using lipids, e.g., fats, oils and greases (FOGs) feedstocks that are "refined" in repurposed, standalone oil refineries following the Hydroprocessed Esters and Fatty Acids (HEFA) pathway. However, production has struggled to keep pace with the rapidly increasing demand for SAF. This shortfall has "catalysed" innovative solutions at certain oil companies such as BP, Eni, Philips 66 and Total to use the co-processing of lipids to produce lower CI fuels.[4]

Co-processing is the simultaneous processing of biogenic feedstocks, such as FOGs, with fossil-based feeds within a refinery. This approach offers several advantages, making it a more attractive alternative to building or repurposing standalone facilities. They include:

1. Lower Financial Investment: By co-processing in existing refineries, this avoids much of the substantial capital expenditure required to repurpose or build a new plant. It also leverages already-developed processes and expertise, thereby reducing both financial and operational risks.
2. Minor Modifications Required: Unlike constructing entirely new facilities, co-processing requires only minimal adjustments to current refineries. This streamlines the transition, making it faster and more cost-effective.
3. Flexibility in Feedstocks: Co-processing's adaptability in handling various feedstocks, both renewable and fossil, ensures that refineries can swiftly respond to market fluctuations and regulatory changes. This flexibility enhances resilience in a dynamic energy landscape.[5] As oleochemical/lipid feedstocks are expensive and likely to become increasingly scarce (as a result of competition), refiners can consider alternative feedstocks such as plastic wastes or biomass-derived biocrudes.
4. Immediate Utilisation of Current Infrastructure: Co-processing capitalises on the existing refinery infrastructure and downstream supply chains, ensuring a more rapid response to SAF demand.

The industry's co-processing standards currently permit the insertion of up to 5% renewable feedstocks, with efforts underway to increase this limit to 30%. As a result, several oil majors are investing in co-processing, and the potential production of a lower CI jet fuel could facilitate the aviation industry's decarbonisation aspiration. British Columbia's two oil refineries (Tidewater and Parkland) have established both standalone and coprocessing processes as ways of reducing the CI of the fuels they produce. These commercial innovations and policies, such as BC LCFS, have fostered increased collaboration among industry leaders and will help further decarbonise long-distance transport (including aviation). However, one ongoing effort is to develop a "quick cheap and representative" method to quantify the carbon intensity of the fuels that are produced as a result of co-processing.

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[4] https://www.greenairnews.com/?p=2815

[5] https://www.bp.com/en/global/air-bp/news-and-views/views/the-role-of-co-processing-in-aviation-s-transition-to-a-low-carb.html

## *Key challenges that have limited the development of SAF*

**Price Discrepancy and Policy Intervention: The price discrepancy between conventional jet fuel/kerosene and SAF, where SAF is notably more expensive (2-5 times higher).**

As mentioned earlier, the price of SAF is much higher than conventional fossil-derived jet fuel. While limited public information is available on the price paid for SAF, Argus Media reported a price of $3,344.74/t on 27 January 2023, which equates to a premium of around $2,330/t compared with the 27 January jet fuel price average. As the cost of fuel is about 30% of an airline's operating costs, paying substantially higher prices for SAF will make an airline uncompetitive with other airlines or other modes of transport. Consequently, bridging the price gap plus "creating a level playing field" are two key issues that must be addressed by policymakers. Previous reports have suggested that policy intervention will be crucial to address the significant price difference between conventional jet fuel and SAF (ICAO CAEP 2022). This work also suggested various policies that could be pursued, including financial incentives, tax relief, mandates, grants, etc., to bridge the price gap and mitigate investment risk.

**SAF Production Costs and Financial Viability:**

The high cost of financing SAF refineries and the inherent risk associated with technologies that are still under development also pose significant challenges. Although it is cheaper to produce renewable diesel than SAF, when producing renewable diesel from FOGs, about 10-15% of the molecules fall within the jet-fuel range. There is also the potential for a larger SAF fraction to be produced via additional processing. However, at this time, in jurisdictions such as BC, all the liquid products can be sold as diesel, as current policies reward the production of lower-CI diesel, not jet fuels. Additionally, the SAF can usually only be "pulled off" after additional infrastructure investment. For example, further processing, such as isomerisation, may be necessary to meet ASTM specifications. As mentioned earlier, by employing additional processes such as hydrocracking, a much larger fraction of the liquid product can be produced in the jet range (up to 70%), but at the expense of overall yield. Although renewable diesel production has been fully commercial for many years, with global production reaching about 7 billion litres in 2021, until recently, only two facilities produced substantial volumes of SAF. However, this situation is changing rapidly due to SAF-specific policies that make SAF production more financially attractive.

