BC-SMART Low Carbon Fuels Consortium

Decarbonising Long-Distance Transport

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BC-SMART Workshop "Where will we be by 2030: Biojet/SAF?"

From the BC-SMART Secretariat

This issue of the BC-SMART newsletter summarises the discussions covered in our most recent biojet/SAF workshop in late February. The workshop's focus concerned our collective ability to meet the 2030 (and 2050) aviation decarbonization targets set by organizations such as ICAO and IATA. It was clear that decarbonizing the fuel that the aviation sector will use will have the biggest impact, with green hydrogen and electricity possibly playing a role by 2050. However, to meet 2030 targets, low carbon-intensity (CI) biojet fuel will predominate, with enabling policies contributing an important role in bridging the price gap between fossil and renewable biojet fuels. As covered in more detail within the newsletter, the workshop was fortunate to have strong international participation, all contributing to lively discussions. IEA's Jeremy Moorhouse set the scene, our US colleagues' detailed initiatives such as the SAF Grand Challenge, the ASCENT program as well as Boeing's own predictions while the meeting was informed of Sweden's PREEM refinery investment in co-processing and renewable diesel production.

British Columbia is well positioned to take the lead in this area, with both of its refineries (Parkland and Tidewater) already investing in the production of low CI fuels, with feedstock supply chain issues being tackled by BC companies such as West Coast Reduction, combined with the BC government encouraging the use of low CI jet fuel by modifying the Provincial Low Carbon Fuels Standard (LCFS) to include jet fuel.

As mentioned before, BC-SMART's "dating agency" role was in full play, with many of the key players that will be needed to establish a successful biojet/Sustainable Aviation Fuel (SAF) supply chain getting to know each other better, with technology, policy, economics and life cycle analysis (LCA) all shown to have essential roles in decarbonizing the aviation sector.

Thank you for reading and participating in the BC-SMART network!

Hana, Susan and Jack:

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Summary and Overview

A more detailed outline of the workshop agenda can be found here. The first part of the workshop highlighted international efforts to decarbonize the hard-to-abate aviation sector. As covered in more detail below, fuel is a major component of aviation's carbon footprint. Although there has been a significant increase in the amount of biojet/SAF produced and used by the aviation sector over the last few years, this is still less than 1% of all jet fuel used today. However, groups such as ICAO, IATA and IEA project significant growth in the production and use of low CI fuels by the aviation sector by 2030 (and particularly 2050!), with biofuels playing a significant role in the short-term and green electricity/hydrogen technologies projected to mature in the longer term.

Policies such as the Inflation Reduction Act (IRA) in the US have catalyzed significant investment in the biojet area. The US has also supported pioneering SAF production companies such as Lanzajet, Gevo and Alder Renewables by incentivizing the production and use of these low CI aviation fuels. Although there was some concern that the current IRA was of short duration, the US's long-term commitment to other biofuels, such as bioethanol, went a long way to reassure the workshop participants that these policies would likely continue to be used and "tweaked" to encourage the growth of biojet fuels. Although Sweden has been at the forefront of movements such as "flight shaming", companies such as PREEM have invested in the production of low CI fuels such as renewable diesel and alternative feedstock supply chains through joint ventures such as Pyrocell and SunPine.

Canada has its own SAF roadmap, which describes how the country might decarbonize aviation, with C-SAF outlining how biojet targets of 1 billion liters (BL) by 2030 and 3.75 BL by 2035 could be achieved. The Province of BC also has innovative companies such as Tidewater, Parkland and a policy environment that encourages ongoing decarbonization. BC is currently the only jurisdiction in North America that has included aviation in its low carbon fuel standard as an obligated fuel category.

As was covered in the latter part of the workshop, policies and the ability to calculate the Carbon Intensity (CI) of any biojet/SAFs that are produced and used will be critical to their rapid development (and to meet the ambitious targets set by groups such as ICAO and IATA).

Hopefully, this issue of the BC-SMART newsletter will give you a sense of the very informative exchange that occurred at the workshop, with the very active follow-up that occurred a good indication that the network's "dating agency" function is alive and well!

