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Sustainable Aviation Fuel – The Technology Is Ready, But Are Consumers Willing?

Net-zero Flightpaths Point To SAF

Sectors:
Portfolio Strategy, Industrials

Our Conclusion

Sustainable Aviation Fuel (SAF) is the most promising decarbonization initiative in aviation, with the capacity to reduce flight emissions by 80%. The fuel leverages existing infrastructure and requires no modification to current engine technology. The key challenge is one of cost; producing SAF is at least two to three times more expensive than traditional jet fuel.

Air Canada is targeting a minimum 10% SAF use by 2030, as part of a greater net zero target by 2050. The airline also has the lowest carbon intensity amongst major North American peers. We continue to view the company as a global leader when evaluated on carbon performance.

Key Points

SAF's biggest proponent is that it is a drop-in fuel. It involves little to no changes in storage, transport or combustion relative to traditional jet fuel. In comparison to some decarbonization strategies that require a systems overhaul (mass electrification), this is a huge advantage. The key drawback is one of price, with minimum supply costs of US$4 to US$6 per gallon compared to a current jet fuel price of just over US$2.50/gal. Without fiscal support, this likely increases economy fares at minimum 30% to 50%.

However, there are two notable tailwinds for SAF. Next year, Canada's Clean Fuel Regulations (CFR) take effect and will require a 15% reduction in carbon intensity in liquid fuels by 2030. While jet fuel is currently excluded federally (B.C. has moved forward to include jet fuel), the CFR will help stimulate capital investments for renewable fuels (diesel). Of note, California has been issuing credits for SAF production since 2019.

Longer-term, SAF is the most crucial decarbonization lever for airlines chasing net zero. Over 70 airlines have announced SAF targets (consensus is 10% by 2030), including Air Canada. Canada's flag carrier also has one of North America's youngest fleets, is invested in direct air (carbon) capture technology, and has even placed an order for 30 fully-electric planes.

On the production side, we note Parkland, Tidewater Renewables, Imperial Oil and Suncor are all either invested or evaluating investments in renewable fuel projects/refineries. Canada's current renewable fuel pipeline is expected to total 65,000 Bbl/d by 2026.

From a broader ESG lens, we highlight SAF impacts even the investor portfolios absent aviation holdings as business travel (Scope 3) can be a company's largest emissions source. This is especially true for service-based sectors such as Technology, which have historically been active in offsetting total emissions. In the future, we anticipate a growing social trend of consumers looking to offset flight emissions.

All figures in Canadian dollars unless otherwise stated.

For required regulatory disclosures please refer to "Important Disclosures" beginning on page 32.

Conclusion And Key Takeaways

SAF can reduce emissions by 80% but will add an extra 50% to the price of your ticket

Sustainable Aviation Fuel (SAF) can reduce aviation emissions 80%, with little changes to prevailing aviation infrastructure. However, this comes at a high cost. SAF requires minimum carbon prices of US$300/tonne-US$500/tonne, likely adding at least 50% to long-haul economy class tickets as shown in the table in Exhibit 1. The key question is whether consumers are willing to pay to offset emissions? We believe the technology should be championed. Physical abatement technology costs are often high, but frankly, lower-cost alternatives (carbon offsets) are likely priced too low. The cost of air pollution will have to increase over time if we are to achieve our climate objectives.

Exhibit 1: Sustainable Aviation Fuel – Implied SAF Carbon Cost And Impact To Passengers On Select Routes

					Cost To Offset (US$/tonne)			Incremental Cost, %		
			Emissions	Roundtrip	VCM	EUA	SAF	VCM	EUA	SAF
Routes	Class	Aircraft	kg of CO2	US$ Price	$25	$100	$350	$25	$100	$350
JFK - LHR	Economy	B777	814	$550	$20	$81	$285	4%	15%	52%
JFK - LHR	Economy	B787	664	$550	$17	$66	$232	3%	12%	42%
JFK - LHR	Business	B777	3004	$4,000	$75	$300	$1,051	2%	8%	26%
JFK - LHR	Business	B787	2654	$4,000	$66	$265	$929	2%	7%	23%
YYZ - YUL	Economy	B737-800	140	$150	$4	$14	$49	2%	9%	33%
YYZ - YUL	Economy	A220	104	$150	$3	$10	$36	2%	7%	24%

Note: VCM = high quality voluntary carbon credits, EAU = E.U. carbon allowances, SAF = assumed average SAF cost. Source: Google Flights and CIBC World Markets Inc.

Takeaway 1: SAF is already fueling your flight

Technologically, 100% substitutable with jet fuel

SAF is a “drop-in” fuel, meaning it can easily be integrated/blended with current jet fuel and fuel infrastructure from a storage, transport and combustion standpoint. Both GE Aviation and Rolls-Royce have successfully run tests on 100% SAF, and late last year, United flew 115 passengers from Chicago to D.C. with one engine entirely run off SAF. Air Canada has four SAF flights departing San Francisco across their 737 MAX 8, A220 and CRJ-900 planes.

Takeaway 2: A promising opportunity, but substantial fiscal support needed

SAF economics depend on fiscal support

However, SAF still requires at least US$5/gallon in fiscal support to scale production economically relative to traditional jet fuel. In the U.S., existing federal and state programs provide up to almost US$5.50/gal in fiscal incentives. Canada remains behind the U.S., and would benefit from additional renewable fuel (SAF) fiscal support. While expensive relative to traditional jet fuel, SAF is cheap relative to alternative transportation modes in Canada (high-speed rail, electric planes, hydrogen planes, etc.).

Takeaway 3: Air Canada is a global leader when evaluated on carbon performance

Air Canada is a best-in-class performer amongst North American airlines

We view Air Canada as a carbon leader relative to peers. It has the lowest carbon intensity amongst major North American airlines and is targeting net-zero by 2050, pulling on various levers to achieve this goal. Air Canada’s leadership is further demonstrated by the fact it is

1) A founding member and first Canadian carrier to join the Aviation Climate Taskforce, signatory of the Clean Skies for Tomorrow Coalition and targeting 10% SAF use by 2030
2) Investing in newer, more fuel-efficient aircraft including 30 battery-powered ES-30 airplanes, and in direct air carbon capture technologies (DAC) via Carbon Engineering
3) Leading other full-service carriers on emissions per kilometer flown based, driven by investments into newer, more fuel-efficient aircraft

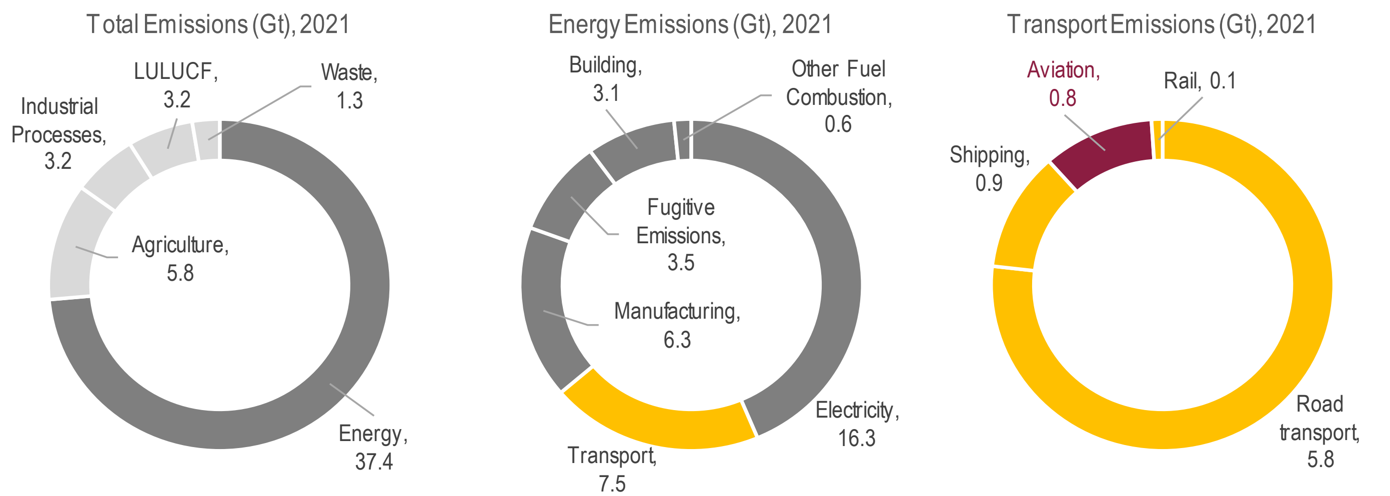
Aviation emissions are reduced by either 1) decreasing fuel consumption by adopting newer, more fuel-efficient planes, 2) reducing the carbon intensity of jet fuel (SAF), or 3) displacing jet fuel entirely (electric/hydrogen planes). Air Canada is pursuing all three initiatives.