**Regulatory Support and Investment in SAF Production, now and in the future:**

As mentioned earlier, the Canada Clean Fuel Regulations currently lack SAF-specific policies. However, with several low-CI fuel facilities in Canada in the planning and construction phases, SAF-specific policies could be developed to encourage additional SAF-related infrastructure investment. As mentioned earlier, as about 99% of the biojet/SAF used in the world uses the HEFA production pathway, it is unlikely that this lipid-based process will be able to supply the estimated 500 billion-plus litres of SAF required by 2050. Consequently, other technology/feedstock pathways need to be soon commercialised. As discussed below, what processes will (soon?) supplement the lipid (HEFA)-to-biojet/ SAF pathway and which "enabling" policies will best drive aviation decarbonisation?

## *What processes will (soon?) supplement the lipid (HEFA)-to-biojet/ SAF pathway?*

About 99% of the biojet/SAF used in the world today uses the HEFA production pathway, based on lipid/oleochemical feedstocks. As these lipid feedstocks, particularly wastes (e.g., fats, oils, and greases, (FOGs)), are available in limited supply, it is unlikely that the HEFA pathway will be able to supply the estimated 500 billion plus litres of SAF required by 2050. Consequently, other technology/feedstock pathways need to be soon commercialised. A recent International Energy Agency (IEA) report has indicated that biodiesel, renewable diesel and biojet fuel producers are "headed for a feedstock supply crunch"[6]. However, although nine SAF pathways have been certified by ASTM (via D7566 and D1655) most of these processes are not yet fully commercial. Although lipid-to-biojet production will continue to grow, if we are to attain the aviation sector's decarbonisation targets, additional volumes of SAF will be needed. It is likely these additional technologies will use more abundant and lower CI/sustainable feedstocks such as low-CI alcohols, biomass residues or green electricity-to-SAF approaches.

As a result, low CI biofuel feedstocks, derived from wastes and residues, are in high demand because they satisfy GHG and feedstock policy objectives. Although "wastes" are expected to be used for about 13% of the biojet/SAF produced in 2027 (up from 9% in 2021[4]), groups such as ICF International have suggested that feedstocks such as FOGs will only be able to supply about 10% of the SAF needed by 2050[7]. This report indicated that the global availability of residues/wastes will likely be limited to about 30-40 million tonnes per year. Lipid feedstocks can be grouped into two kinds. Residues or wastes, such as FOGs, or crop/vegetable-derived lipids, such as canola, soy, etc. "Waste lipids" tend to be in high demand due to their low carbon intensities, while crop/vegetable-derived lipid feedstocks, such as canola/rape, soy and sunflower, typically have higher CI as their production includes inputs such as fertiliser, tractor usage, etc. It should also be noted that some potentially high-yielding lipid feedstocks, such as palm oil, are rarely used due to sustainability concerns, primarily related to land-use changes. Although there will be continued growth in lipid-derived biojet fuels, the world does not produce enough lipids to support anticipated global SAF demand and, additionally, there are significant, already existing markets (e.g., food, cosmetics, etc.) where lipids are, and will continue, to be used.