Potential for ongoing global decarbonization of aviation

As eloquently described by IEA's Jeremy Moorhouse, achieving net-zero emissions (NZE) by 2050 will not be achieved without growth in the production and use of biojet/SAF. Although total global use of SAF in 2022 was less than 1% (Figure 1), based on projected growth by established companies such as Neste, World Energy, Montana Renewables, etc., and announcements by other companies, it is hoped that this will grow to 10% by 2030.

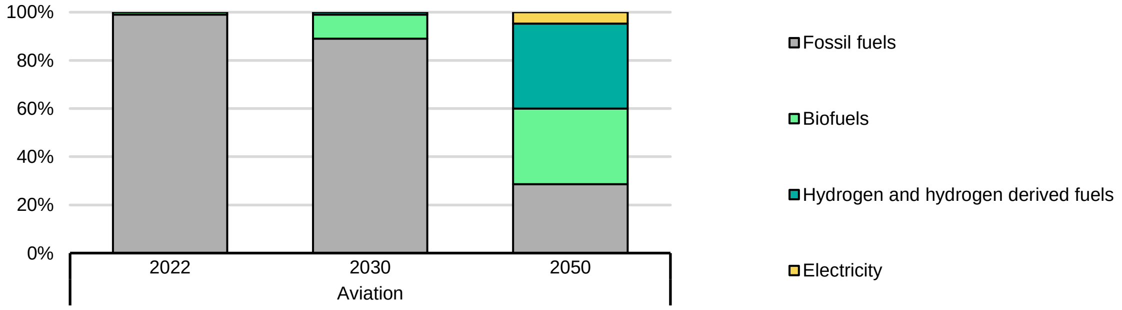

Figure 1. Share of aviation fuel demand, 2022 to 2050, NZE (IEA)

In the longer term (2050), alternative, low-CI fuels such as (green) electricity/hydrogen are expected to play an increasing role. However, their "non-drop-in" nature will require establishing a much more extensive supply chain, plus it is unlikely that any trans-oceanic flights will be readily undertaken using these types of fuels.

Lipid feedstocks are expected to predominate over the next few years, with most of the SAF produced and used by 2030 making use of established technologies and FOGs (Fats, oils and greases) as well as a range of vegetable lipids (e.g., canola, soya, sunflower, etc.) via the HEFA (lipid-to-jet) pathway. By 2050, it is hoped that various biomass feedstocks will be sustainably produced and used for various bioenergy/biofuel applications, including SAF (Figure 2). IEA and IPCC projections indicate that by 2050, there will be no overall increase in the cropland used for bioenergy/biofuel production, and there should be little-to-no encroachment on forested lands compared to current levels.

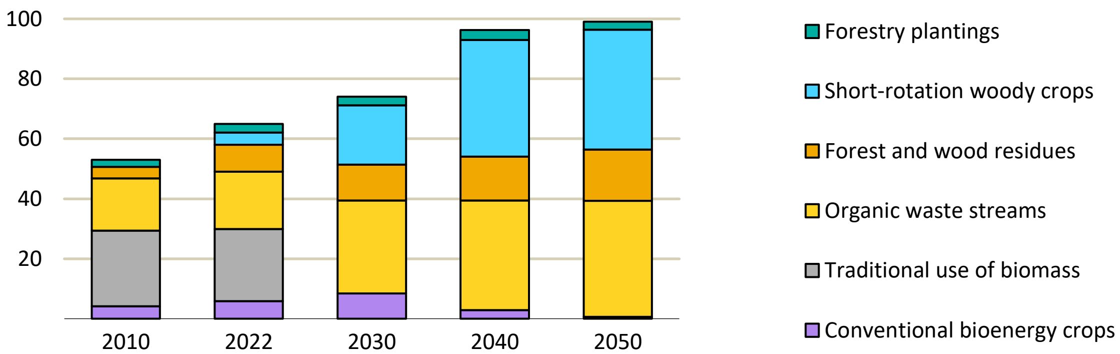

Figure 2. Bioenergy supply, 2010 to 2050 based on IEA's NZE by 2050 (IEA, 2024)

As summarised below (Figure 3), the IEA projects that the "waste" Fats, Oils and Greases, (FOGs) used to make bio/renewable diesel and biojet fuel will be in high demand, resulting in increasing use of various vegetable oils.