Aviation: The High-hanging Fruit For Decarbonizing Transport

Air travel accounts for 2% of global emissions

Today, around 50 billion tonnes (gigatons) of greenhouse gas is emitted each year, with over 37 billion tonnes from the combustion of three main fossil fuels – oil, natural gas and coal. Transportation accounts for the majority of oil consumption, about 60% of global oil demand or 56-58 million barrels per day. This is in turn results in 7 to 8 billion tonnes of greenhouse gas (or carbon equivalent) emissions each year. For a breakdown of global emissions across the transport sector in 2021, refer to the donut charts in Exhibit 2.

Exhibit 2: Global Emissions – Breakdown By Major Economic Sector, 2021



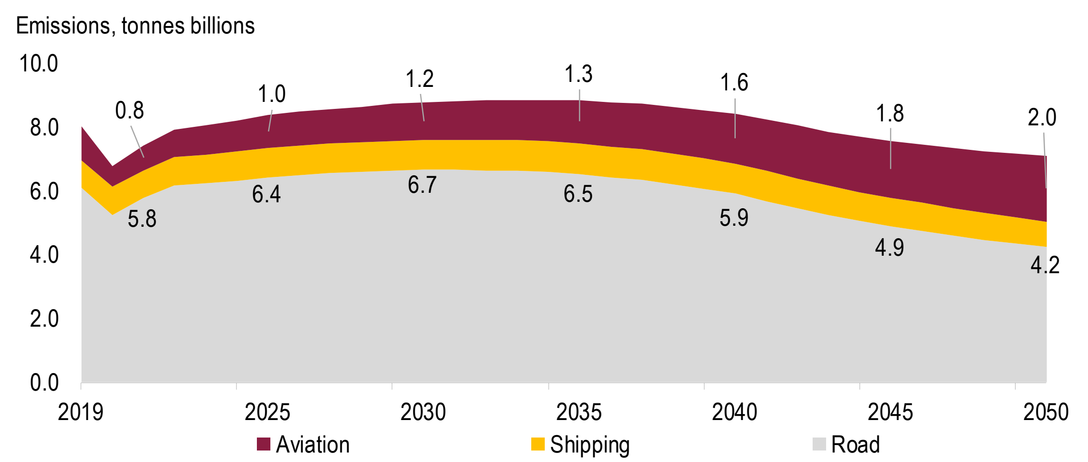
Note: Gt stands for gigatons, or billion tonnes. Source: Bloomberg New Energy Finance, ClimateWatch and CIBC World Markets Inc.

Transport emissions can be grouped into two categories, segregated by a varying ease/cost of abatement. The first group is considered the low-hanging fruit – i.e., mobility more easily electrified. This largely consists of passenger road vehicles, but also includes light-duty freight, buses and potentially short-range heavy freight. The second group is more difficult to abate, consisting of aviation, shipping and likely long-range heavy freight.

Aviation is amongst the hardest-to-abate sectors

Road transport represents the bulk of total transport emissions. This is promising as the broad permeation of electric vehicles should drive emissions lower. The not-so-great news is the scale of the challenge remains large. First, electrifiable transport still requires considerable infrastructure investments. Second, the inability to electrify road transport completely (long-haul freight, lower adoption in developing countries, etc.) means there will still be over 4 billion tonnes of road transport emissions globally by mid-century, according to Bloomberg New Energy Finance (BNEF). This is shown in the chart below in Exhibit 3.

Exhibit 3: Global Emissions – Transport Emissions By Type, 2019-2050E



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

Finally, non-road transport emissions (marine and aviation) are very challenging to displace. For aviation specifically there is no substitute for the airplane when it comes to expedient long-distance travel, which will continue to be almost entirely fueled by jet fuel. In addition, this wedge of hard-to-abate emissions is expected to grow meaningfully through the remainder of this century, driven by

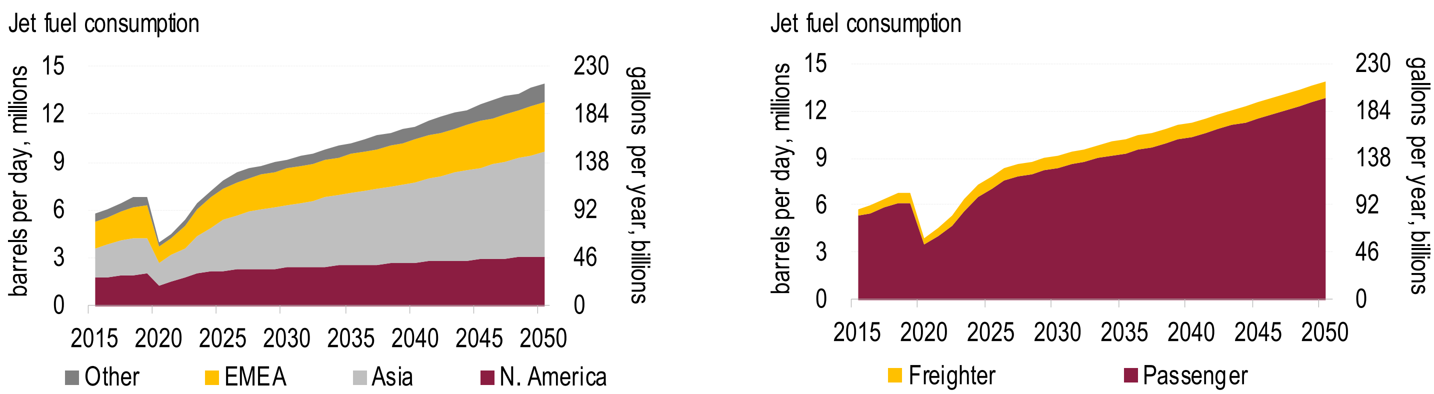
1) Rising income levels, especially in less mature markets (Asia)
2) Improved service offerings (new routes, more competition, etc.)
3) Lower supply costs (improved operational reliability and improved fuel efficiency)

The increase in aviation emissions could wipe out the gains from EVs if left unchecked

As a result, global aviation fuel consumption is expected to reach almost 215 billion gallons annually (800+ billion litres annually, or 14 million barrels per day) by 2050, compared to 105 billion gallons pre-pandemic and 82 billion gallons today (estimated by BNEF). This growth scenario is shown below in Exhibit 4.

From an emissions standpoint, this results in 2 billion tonnes of carbon annually by 2050, compared to 0.8 billion tonnes today. As shown in the right-hard chart of Exhibit 4, almost all of aviation fuel consumption (hence, emissions) continues to be in the passenger segment.

Exhibit 4: Oil Demand – Growth In Aviation Fuel Consumption By Region And Type, 2015-2050E



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

A number of levers to reduce air travel emissions

Given this reality, we see two key takeaways. First, growing aviation emissions (if left unchecked) could offset the decarbonization gains from increased adoption of electric vehicles (EVs). Second, aviation's hard-to-abate nature means the industry will likely need to pull numerous potential levers to align with net zero. Those levers are summarized in table form in Exhibit 5, which provides a brief description, decarbonization potential and total cost for each strategy. Of the levers below, the industry is increasingly looking to Sustainable Aviation Fuel as the primary tool to decarbonize the sector.

Exhibit 5: Emissions Reductions – Major Aviation Decarbonization Strategies

Decarbonization Strategy	Impact	Cost	Description
Improved utilization	Low	Low	Higher load factors, improved reliability/scheduling reduce emissions per passenger-km
Carbon offsets	Uncertain	Low	Carbon offsets (if legitimate) can offset physical emissions
Fleet upgrades/retrofits	4% - 16%	Medium	Incorporating newest engine technologies and airplane modifications (e.g. wingtips)
Air traffic infrastructure	15% - 40%	Low - High	Reduced delays for incoming and outbound traffic will improve utilization rates
Fleet modernization	20% - 25%	High	Replacing older fleet with more fuel efficient newer generation aircraft
Sustainable aviation fuel	Up to 80%	High	SAF carbon intensities can be as high as 80% less than traditional jet fuel
Electric/hydrogen planes	Up to 100%	High	Use of alternative energy planes for lighter, short haul travel

Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

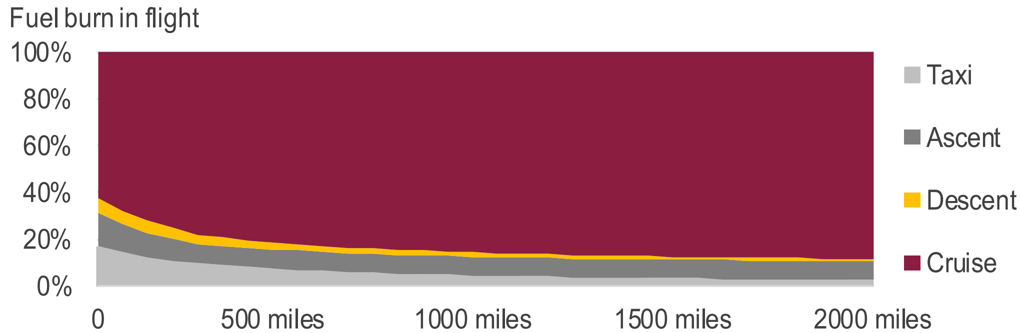
Can SAF Solve Aviation's Emissions Problem?