Consequently, a considerable amount of work is currently underway to supplement the lipid-based approach to making SAF/biojet fuels. The ASTM has already certified several SAF pathways and additional pathways are likely to be certified soon. Although the power-to-liquid approach is approved, it is likely to be a longer-term strategy due to increasing competition for "green" electricity (plus converting $CO_2$ to SAF is likely to be expensive!). Although gasification of sustainably sourced biomass followed by Fischer–Tropsch conversion to SAF has also been certified by ASTM, challenges such as gas clean-up, high capital costs and economies of scale have yet to be resolved. In contrast, companies such as Lanzajet, Gevo and Swedish Biofuels hope to soon commercialise the "alcohol-to-jet" process and it may prove to be the pathway that is most able to supplement the lipid-to-biojet approach. For example, ethanol is currently produced at a commercial scale from sugars (Brazil) and starch (US), the alcohol-to-jet pathway has been technically proven, and ASTM has approved this route. While some groups have suggested that one-third of SAF demand could be produced via this route (by 2035) this would require the use of most of the world's ethanol, leaving little ethanol available for blending with gasoline, producing chemicals, solvents, etc. Although it is also worth noting that there are several other ways to make SAF, such as via pyrolysis, hydrothermal liquefaction, use of isoprenoids, etc., most of these processes are still developing with commercialisations still some ways off.

Whichever SAF route soon supplements the lipid-to-biojet route, it will have to show a significant reduction in the CI of the fuel and be cost-competitive with the already established lipid-based process that currently provides 99% of the biojet/SAF that is used by the world's aviation sector.

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[6] *IEA (2022), Is the biofuel industry approaching a feedstock crunch? IEA, Paris https://www.iea.org/reports/is-the-biofuel-industry-approaching-a-feedstock-crunch, License: CC BY 4.0*

[7] *ICF report for ATAG Waypoint 2050, Fueling net zero: How the aviation industry can deploy sufficient sustainable aviation fuel to meet climate ambitions, Sep. 2021. https://www.icf.com/insights/transportation/deploying-sustainable-aviation-fuel-to-meet-climate-ambition*

## The key role that policies will play in decarbonising aviation

Policies have been shown to play a key role in decarbonising the automotive sector and they will be essential if the aviation sector is to meet its decarbonisation goals. Potential SAF-related policies could include producer and blender incentives, tax relief, blending mandates, mandatory CI reduction targets, public procurement, loan guarantees and capital grants. For example, the US and EU recently introduced major policies targeting SAF development, with the US taking more of a "carrot" approach, which outlines significant incentives, while the EU opted for more of a "stick" approach, such as blending mandates. These types of policies have already had a significant impact on SAF growth as several new facilities have been announced, with some reports suggesting that global production of SAF could reach 30 billion litres by 2030.

## US policies that have facilitated SAF development

The US has implemented various successful biofuel policies at both the federal and state levels. They include the Renewable Fuel Standard (RFS), which mandates a minimum level of renewables in transportation fuels, and Renewable Volume Obligations (RVOs), which targets fuel refiners, blenders and importers. Renewable Identification Numbers (RINs) are also used to track compliance. They also serve as proof of meeting RVOs, with the RINs acting as credits, consequently incentivising fuel producers. Although the RFS was expanded to include renewable jet fuel on an "opt-in" basis, this has not, as yet, had much of an effect. Individual US States (such as California) have also created their own policies, which can be "stacked" with federal ones.

In 2022, the Inflation Reduction Act (IRA) introduced substantial SAF incentives via tax credits for blenders and producers. The IRA also includes broad policy measures that support renewable and biofuel production. Although the Act highlights a SAF Blenders Tax Credit (BTC) which is used to promote SAF production and use, to be eligible, the SAF must achieve at least a 50% CI reduction, as compared to conventional jet fuel, with an extra cent per gallon (up to $1.75) for each additional percentage reduction in CI. After 31 December 2024, SAF, biodiesel, renewable fuels and alternative fuels will benefit from clean fuel production credits. However, this will only apply to US-produced transportation fuels made at recognised facilities. The producer tax credit amounts to 20 cents per gallon if emission reduction limits are not met and $1 per gallon if reductions surpass a specific threshold. For SAF, the production credit is 35 cents per gallon if it does not meet the CI reduction limits or $1.75 per gallon if the CI reduction minimum is achieved.

As mentioned earlier, as well as the federal IRA, several states have also implemented SAF credit policies. For example, Illinois enacted a $1.50 per gallon SAF credit, with the credit valid for a decade. This credit will start in June 2028 and will only apply to SAF made from domestic feedstocks. Similarly, Washington State introduced a SAF credit to incentivise SAF production. Credits start at $1 per gallon, but can increase with increased emissions reductions. In Minnesota, a SAF Tax Credit was established in March 2023, which offers a refundable credit of $1.50 per gallon for SAF blending or production until January 2035. The Act also exempts SAF from certain taxes and provides a sales tax exemption for SAF-related construction.