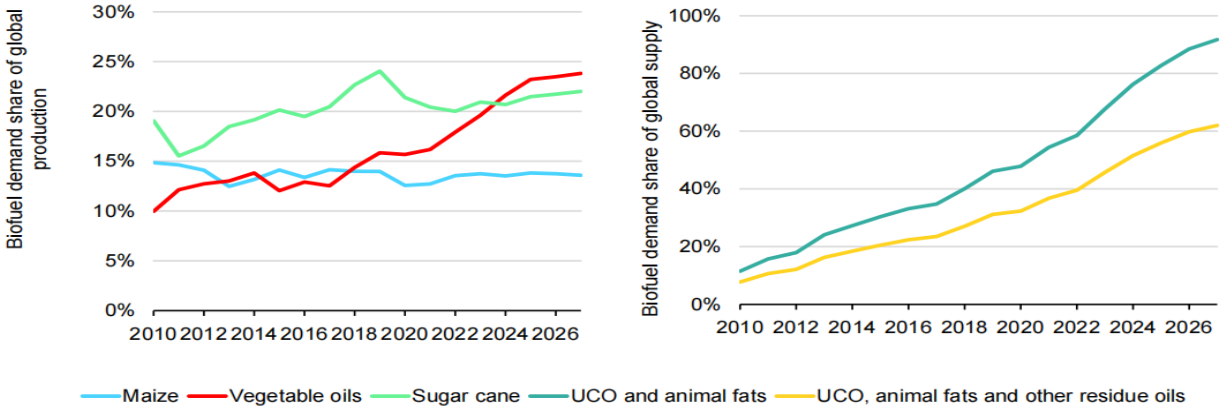

Figure 3. (left) Biofuel feedstock demand as a share of global crop production **(right)** Availability of "bio-residues", 2010 – 2028 (IEA, 2024)

The hydrotreatment of lipids is already at a commercial scale (Table 1). However, is primarily used to make renewable diesel as making more SAF rather than renewable diesel usually comes at the expense of yield and lower fossil fuel carbon mitigation. As covered in more detail within the workshop (and below), although the amount of co-processing carried out by the world's refineries could not be readily determined, this is an area that is likely to expand as it also helps decarbonize refineries as well as the fuels they produce.

Table 1. Announced biojet volumes (BLPY), based on technology (Argus)

Volumes by technology current announcements (BLPY)	
HEFA	24.2
FT	2.24
AtJ	2.84
PtL	2.3
Co-processing	?
Pyrolysis	0.13

SAF policies and the developing market in North America

As also covered in the workshop, the ICAO CAAF/3 agreement describes a global framework where biojet/SAF production can be increased to achieve a 5% CI reduction by 2030. However, (as described by several of the speakers), this will involve incorporating strategies such as the "Finvest Hub" and encouraging a supply-and-demand biojet/SAF market (C-SAF, 2024).

Several of the talks emphasized the need for enabling policies to encourage SAF growth and use, with jurisdictions such as the US and the EU already implementing policies, with others (such as Brazil, India, Indonesia, Singapore, the UAE, Malaysia and the United Kingdom) in the process of developing policies. In many ways, the US (and California in particular) are leaders (Figure 4) in providing supportive low carbon policies which have encouraged the growth of renewable fuels such as bio/renewable diesel and SAF. Multiple other US states now have low carbon fuel standards, including Oregon, Washington State and New Mexico, with several other states likely to soon pass legislation to implement similar policies.