Aviation emissions ultimately stem from the combustion of fuel, and will be reduced by either

1. Decreasing the level of jet fuel consumption (improvements in plane design),
2. Improving the carbon intensity of jet fuel (SAF), or
3. Displacing jet fuel consumption entirely (alternative propulsion, e.g. electric planes)

Achieving net zero requires all three mechanisms, but which option to target depends on the nature of flight. The majority of flight is at cruising altitude, but on a relative basis fuel burn is more pronounced during take-off and to a lesser extent, descent. This is seen in Exhibit 6, which tracks the respective proportion of fuel consumption during varying flight lengths.

Exhibit 6: Fuel Burn – Proportion Of Fuel Consumption In Flight



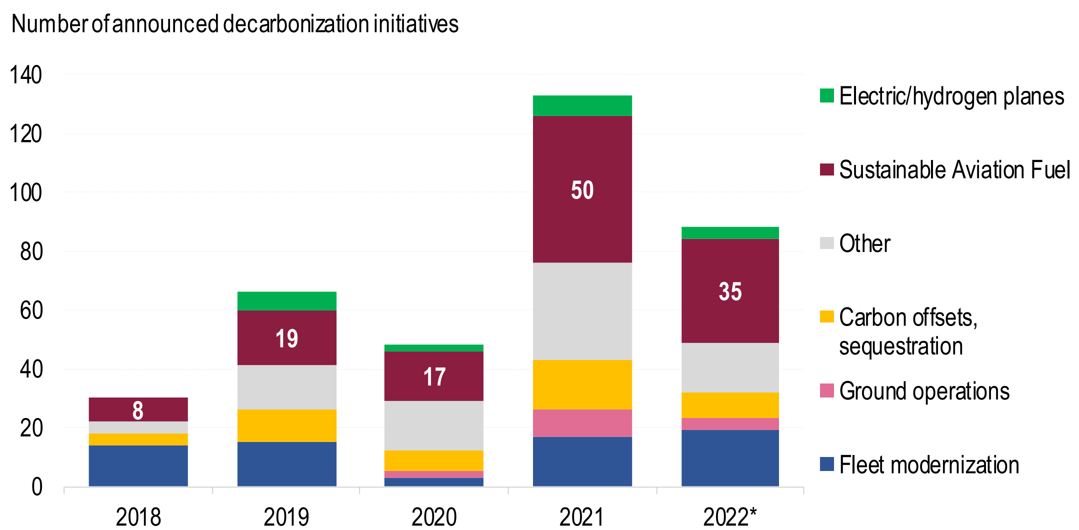
Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

In this report we touch upon all three methods of reducing emissions, but mainly concentrate on SAF (though note the other two methods are discussed on pages 13–16). This is for three key reasons. First, SAF has the potential to be very impactful, reducing aviation emissions up to 80%. Second, it is scalable. SAF can be used across varying planes of varying flight duration, unlike range/weight-limited electric or hydrogen planes.

SAF has become the most popular decarbonization strategy amongst airlines

Finally, it is the most popular decarbonization strategy, as seen in the bar chart in Exhibit 7. There are over 70 airlines (commercial and logistics) which have announced SAF targets. Most have adopted a 10% SAF target by 2030, but globally Ryanair leads with a 12.5% target. In North America, all major airlines except United have specific SAF targets, including Air Canada and WestJet. The two also unveiled SAF routes to San Francisco this year.

Exhibit 7: Emissions Reductions – Major Aviation Decarbonization Strategies



Airline	SAF Target
Air Canada	10% by 2030
Delta	10% by 2030
United	n/a
American	10% by 2030
Southwest	10% by 2030
jetBlue	10% by 2030
Alaska	10% by 2030
IAG	10% by 2030
KLM-Air France	n/a
Lufthansa	n/a
Ryanair	12.5% by 2030
Emirates	n/a
Qatar	10% by 2030
Etihad	n/a
Qantas	10% by 2030

Source: Bloomberg New Energy Finance, Company reports and CIBC World Markets Inc.

Sustainable Aviation Fuel Overview

Sustainable Aviation Fuel is expected to be the primary decarbonization driver within aviation but what exactly does it entail? Largely speaking, there are two key primary considerations for aviation fuel to be considered sustainable: 1) the fuel delivers low carbon or zero-carbon emissions when combusted, and 2) the fuel can be easily blended with existing infrastructure and traditional jet fuel, i.e., it is a "drop in" fuel.

The potential to reduce emissions up to 80%

The key benefit to SAF is it can reduce lifecycle emissions by up to 80% while largely leveraging existing infrastructure already in place. The key challenge is cost – producing SAF is about three times more expensive than traditional jet fuel.

As noted above, SAF is a blended fuel. The product is mixed with traditional jet fuel, but the type of SAF and the manner in which it is produced varies. Largely speaking, there are five primary SAF production methods producing two variants of SAF – either synthetic paraffinic kerosene or synthetic isoparaffins. A summary of the major production methods is shown below in table form in Exhibit 8.

HEFA the dominant production method

1. HEFA (hydroprocessed esters/fatty acids) → synthetic paraffinic kerosene
2. Fischer-Tropsch → synthetic paraffinic kerosene
3. Alcohol-to-jet → synthetic paraffinic kerosene
4. HFS (hydroprocessed fermented sugars) → synthetic isoparaffins
5. Power-to-liquid → synthetic paraffinic kerosene

Exhibit 8: Five Pathways To SAF Production

	HEFA	HFS	Gasification/ Fischer-Tropsch	Alcohol-To-Jet	Power-To-Liquid
Description	Safe, proven and scalable. By far the most popular production method.	Expensive but feedstock (sugarcane) is readily available	Potential in the mid term but more techno-economical uncertain than HEFA		Proof of concept, cheap high-volume of electricity is required
Production Method	Converts oils and fats to hydrocarbons via hydroprocessing	Converts sugars to hydrocarbons via hydroprocessing	Converts synthetic gas derived from biomass into synthetic crude	Converts sugars into alcohol via fermentation, then upgraded to crude	Converts hydrogen produced from electrolysis and CO2 to liquid hydrocarbons
Technology Maturity	Mature	Mature	Commercial pilot		In development
Capacity in 2025	42.1 Mt p.a.	De minimis	1.1 Mt p.a.	0.4 Mt p.a.	0.3 Mt p.a.
Feedstocks	- Waste and residue lipids - Transportable and with existing supply chains - Potential to cover 5-10% of total jet fuel demand	- Sugarcane - Significant land and water use concerns	- Agricultural and forestry residues, municipal solid waste, purposely grown rotational cellulosic energy crops - High availability of cheap feedstock, but fragmented collection		- Carbon dioxide, renewable electricity, hydrogen - Unlimited potential via direct air capture - Point source capture as bridging technology
GHG Reduction	70-85%	~60%	82-94%		85-100%

Source: World Economic Forum and CIBC World Markets Inc.

Renewable fuel produced from all five methods above can be blended with traditional jet fuel up to 50%. This is not a limitation of the fuel itself, but rather a result of the lengthy certification process to ensure product integrity – as should be the case when it comes to addressing safety concerns in commercial aviation.

HEFA is the most popular, with over 90% of current production capacity. Vegetable oils, cooking oil and waste fats are ultimately hydroprocessed/refined at oil refineries into a slate of end-use products, such as biodiesel or SAF. The process of hydrotreating is exactly what an oil refinery does, and as a result, capacity is entirely dominated by the oil refiners. A list of the major North American HEFA producers is provided later in this report.

Fischer-Tropsch (FT) involves the use of a synthesis gas (syngas) converted into a synthetic crude oil (syncrude), with the final SAF product a synthetic paraffinic kerosene. As energy veterans know, FT has been around for almost a century – commonly referred to as gas-to-liquid (GTL) which converts natural gas into fuel. In 2009, Qatar Airways ran the first commercial flight using GTL fuel, blended 50/50 with kerosene and fossil-fueled natural gas.

FT from an SAF perspective involves the same process, but with natural gas sourced from non-fossil fuels (biogas). The range of biogas sources includes municipal, forestry or agricultural waste (biomass to gas to liquid) or even as an e-fuel (power to liquid). The range of gas sources allows for a lot of flexibility for FT, which is one of its major advantages.

Where will all the ethanol go?