## *European Union SAF policies- ReFuelEU*

Although the main European policy that relates to biofuels is the Renewable Energy Directive (RED) II, more recently, RefuelEU, which is part of the EU's Fit-for-55 strategy, introduced a mandate to encourage the blending of SAF into jet fuel. This also included a sub-mandate for SAF based on power-to-liquids. Under the final agreement, the percentage of SAF that must be blended with kerosene will start at 2% by 2025, moving to 6% by 2030, 20% by 2035, 34% by 2040, reaching 70% by 2050. A dedicated, sub-target for synthetic fuels derived from green hydrogen will also come into force from 2030. Starting at 1.2%, this will increase to 5% by 2035, reaching 35% by 2050. In addition to the EU, other European countries, including Norway, Sweden and the UK, have established additional policies for SAF.

Although the ReFuelEU mandate does not provide incentives to reduce the price gap between SAF and conventional jet fuel, it does create more of a "level playing field" as all airlines will need to use SAF blends (likely at a higher price). Thus, it is hoped that by creating a longer-term structural demand, a mandate will provide certainty for SAF investors.

## *Currently, the Canada Clean Fuel Regulations (CFR) does not cover SAF*

The 2022 Canadian Clean Fuel Regulations (CFR) came into force in July 2023 and requires fuel suppliers (producers and importers) to gradually reduce the lifecycle CI of the gasoline and diesel that they produce and sell in Canada. The CI requirement starts at 3.5 g $CO_2$e /MJ and will increase by 1.5 g $CO_2$e /MJ each year, reaching 14 g $CO_2$e /MJ by 2030. It is hoped that the CFR will establish a credit market with regulated parties creating or buying credits to comply with reduction requirements. Although there is no CI reduction requirement for aviation fuel, SAF can earn credits under the regulations. More recently, the Canadian Council for Sustainable Aviation Fuels (C-SAF) released a road map that suggested various ways by which Canada could become self-sufficient in SAF production.

The **C-SAF Roadmap** describes various strategic priorities by which Canada can facilitate the adoption and production of SAF. The roadmap also emphasises the importance of policy and strategic investment in SAF production. For example, ensuring any incentives used to increase SAF production exceed those used for renewable diesel production. The roadmap also highlights the inherent sustainability of Canadian feedstocks, especially plant-based oils such as canola. It also suggests aligning SAF accounting and certification methodologies with international frameworks such as CORSIA (Carbon Offset and Reduction Scheme).

However, achieving the C-SAF roadmap's aspirations will be challenging, given the influence of other nations' policies, such as the US IRA, where Canadian feedstocks could be exported into the US and Canada buying back SAF from our neighbours.

### Possible inclusion of jet fuel within the BC LCFS

The BC government has been discussing the possibility of including aviation fuel in its LCFS. The proposed legislation could include two significant components, such as the jet fuel being subject to CI reduction requirements and that some percentage of renewable fuel content will be required. It is hoped that, in combination with mandatory blending of SAF, the policy will create a supporting environment for both

SAF production and consumption. In early 2023, the Ministry published an Aviation Fuel Regulation Intentions Paper, which outlined the proposal, while asking for feedback from stakeholders by early summer. The proposed CI reduction requirements for the jet fuel category are summarised below (Table 2).

**Table 2** CI reduction requirements for the jet fuel category under the New BC Act.

| **Compliance period** | **CI reduction for the jet fuel category** | **Target CI for the jet fuel category (g $CO_2$/MJ)** |
|---|---|---|
| 2024 | 0% | 88.83 |
| 2025 | 1.67% | 87.35 |
| 2026 | 3.33% | 85.87 |
| 2027 | 5.00% | 84.39 |
| 2028 | 6.67% | 82.91 |
| 2029 | 8.33% | 81.43 |
| 2030 and subsequent compliance periods | 10.00% | 79.95 |

The renewable fuel content requirements for the jet fuel category must be met with non-fossil-derived alternatives to jet fuel, as prescribed in the Regulation, and may not be met by over-compliance by the renewable fuel content requirements in the gasoline or diesel fuel categories. The BC government will accept *low-carbon jet fuels* that are produced from renewable feedstocks in a standalone facility or co-processed from renewable feedstocks in a conventional petroleum refinery. However, as discussed below, aircraft manufacturers, such as Boeing, need the overall "sustainability" of the fuel to be certified.