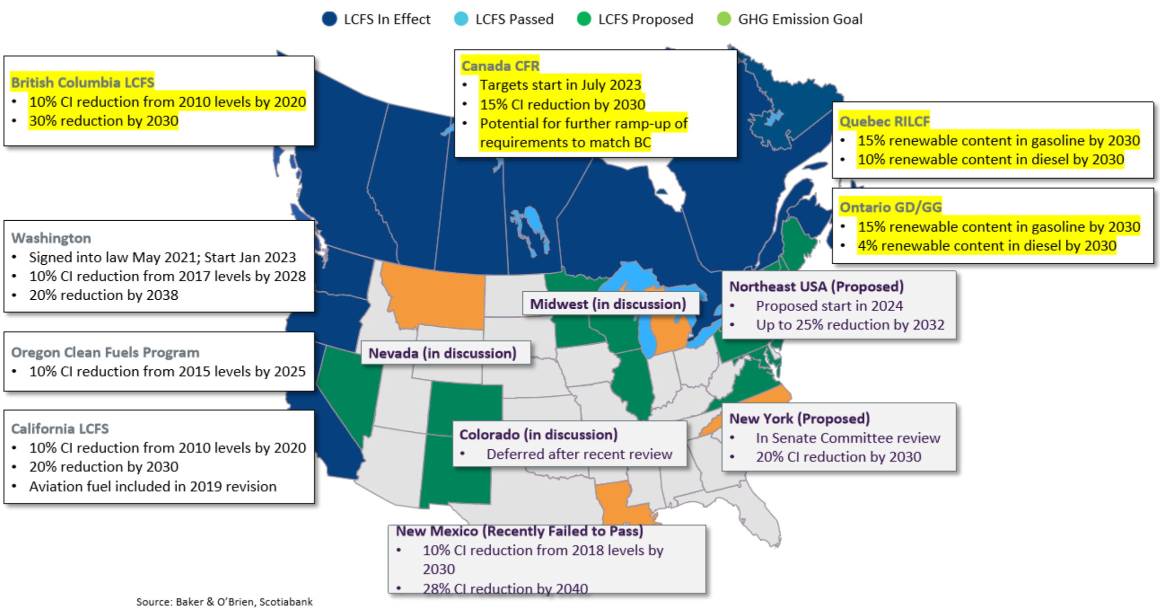

Figure 4. North American Low Carbon Fuel Regulation Summary

While the Inflation Reduction Act offers very favourable incentives for SAF, the short duration of the incentives raised some concern as the blenders tax credit currently only runs for 2 years (2023-2024, \$1.25-\$1.75/gallon for at least a 50% CI reduction) and the clean fuel production credit for 3 years (2025-2027) at \$0-\$1.75/gallon for a CI of less than 50 kg CO2e/MMBtu. A confounding issue is that, as mentioned earlier, the US Renewable Fuels Standard (RFS) favours renewable diesel over SAF (e.g., an Energy Equivalence factor (1.7 vs. 1.6) as energy density is used in calculations, resulting in renewable diesel generating more credits per volume than SAF. The Canadian C-SAF Roadmap, which has set a target of 1 BL by 2030, and 3.75 BL by 2035, suggested that the targets could be achieved by focusing on a few regions to consolidate national demand while delivering the 2030 target at a lower cost. For example, 1BL = ~30% SAF usage in BC + Alberta or ~25% SAF in Ontario (Figure 5, C-SAF, 2024).