Alcohol-to-jet (ATJ) converts sugars to hydrocarbons via fermentation, such as ethanol. The alcohol is usually sourced from sugarcane or corn (starch), but can also be sourced from agricultural or forestry residues. Given the push for EVs in smaller passenger vehicles, there is concern across U.S. farmers about whether EVs will meaningfully reduce the demand for ethanol. Policymakers have a few levers here, whether it be increasing ethanol limits to beyond 15% (E15), or increasing ethanol feedstock in biodiesel and/or SAF.

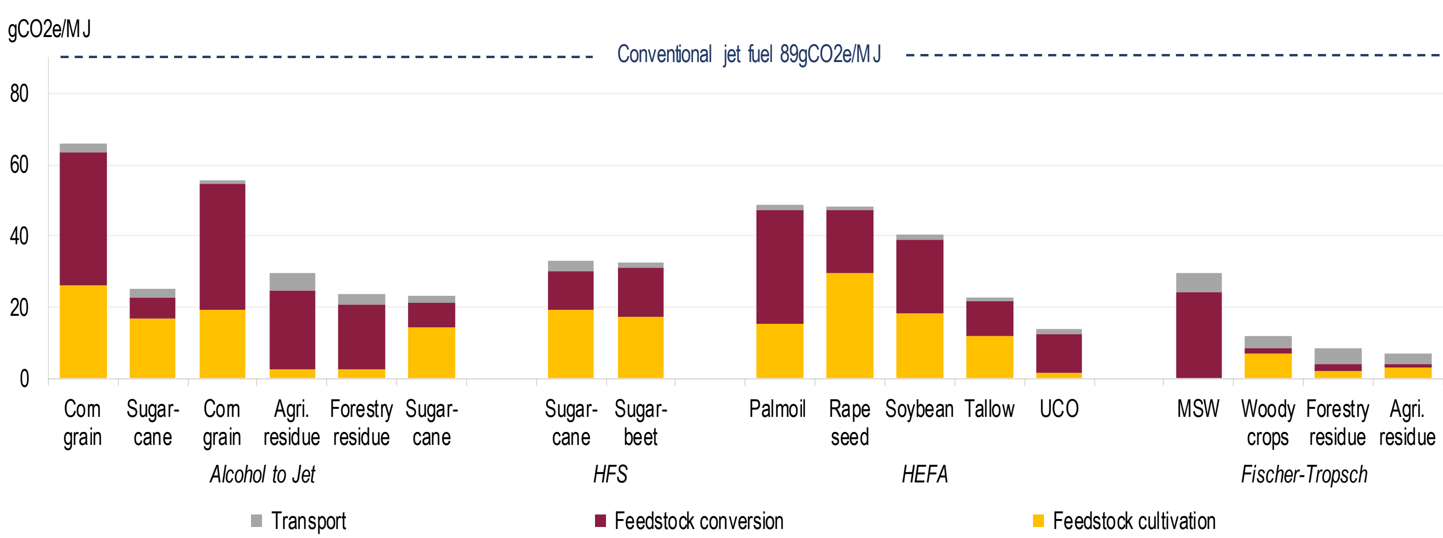
The hydroprocessed fermented sugars (HFS) production method is similar to alcohol-to-jet, but skips the conversion of the sugar to an alcohol. Rather, the sugars can be converted directly to a hydrocarbon and blended with jet fuel. Unfortunately, under this method, the hydroprocessed sugar (called farnesane) can only be blended with jet fuel whereas other methods can result in a slate of refined products (diesel, jet fuel, etc.).

Hydrogen to create 100% clean fuels

Power-to-liquid (PTL, or e-fuels) uses electrolysis to separate hydrogen (H) from water to combine with captured carbon (C) to create natural gas (CH_4). While it is the least technically and commercially ready production method, given the high cost of inputs (renewable electricity, hydrogen and carbon dioxide), it is highly scalable and has the potential to reduce 100% of emissions. Further, costs are expected to come down meaningfully through this decade as capital is directed towards carbon capture, green hydrogen, etc.

The five methods of production will vary on their emission reduction capacity. As shown in Exhibit 9, the lifecycle carbon intensity (CI) across the methods ranges from less than 10g CO_2e per megajoule (forest residue FT) to over 60gCO_2e/MJ (corn-based ethanol), versus traditional jet fuel of about 90gCO_2e. Given the overwhelming majority of SAF is sourced from either tallow, used cooking oil (UCO) or grain (corn, soybean, etc.), the industry average carbon intensity across all SAF is likely around 40 gCO_2e/MJ, about half of traditional jet fuel.

Exhibit 9: Sustainable Aviation Fuel – Carbon Intensities By Major Production Method



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

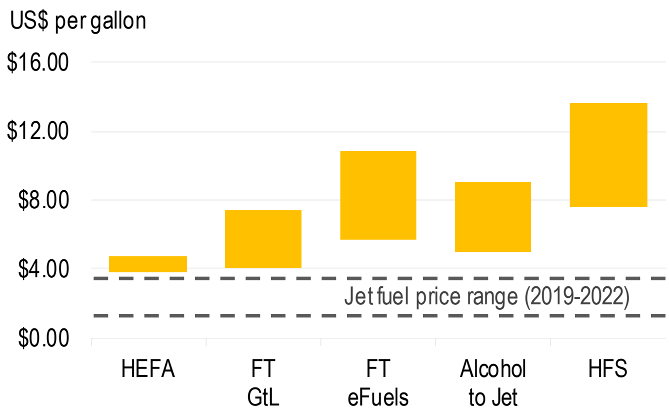
Economics Dependent On Fiscal Support

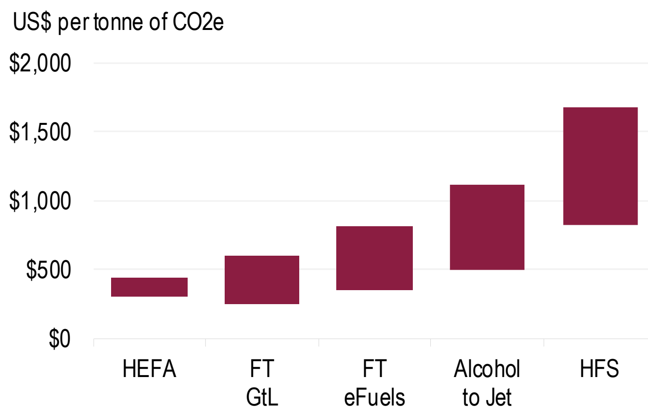
SAF's capacity to meaningfully reduce carbon footprints is its key benefit. The key challenge, however, is reducing supply costs to a level comparable with traditional jet fuel. Generally, a US$65/Bbl WTI price results in jet fuel prices of about US$2 per gallon depending on crack (refining) spreads. Earlier this year, jet fuel costs rose as high as over US$4/gal on the back of US$120/Bbl oil prices, but have since come down to US$2.60/gal (U.S. Gulf Coast).

SAF is very expensive to make, relative to traditional jet fuel

Comparatively, the cost of SAF production ranges between US$4/gal to US$12/gal, as shown in the bar chart on the left of Exhibit 10. Said another way, the cheapest SAF production method competes with traditional jet fuel only at oil prices well north of US$120/Bbl (give or take). Alternative methods of production require equivalent oil prices of US$200-US$300/Bbl.

Exhibit 10: Supply Economics – Cost Per Gallon And Implied Carbon Cost Across Varying SAF Production Methods





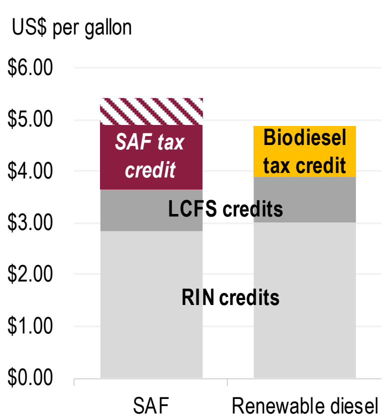
Source: Bloomberg, Bloomberg New Energy Finance and CIBC World Markets Inc.

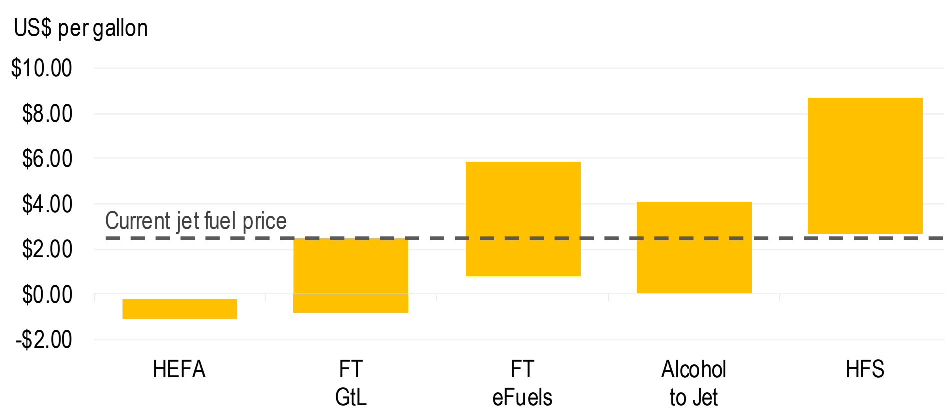
If we consider the implied cost of carbon, SAF requires carbon prices between US$300/tonne and US$1,500/tonne to reach cost parity with traditional jet fuel. At *minimum* this is 3x current E.U. carbon prices and 8x current Canadian carbon prices. The implied carbon prices by technology are shown in the bar chart on the right of Exhibit 10. Of note, alcohol-to-jet needs higher carbon prices (relative to eFuels, yellow bars) given it has a higher carbon intensity.