### *Boeing's Cascade Climate Impact Model and its SAF Dashboard*

Commercial aviation aims to achieve net zero carbon emissions by 2050. Boeing has introduced two tools, the Cascade Climate Impact Model and the SAF Dashboard, to support efforts in aviation decarbonisation. The Boeing Cascade Climate Impact Model, launched in May 2023, is a dynamic tool that assesses various strategies to reduce aviation emissions. It offers insights into the effects of strategies like fleet renewal, future aircraft technologies, operational efficiency improvements, renewable energy adoption (including SAF, renewable electricity, and hydrogen), and market-based measures. Users can manipulate these strategies and forecast their impacts on aviation emissions up to 2050, considering various factors such as traffic growth. As evident from the classifications provided (within the Cascade model), although SAF is not the primary focus, it plays a pivotal role in driving the decarbonisation of the aviation sector and will exert a more significant impact than other elements.

The SAF Dashboard, launched on 20 June 2023, is a visualisation tool that estimates global SAF production capacity. It allows users to track and project SAF production and highlights the gap between supply and demand. The dashboard provides detailed information on SAF capacity by production pathway, country, and operational date. In this way, it hopes to promote transparency and data-driven decision-making. The investment in these "tools" signifies Boeing's commitment to advancing discussions and actions related to aviation decarbonisation. Through the use of these models, Boeing hopes that insights into emissions reduction strategies and sustainable fuel production will be derived

## *Conclusions*

Although significant progress continues to be made in the "greening" of the world's automotive sector via the increased production and use of electrified cars, globally, the majority of the electricity used to charge these cars is derived from fossil fuels such as coal or natural gas. Biofuels, such as ethanol produced from sugars and starch, still contribute much more to the "greening" of the automotive sector than the use of "green" electricity. However, the hard-to-electrify long-distance transport sector, such as marine, aviation long-distance trucking and much of the world's railways, will be hard to electrify. As described in this issue of the BC-SMART newsletter, the aviation sector will be particularly difficult to decarbonise, with the use of biojet/SAF playing a major role in this decarbonisation strategy. The sector, through associations such as IATA and ICAO, has formed CORSIA and has established clear goals and suggested ways in which the carbon intensity (CI) of any alternative fuels might be assessed. Despite these efforts, SAF production has been slow to develop and there remain several challenges to expanding SAF production and use, such as the high cost of SAF, its limited availability, sustainability concerns, etc. Consequently, many additional SAF facilities need to be constructed to achieve the volumes targeted by ICAO. As it is recognised that supporting policies will be needed to enhance SAF production and consumption, regions such as the US and the EU have implemented policies that hope to increase SAF production and use.

Although the federal Canada Clean Fuel Regulations currently does not provide a policy framework that supports the development of SAF, at a regional level, British Columbia plans to include low-carbon-intensity jet fuel within its Low Carbon Fuels Standard (LCFS) with the hope of encouraging BC-based SAF production and use. The BC's LCFS has established a robust credit market and it is hoped that the high cost of making SAF can be mitigated with domestic production finding added support via Part 3 agreements.

Although BC is not a major producer of lipids, much of Canada's agricultural products pass through the Port of Vancouver, and BC's two refineries (Parkland and Tidewater) already use lipids in their standalone and co-processing facilities. As covered in this newsletter, in the longer-term, it is anticipated that SAF will be produced from residual biomass or green electricity. Consequently, BC should be well positioned as it is a major producer of these resources and, with the right policies in place, it is likely to become a major producer and user of low CI, long-distance fuels.

If you would like to be part of the **"Coalition of the Willing"** and continue to receive our newsletter and occasional updates about BC-SMART consortium, please contact us at:

***The BC-SMART secretariat (www.BC-SMART.ca)***

***Dr. Hana Mohammadi***

***Email: hana.mohammadi@ubc.ca***

BC SMART- Decarbonising Long Distance Transport