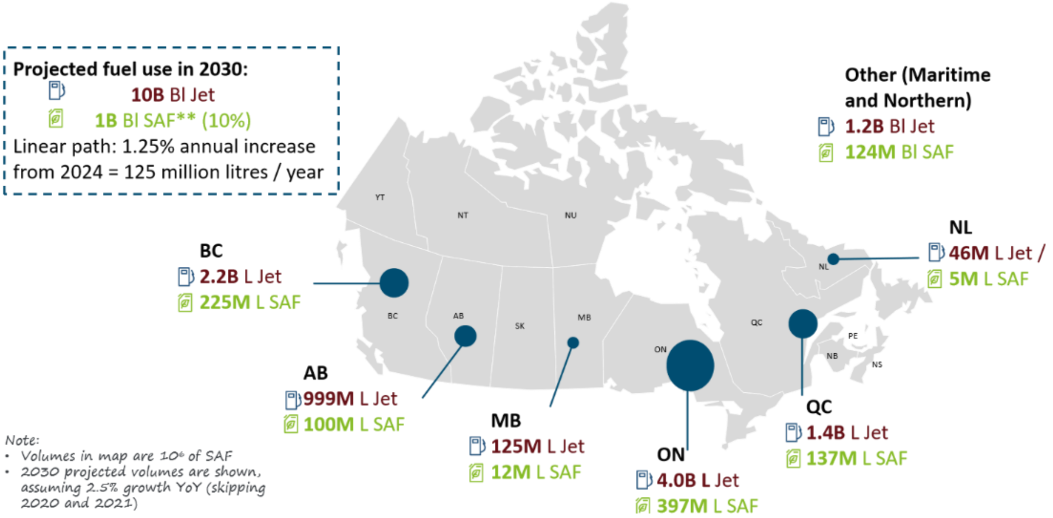

Figure 5. Projected jet and biojet use by 2030 (LCFPP, 2024)

In its presentation, Air Canada highlighted significant operational barriers to scaling up SAF production. For example, although SAF production reached 300 million liters (ML) in 2023, a 200% increase from 2021, this only represents 0.2% of global conventional jet production. As at this point in time, there are no Canadian SAF producers, consequently, Canada will likely have to rely on imports. There are also infrastructure challenges, with biojet/SAF production and distribution facing slow permitting processes and complexities in blending biojet/SAF with conventional fuel. As well as these challenges, policies will be required to bridge the price gap between the likely cost of biojet/SAF and conventional jet fuels (Figure 6).

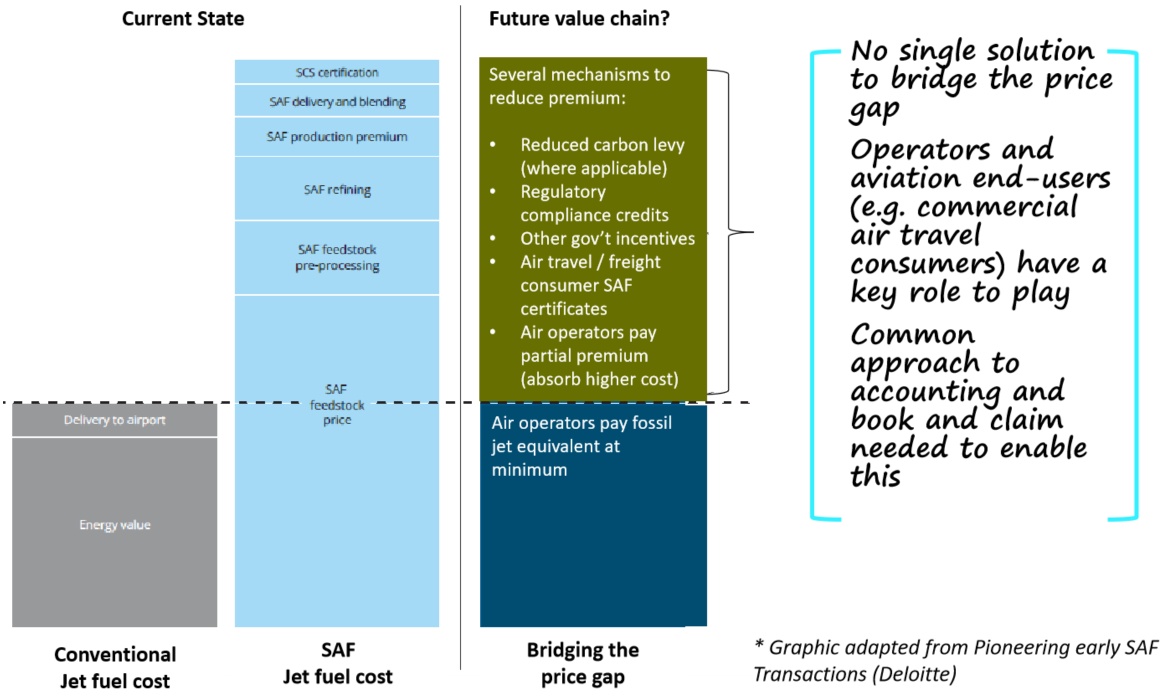

Figure 6. How to bridge the price gap between jet/biojet fuels (adapted from Deloitte)