The U.S. is far ahead of Canada in incentivizing renewable fuel production

From a supply standpoint, fiscal incentives help improve SAF' cost competitiveness. In the U.S., this includes Renewable Identification Number (RIN) credits, Low Carbon Fuel Standard (LCFS) credits (California and Oregon) and a biodiesel/SAF tax credit. These credits when stacked amount to US$5/gallon, as shown in the bar chart on the left in Exhibit 11. The SAF tax credit was part of the Inflation Reduction Act of 2022 and can be as high as US$1.75/gallon for 100% non-emitting SAF, which would take total incentives to US$5.50/gal.

Exhibit 11: Supply Economics – U.S. Fiscal Subsidies For Renewable Fuel Production And SAF Production By Type





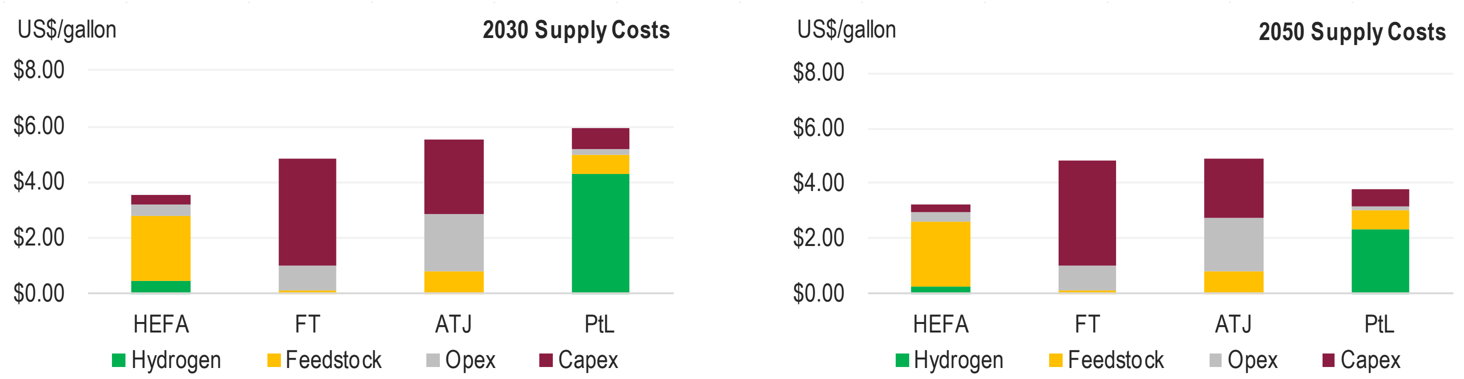
Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

After incorporating these fiscal incentives, both HEFA and Fischer-Tropsch (FT) GTL production becomes cost comparable at current jet fuel prices. For HEFA, the subsidies cover the cost of production entirely. For FT GTL and alcohol-to-jet, the cost falls to less than US$2/gal. Only HFS and eFuels (FT renewable power to liquids) remain largely uncompetitive given current U.S. subsidies in place.

Power-to-liquid expected to see the most dramatic cost reductions by 2050

However, supply costs are expected to come down by mid-century, although varying by technology. HEFA is expected to remain the cheapest form of production through 2050 (Exhibit 12), but relative to other technologies HEFA costs are largely flat over time – and likely to remain so unless feedstock costs drop meaningfully. In addition, limiting the amount of crop for transport use could result in a production cap on HEFA. This would likely increase marginal supply costs to US$5 to US$6 per gallon as shown in Exhibit 12.

Exhibit 12: Supply Costs – Future Cost Of SAF Production By Major Method, 2030 And 2050



Source: World Economic Forum and CIBC World Markets Inc.

U.S. programs such as the Federal RIN and SAF credits or California's LCFS credits ultimately incentivize all renewable fuel production (not just SAF). As such, SAF competes with both traditional jet fuel and renewable diesel. Given the additional processing required to produce jet fuel (or gasoline) relative to diesel, margins on renewable diesel production are about US$1 to US$2 per gallon better than SAF (even after passage of the U.S. IRA). As a result, almost all current production capacity is weighted to biodiesel (over 95%).

easyJet is ditching the use of carbon credits

From a demand perspective, airlines setting minimum SAF thresholds should help provide additional support for SAF uptake. As noted before, the interest in SAF has increased notably over the last two years. In addition, EasyJet's renunciation of using carbon credits as part of its decarbonization strategy could be the start of a trend for airlines distancing themselves from efficacy concerns of carbon credits, and focus rather on physical emission reduction technologies (more fuel-efficient aircraft, use of greener fuels, etc.).

Canada remains significantly behind the U.S. in adoption of SAF from both production and policy standpoints. Admittedly, some of this is simply due to size of the market in Canada relative to the U.S. However, Canada is generally more progressive on environmental policy – most notably through the federal pricing of carbon (currently C$50/ton). Still, we generally lack policies to incentivize renewable fuel production, to date.

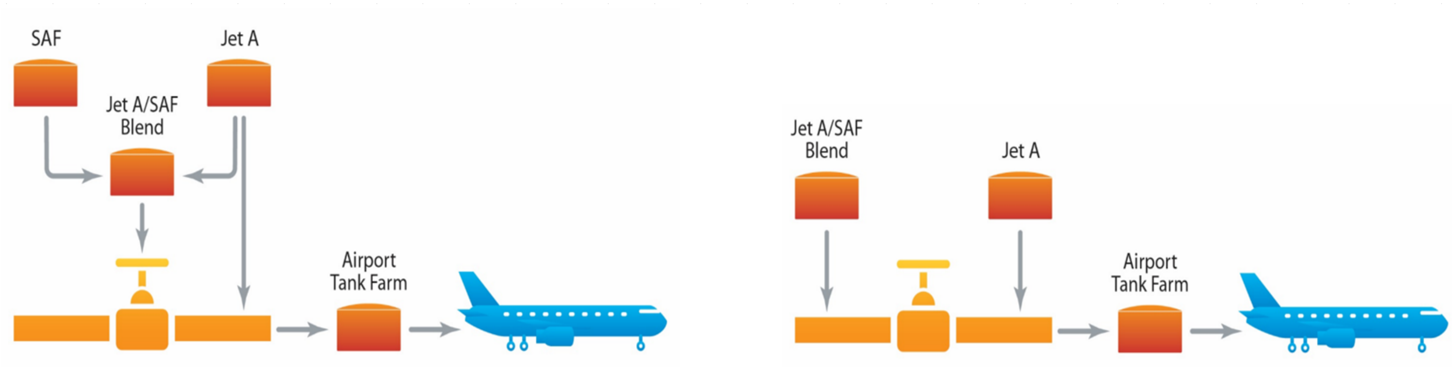
Under the Biden Administration, the U.S. has moved further ahead by creating additional incentives to spur SAF production with the U.S. Inflation Reduction Act. Canada's national Clean Fuel Regulation Standards commence next year, on top of British Columbia's LCFS. Still, we think more can be done to bridge the gaps – especially on SAF.

Of note, leading aviation industry members formed the Canadian Council for Sustainable Aviation Fuels (C-SAF) this year. The organization (which includes Air Canada, Airbus, Shell, GE, etc.), aims to facilitate the production of low carbon SAF in Canada. While no target has been provided we anticipate a target of 500 millions gallons by 2030 (32,600 Bbl/d).

SAF As A Drop-in Fuel Is A Key Advantage

As noted, SAF is a drop-in fuel. The ability to easily blend with existing infrastructure is one of its greatest advantages. SAF is usually either railed or trucked to a designated terminal where it can be stored in a separate tank and then blended with traditional jet fuel (Jet A) to the desired blend ratio. Alternatively, SAF could also be deposited/blended straight with traditional jet fuel. Examples of SAF delivery through existing infrastructure are shown below in Exhibit 13.