In its presentation, the Treasury Board Secretariat (TBS) described how it has enlisted the help of the Council on SAF Accountability (COSAFA) to help facilitate the adoption of biojet/SAF, particularly in regions such as British Columbia where favorable policy conditions have been developed (LCFPP, 2024). In British Columbia, to comply with the BC-LCFS, fuel suppliers, including importers, must adhere to annual renewable fuel content and low carbon fuel requirements. For example, diesel must contain a minimum of 4% renewable fuel content by volume annually, while gasoline must have at least 5% renewable fuel content by volume annually. Both diesel and gasoline must achieve a 30% CI reduction by 2030. It was apparent that BC's regulations hope to incentivize renewable fuel use while reducing the CI of transportation fuels.

BC's Aviation Fuel Regulation Intention Paper (released on April 6, 2023) describes its Renewable Fuel Requirement and Low Carbon Fuel Requirement for jet fuel. The Low Carbon Fuel Requirement, (from 2026), imposes a CI reduction target that will increase from 2% to 10% by 2030. The Renewable Fuel Requirement (from 2028) mandates aviation fuel suppliers to incorporate a minimum of 1% renewable fuel content, with this amount increasing to 2% by 2029 and to 3% by 2030 (Table 2).

Table 2. BC-LCFS jet fuel requirements (BC government, 2024)

Year	Renewable Content [1]	CI Reduction [2]	Exemption for Jet Fuel (Quantity supplied [3])
2024	0%	0%	100 ML
2025	0%	0%	100 ML
2026	0%	2%	100 ML
2027	0%	4%	100 ML
2028	1%	6%	10 ML
2029	2%	8%	10 ML
2030+	3%	10%	4 ML

[1] Annual volumetric average
[2] Measured from the 2010 baseline of 88.83 gCO_2e/MJ
[3] Fuel suppliers may request an exemption if their annual volumes are less than these exemption limits.

Under the BC-LCFS, the costs associated with meeting these requirements include a ~$600 per tonne debit for low-carbon fuel and deficit charges ranging from $0.30 to $0.50 per liter for renewable fuel. Projected demand for Low Carbon Jet Fuel (LCJF) could range from 24-53 ML in 2028 to 73-184 ML in 2030. Additionally, supplying "green" electricity to ground support equipment at airports qualifies for credit generation, with the hope that this will promote sustainable practices in airport operations (BC government, 2024). As summarised below (Table 3), the Low-Carbon Fuel Regulations are driving major changes in the liquid fuels industry.

Table 3. Primary compliance pathway is the substitution of conventional fossil fuels with biofuels (Parkland, 2024)

Biofuels	Substitution rate Canada	Substitution rate BC
Ethanol	8.2 % of gasoline	9.2% of gasoline
Biodiesel	1.3% of diesel	2.8% of diesel
Renewable Diesel	0.9 % of diesel	4.5% of diesel

Progress in the decarbonization of BC's refineries

Starting in 2020, the **Tidewater** refinery in Prince George initiated modifications to allow them to co-process renewable feedstocks with conventional crudes. Co-processing feedstocks such as canola oil, tallow and used cooking oils resulted in the CI of the final gasoline and diesel being reduced by about 5%. Around the same time, Tidewater also initiated the design of a possible renewable diesel facility that would be located within the existing refinery complex. Currently, the facility produces approximately 2,300 barrels per day of -35°C cloud point renewable diesel from Canadian waste oils and canola oil. More than 24 ML has been produced to date, with the majority (22 ML) sold locally in the BC market. However, when the SAF/RD Sales and credit revenue are compared with production cost (Figure 7), the high cost of low-CI feedstocks and the important role that "enabling" policies play is apparent.

Consequently, the challenge to increase the production of SAF includes the high cost of feedstocks, limited availability of low-CI/waste feedstock and the higher return on making renewable diesel rather than SAF.

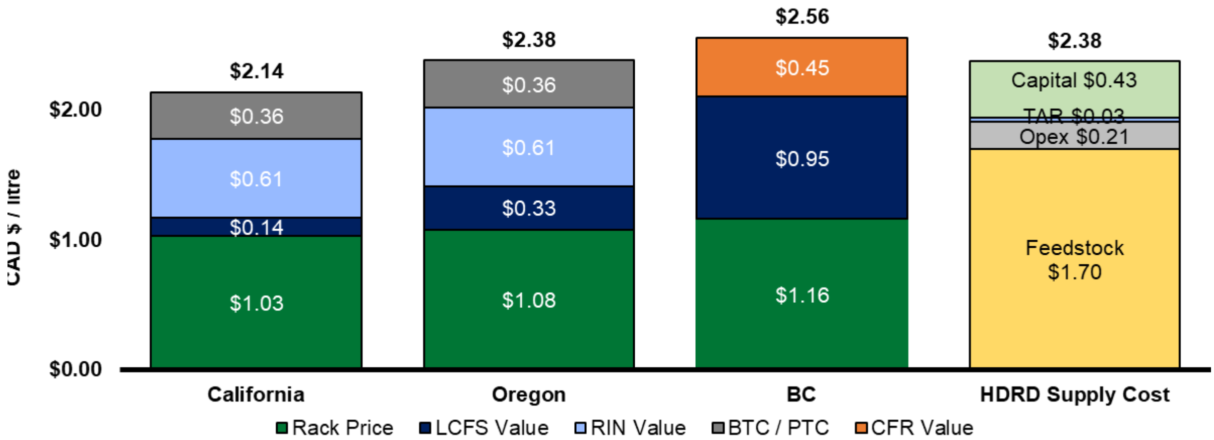

Figure 7. Summary of possible SAF/RD Sales & credit revenue vs. Production cost (Tidewater, 2024)

Parkland has been a pioneer in co-processing (Figure 8) and is currently planning a significant expansion of its co-processing capabilities from 3500 barrels per day (BPD) to 7500 BPD (by 2028). It is also assessing the potential to supplement lipids with additional renewable feedstocks such as pyrolysis oils (e.g., biocrudes/bio-oils). Parkland is also considering making low-CI jet fuels and SAF and is actively working with groups such as the CGSB and ASTM to increase the co-processing limit for SAF production from 5% to higher levels (20-50%). Their presentation underscored Parkland's commitment to producing low-CI fuels.

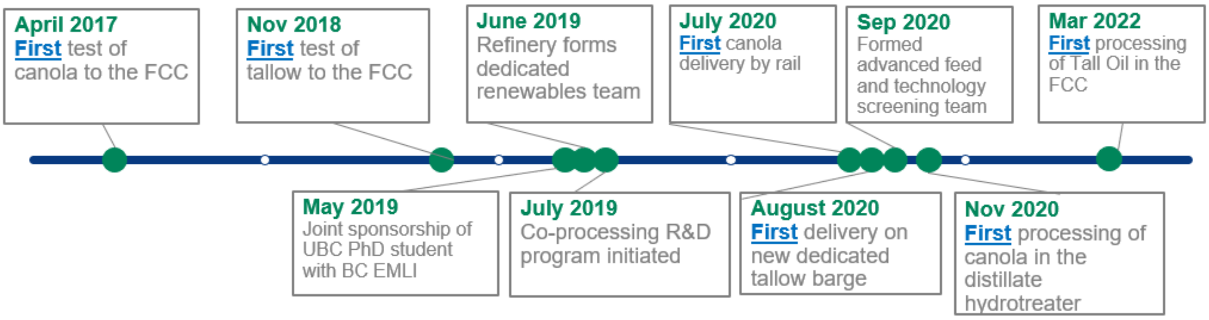

Figure 8. Parkland's renewable production development timeline (Parkland, 2024)

Preem is Sweden's largest oil company, the company runs two refineries, it has more than 1500 employees and it plays a pivotal role in supplying petroleum products to Sweden and Norway. Preem currently carries out co-processing, it also produces renewable diesel and it has invested in low-CI feedstocks (e.g., Pyrocell and SunPine). The company is also considering how it might supply low-CI jet fuel to the sector. It was also worth noting that the Preem presentation provided valuable insights regarding the operational challenges encountered when either co-processing or when producing renewable diesel.