Exhibit 13: SAF Delivery – Examples Of Blending And Transportation Options For SAF Deliveries

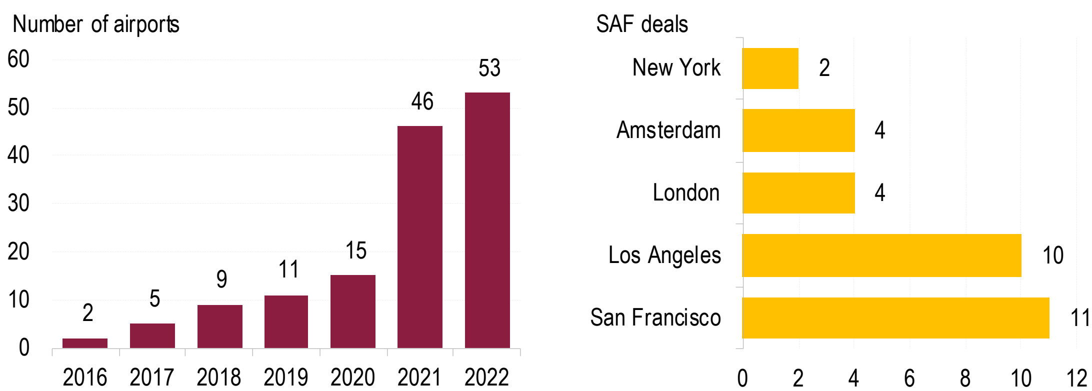


Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

No Canadian airport offers SAF thus far

In the U.S., both Los Angeles' LAX and San Francisco International (SFO) are well established SAF providers, resulting from California's LCFS mandate. Recently, LAX had its first large volume SAF delivery, delivering 500,00 gallons of Neste SAF via barge, compared to the more frequent trucked deliveries. Infrastructure at SFO is a bit more modern/advanced, with SAF delivery available via pipeline. As shown in Exhibit 14, there are over 50 airports worldwide with ongoing SAF delivery. In the U.S., LAX and SFO lead the way. To date, no Canadian airports offer SAF but as noted before, this has not stopped Canadian airliners such as Air Canada or WestJet from offering SAF-driven routes (San Francisco).

Exhibit 14: SAF Infrastructure – Global Airports Providing SAF



Source: International Civil Aviation Organization and CIBC World Markets Inc.

The capacity to act as a drop-in fuel also has advantages at the fleet level. Currently, international standards permit airlines to use a maximum of 50% SAF on commercial flights but engines today can operate on 100% SAF. In late 2021, United flew 115 passengers on board from Chicago O'Hare to Reagan National (D.C.) with one engine 100% fueled by SAF (and the other with traditional jet fuel). Both GE and Rolls-Royce have had success testing 100% SAF on their engines.

Long-term Supply/Demand Outlook

Today, the U.S. produces over 1.7 billion gallons annually (110,000 bbl/d) of renewable fuel across a few select projects. The list of projects is shown in Exhibit 15, with all but one (Fulcrum) using hydroprocessing (HEFA) to create renewable diesel sourced from organic feedstocks such as crops, fats or oils. Again, the large refiners dominate current production.

Renewable fuel production oriented to diesel, as road emissions are easier to abate

Most production is geared towards diesel and only a few projects target SAF. As noted, the preference for diesel is a function of three drivers: 1) greater focus on decarbonizing road transport given the lower cost of abatement, 2) higher historical fiscal incentives for diesel production (pre Inflation Reduction Act), and 3) higher production margins, given the costs of additional processing required for jet fuel/gasoline vs. diesel.

Exhibit 15: Renewable Fuel Production – Announced And Operating U.S. Renewable Production Facilities, Current

Location	Company	Gallons mln/yr	Bbl/d	Operation Year	Diesel	Jet fuel	Feedstock
Geismar, LA	Renewable Energy	90	5,871	2010	Y		Tallow, soybean, corn oil, UCO
Norco, LA (+expansion)	Diamond Green D	720	46,967	2013	Y		Animal fats, UCO and DCO
Paramount, CA	World Energy	46	3,000	2015	Y	Y	Tallow, animal fats
Sinclair, WY	HollyFrontier	153	10,000	2018	Y		Soybean
Cherry Point, WA	BP	42	2,740	2018	Y		Animal fat
Dickinson, ND	Marathon Petroleum	184	12,000	2020	Y		Soybean oil and other organic feedstock
Rodeo, CA	Phillips 66	120	7,828	2021	Y		Soybean oil
El Segundo, CA	Chevron	31	2,000	2021	Y	Y	Vegetable oils
Artesia, NM	HollyFrontier	138	9,000	2022	Y		Flexible, DCO but not animal fats
Cheyenne, WY	HollyFrontier	92	6,000	2022	Y		Soybean
Wynnewood, OK	CVR Energy	100	6,500	2022	Y		Soybean and corn oil
Sierra plant, NV	Fulcrum Bioenergy	11	718	2022	Y	Y	Municipal solid waste

Note: UCO = used cooking oil, DCO = distillers corn oil. Source: Company reports, Bloomberg New Energy Finance and CIBC World Markets Inc.

65,000 Bbl/d of renewable fuel in Canada by 2026

Canada does not have commercial SAF production yet but there is a pipeline of 1 billion gallons/year (65,000 Bbl/d) of renewable diesel and SAF production by 2026. Major projects are shown below in Exhibit 16. Parkland is investing C$600 million at its Burnaby Refinery to expand current co-processing volumes to 5,500 Bbl/d and a standalone renewable diesel facility (6,500 Bbl/d). Tidewater Renewables is also co-processing an additional 600 Bbl/d at its Prince George Refinery, with Imperial Oil's Strathcona Refinery awaiting FID.

Exhibit 16: Canadian Renewable Diesel/SAF Projects – Announced And Operating, Until 2026

Location	Company	Gallons mln/yr	Bbl/d	Operation Year	Diesel	Jet fuel	Feedstock
Ontario	Ensyn	3	196	2006			Wood residue
Cote du Nord	Ensyn	11	685	2018			Wood residue, co-located at sawmill facility
Alderside, AB	Cielo	5	326	2020	Y	Y	Municipal solid waste, compost, plastics, etc.
Burnaby	Parkland	38	2,500	2020	Y	Y	Canola and tallow 5%-20% co-processed
Prince George, BC	Tidewater Renewables	46	3,000	2023	Y		UCO, DCO, tallow, canola, soybean
Come by Chance, NL	Braya Renewable	276	18,000	2023	Y	Y	UCO, DCO, animal fat
Varennes	Enerkem/Suncor	33	2,154	2023*	Y		Non-recyclable waste, wood waste
Saskatchewan	Covenant Energy	100	6,500	2024	Y	Y	Canola
Strathcona, AB	Imperial Oil	307	20,000	2024	Y		Plant-based materials (e.g. canola)
GTA, ON	Refuel Energy	46	3,000	2025	Y	Y	Waste fats, oils and greases (UCO, etc.)
Burnaby (expansion)	Parkland	46	3,000	2026	Y	Y	Canola and tallow 5%-20% co-processed
Burnaby (stand-alone)	Parkland	100	6,500	2026	Y		Canola, tallow

Note: UCO = used cooking oil, DCO = distillers corn oil. *Enerkem's Varennes facility is expected to be commissioned by 2023, and could possibly generate SAF.
Source: Company reports, Bloomberg New Energy Finance and CIBC World Markets Inc.

5% of global jet fuel is SAF by 2030 (BNEF)

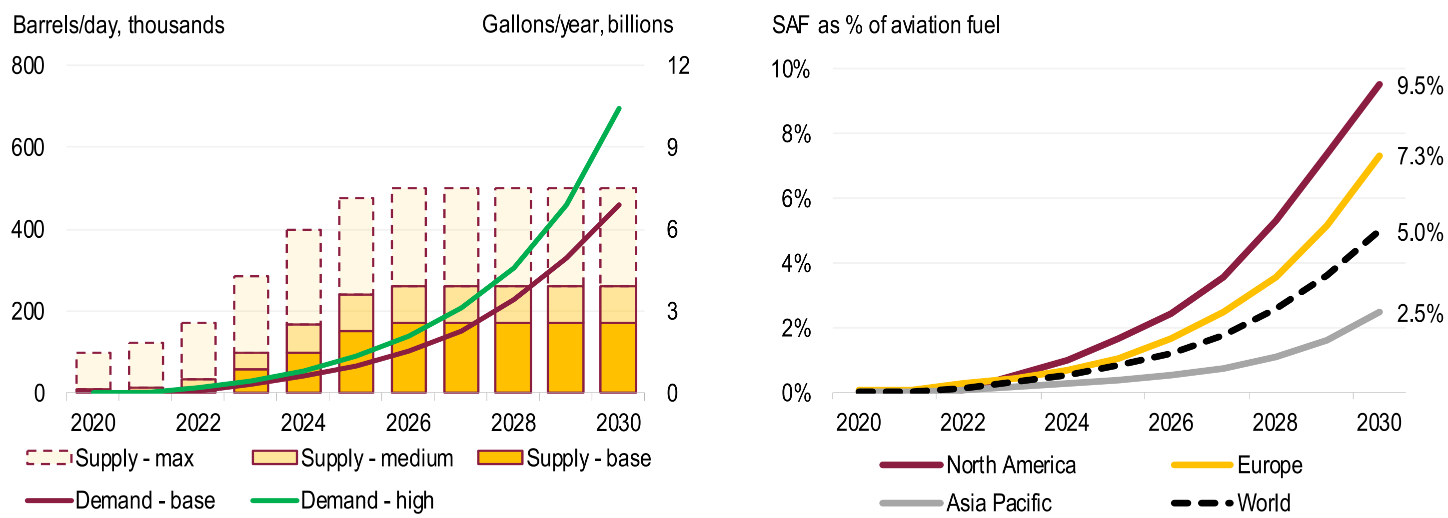
Looking out to the remainder of this decade, we have leveraged Bloomberg New Energy Finance's long-term SAF outlook (Exhibit 17). Under BNEF's base case, SAF production is expected to grow from 100 million gallons per year today (<7,000 Bbl/d) to over 7 billion gallons (450,000 Bbl/d) by 2030 or about 5% of total jet fuel consumption. Of note, Royal Dutch Shell is targeting 10% of its global jet fuel sales to come from renewable fuels by 2030. As a reminder, most all major U.S. and North American airlines have announced SAF targets of at least 10% by 2030, as shown previously in Exhibit 7.

Geographically, North America and Europe have the highest SAF adoption, about 10% and 7% of total aviation demand, respectively, as shown in the charts in Exhibit 17. For North America, this comes out to SAF production of 3.4 billions of gallons per year. This is directionally aligned with a recent SAF roadmap put out by the Biden Administration, targeting 2030 production capacity of 3 billion gallons per year.

Europe and North America dominate SAF production

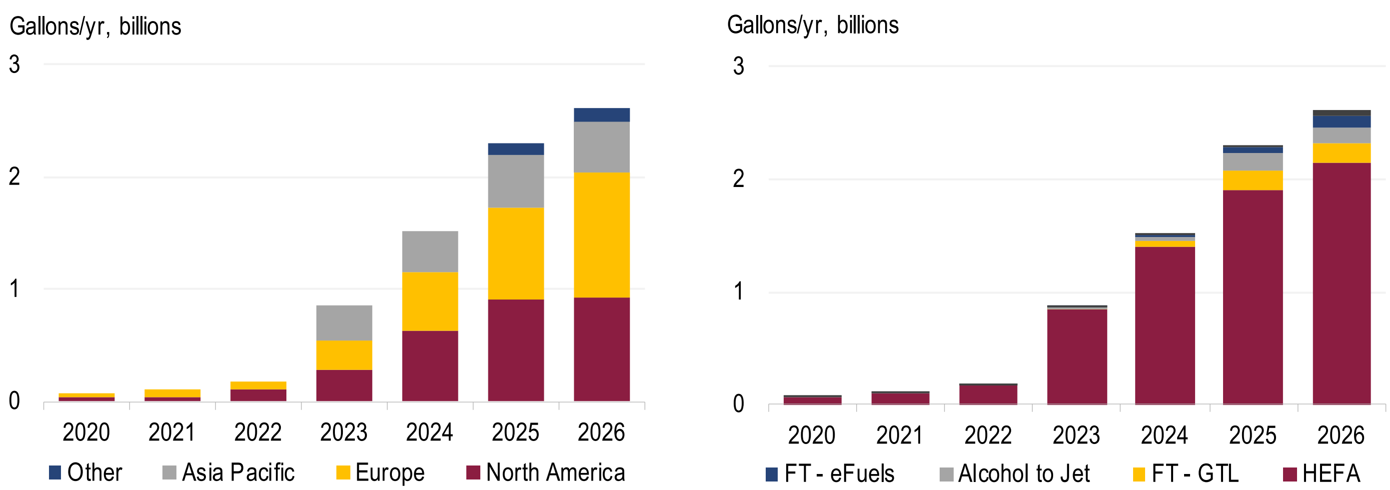
From a supply standpoint, Europe is expected to be the largest provider of SAF globally over the next four years, followed by North America. By technology, HEFA is still expected to be the most widely sourced technology. This is shown in the bar chart to the right of Exhibit 18. Post-2030, supply costs across the other production methods come down to under US$5/gallon, likely the key driver scaling SAF adoption beyond 2030 (Exhibit 12).

Exhibit 17: SAF Supply And Demand – Long-term Outlook Of SAF Use, 2020-2030



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

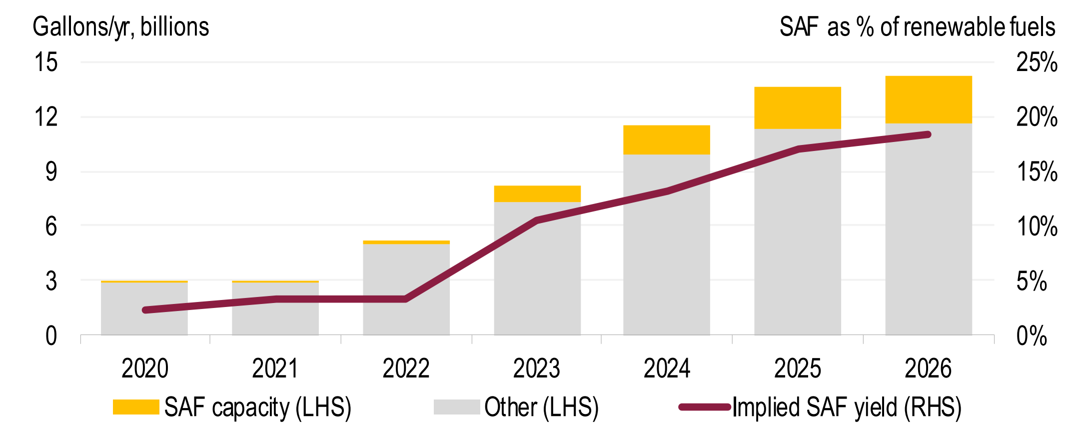
Exhibit 18: SAF Supply And Demand – Medium-term Outlook For SAF Production By Region And Geography



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

As the demand for SAF grows, its share as a proportion of renewable fuels is also expected to grow to almost 20% by 2026. However, the better economics for renewable diesel means SAF still struggles to compete with the likes of biodiesel and other renewable fuels. Exhibit 19 highlights the expected SAF yield as a percent of total renewable fuel production.

Exhibit 19: Supply/Demand – SAF Outlook As % Of Total Renewable Fuel Production



Source: Bloomberg New Energy Finance and CIBC World Markets Inc.

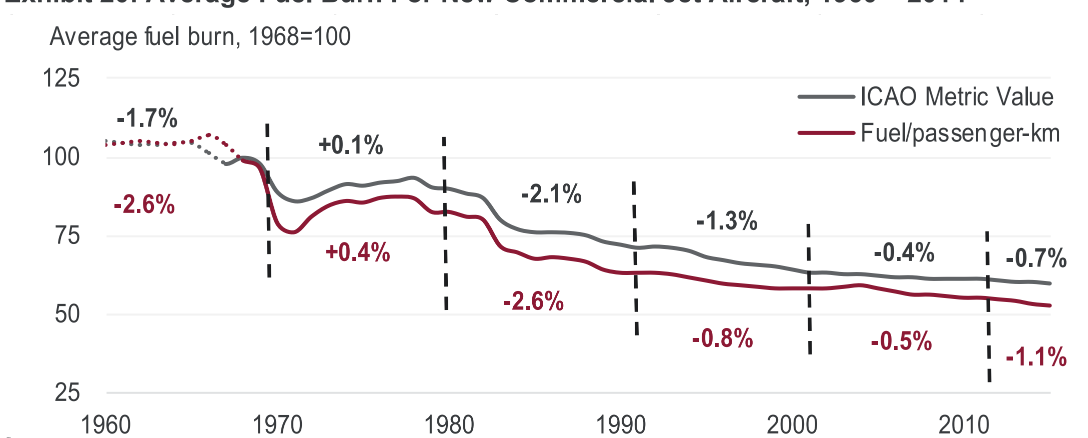
Improvements In Fuel Efficiency, Fleet Modernization

Until now, this report has primarily focused on SAF. In the next two sections, we pivot away from SAF and focus on the two other main decarbonization strategies: 1) increasing fuel efficiency through newer planes, and 2) the use of alternative propulsion technologies.

Aircraft fuel efficiency has consistently improved over the last half century, with average fuel burn of new aircraft falling 45% from 1968 to 2014 (annual reduction of 1.3%). This is shown in the line graph in Exhibit 20. These reductions were achieved through technological advancements in both airframe (improved aerodynamics, use of lighter/composite materials, etc.) and propulsion systems (engine architecture, thermal and propulsive efficiency, etc.).