Challenges in measuring the carbon intensity of Biojet/SAF (LCA and CORSIA)

It was clear that the increased use of biojet/SAF is likely to be the major way in which the aviation sector will be able to decarbonize. However, as biofuel policies shift from more "traditional" volumetric/energy blending mandates to Carbon Intensity (CI) reduction mandates, the need for a representative life cycle assessment (LCA) will be required to assess the full sustainability of biofuels. While CI is a critical aspect of sustainability, as the forest sector has learned, sustainability encompasses three main dimensions, economic, environmental and social, which all impacting how sustainability is defined. As covered in the workshop, even determining the CI of a biofuel is complex, with the various LCA models such as the US's GREET, Canada's GHGenius/ECCC open-source model, Brazil's RenovaCalc and EU's RED II often reporting different values. The CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) LCA model was discussed at length, as this international framework hopes to evaluate the sustainability of biojet/SAF beyond just CI metrics by integrating environmental, economic and social factors.

As discussed, there are ongoing disparities between results from the GREET and CORSIA LCA models. For example, if US biofuel producers use GREET, they can show a lower CI for the fuels, resulting in increased credits, mostly due to reduced indirect land-use change (ILUC) emissions and credits from using sustainable on-farm practices. However, given the global nature of aviation, a CORSIA-like framework that incorporates both CI and broader sustainability issues will likely be required. The workshop participants agreed that, by incorporating updated regional data, the LCA models should show the impact of improved agricultural practices, consequently fostering the increased sustainability of biojet/SAF.

Conclusions

Over the last few years, significant progress has been made in the production and use of biojet/SAF. However, there are ongoing uncertainties regarding the use of incentives, enabling policies, evolving technologies such as Power-to-Liquids (PtL), etc., as well as increasing feedstock competition (e.g., lipids, biocrudes, sugars, etc.) with other biofuels such as bio/renewable diesel, ethanol, etc. As was discussed multiple times during the workshop, SAF/biojet fuel is a topic ripe for collaboration and shared responsibility and increased cooperation will likely be needed to help foster the sustainable growth and use of biojet/SAF production.

It was apparent that even meeting 2030 goals will be challenging while achieving the 2050 targets of producing over 400 BL per year of SAF will require the commercialization of a range of evolving technologies and the ongoing use of enabling policies. Currently, SAF constitutes less than 1% of all of the world's jet fuel used, with the lipid-based HEFA pathway dominating and likely to continue to be the predominant technology used to meet 2030 targets. In the longer term, the use of biocrude feedstocks and other technology pathways, such as AtJ, PtL, etc., will have to be commercialized if we are to meet 2050 targets.

British Columbia is well positioned to be a major participant in this area, with enabling policies such as its carbon tax, low carbon fuels standard (with the inclusion of jet fuel), ready access to biomass and potential lipid feedstock that pass through the Port of Vancouver as well as its green hydroelectricity, all valuable assets. Combined with federal policies such as the Renewable Fuel Standard, BC should be an attractive destination for low-carbon fuel investment. In the near future (2025), BC plans to progressively mandate CI reductions for jet fuel, with volumetric SAF blending mandates implemented from 2028 onwards.

In future BC-SMART newsletters, we plan to describe progress in the decarbonization of the other long-distance sectors such as marine, long-distance trucking and rail. However, the large impact that the cost of fuel has on the commercial viability of aviation and its relatively unique dependence on drop-in biofuels such as biojet/SAF means that the challenges and opportunities that were discussed in the recent workshop will likely continue to be a focus of BC-SMART activities.

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:

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