Each new generation of aircraft improves fuel efficiency by 15-20%

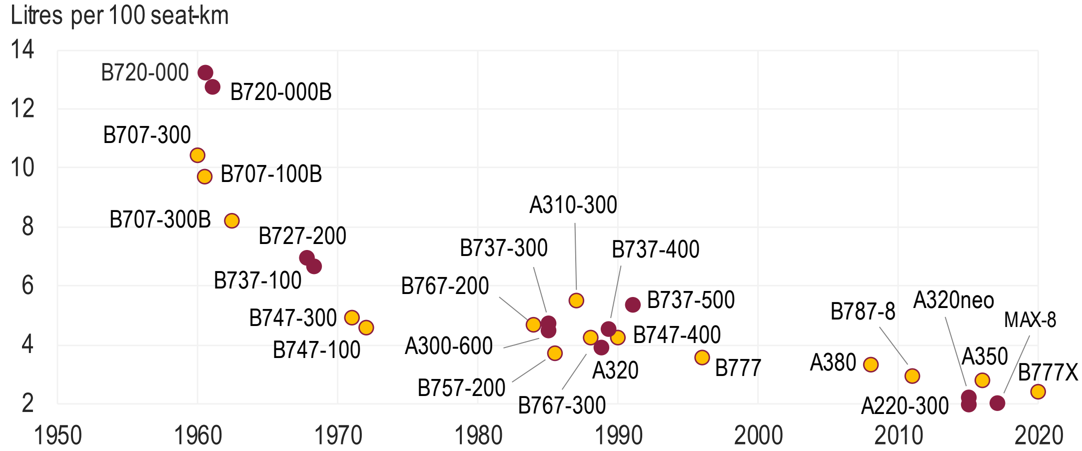
Exhibit 20: Average Fuel Burn For New Commercial Jet Aircraft, 1960 – 2014



Source: International Council on Clean Transportation (ICCT) White Paper: *Fuel Efficiency Trends for New Commercial Jet Aircraft: 1960 to 2014.*

As a general rule of thumb, each new generation of aircraft drops fuel use by 15-20% relative to current models. New designs such as Airbus' A350 and the Boeing's 787 have notable lower fuel burn than predecessors (A330/340 and B767/B777), as shown in the scatter plot in Exhibit 21. For narrow-body jets, engine improvements from GE and Safran on 737 MAX series and the A319/320/321 NEO series yield as much as 20% in fuel savings relative to legacy models. As a result, planes today have fuel efficiencies of 2.0-2.5 L per 100 seat-km.

Exhibit 21: Fuel Consumption Of Commercial Aircraft, 1960s – 2010s



Source: Knoblach and CIBC World Markets Inc.

Planes today consume 2.0-2.25 L per 100 seat-km, half of 1980 levels

While these achievements should be celebrated, we need to see similar (if not greater) improvements if we are to keep on track to net zero. More so, Exhibit 21 demonstrates diminishing marginal improvements in fuel efficiency under the current 'tube and wing' configuration of conventional aircraft – i.e., a tubular fuselage with two adjacent flat wings. According to ATAG in its Waypoint 2050 publication (see link), achieving more than 30-35% reduction in fuel burn by reconfiguring airframes only will be a challenge.

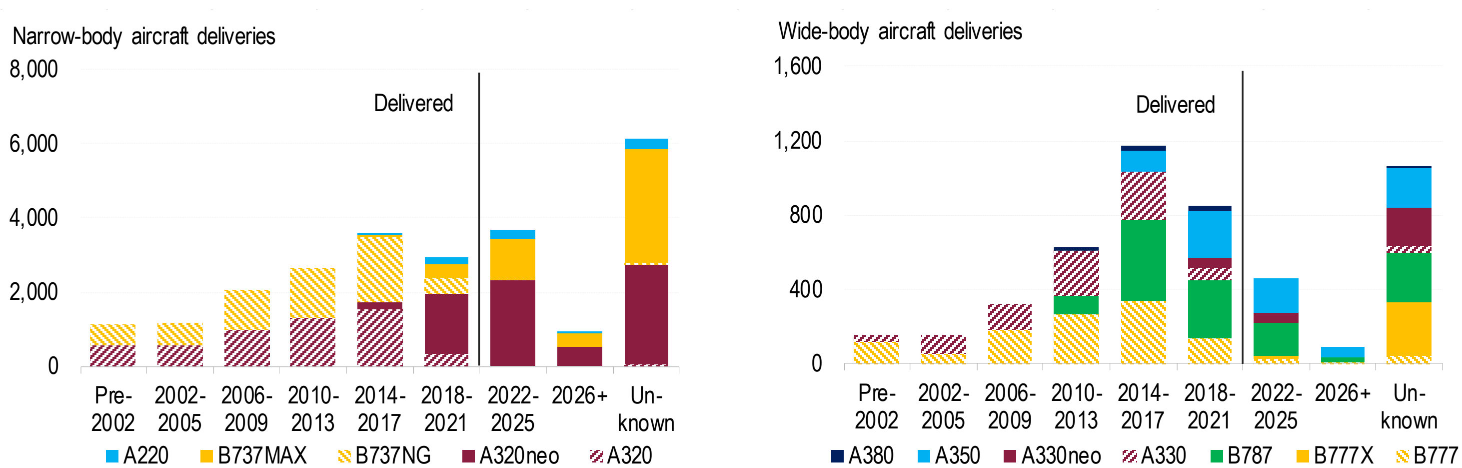
Swapping for newer planes can result in 20-25% in fuel savings

The good news is airlines have a long runway to decarbonize even based on current technologies, as fleets are upgraded and older planes retired. As mentioned, replacing an ageing B777 with a B787/A350, or an A321 with a NEO variant can yield as much as 20% to 25% in fuel savings. Across narrow-body jets, the industry expects over 10,000 deliveries of either Airbus' A320 NEO series or Boeing's 737 MAX variants. This revamp alone could drive a 10% to 15% drop in total industry emissions.

Over 10,000 NEO and MAX-series planes on order

Across wide-body jets, airlines have begun the process of retiring B777 fleets with B787s, A350s and (in the future) the yet to be released B777X. Together these three planes yield fuel improvements of about 10% to 20% on most long-haul routes, relative to the older 777. The list of scheduled deliveries across major narrow-body and wide-body jets can be seen below in Exhibit 22.

Exhibit 22: Aircraft Deliveries – Historical And Scheduled Deliveries Across Narrow-Body And Wide-Body Jets



Source: Bloomberg New Energy Finance, ch-aviation and CIBC World Markets Inc.

Revolutionary Breakthrough Technologies

In this section, we highlight long-term technological breakthrough opportunities that could address the limitations with existing "tube and wing" configurations. We specifically highlight two designs, both of which are more futuristic looking relative to traditional aircraft: the blended-wing-body concept and the truss-braced wing concept.

Photographs of both aircraft are shown in Exhibit 23 and Exhibit 24. These alternative designs ultimately attempt to improve aerodynamics and fuel efficiencies in flight. For more information on this, we provide a list and brief description of 'revolutionary' technologies in aircraft configurations in Appendix 1.

Exhibit 23: Plane Design – Blended-wing-body Concept

Source: Boeing

Exhibit 24: Plane Design – Truss-braced Wing Concept

Source: Boeing

Airplane manufacturers are also exploring alternative propulsion systems to make flight carbon free. To date, this has largely revolved around either electric planes (battery powered) or hydrogen planes (hydrogen fuel cells or combusted hydrogen). For a more complete list of alterative propulsion systems, please refer to Appendix 2.

Electric planes

Batteries will take up space and weight

Electric propulsion is limited by the lower energy density of battery storage. The energy density of leading lithium ion battery technology is 250 watt-hours per kilogram, compared to traditional jet fuel at 12,000 Wh/kg or 48x the density. Increasing battery power implies more batteries, which generally are quite heavy. Similar to EVs, the added battery weight reduces 1) the physical space on board to house passengers, and 2) the range of travel.

Dissimilar to traditional aircraft, however, electric planes do not benefit from in-flight weight improvements. Meaning, as fuel is burned through flight planes become naturally lighter and improve range. This is not the case with batteries.

Air Canada has ordered 30 ES-30 electric aircraft (range 200-800 km)

Until improvements are made in improving effective battery storage or reducing battery weight, electric propulsion aircraft likely is limited to personal transportation (air taxis, air ambulances, private jets, etc.). There are opportunities for electric flight to serve small commuter aircraft traveling under 500km. As an example, Air Canada recently ordered 30 ES-30 electric aircraft from Heart Aerospace (see **link**). The plane can carry 30 passengers and has a range of 200 km under an all-electric power system, but can be increased to 800 km under hybrid mode. First deliveries (to industry) are expected in 2028.

Airports would in turn need to be fitted with appropriate charging technologies. For larger planes, battery swapping stations could be set up to shorten turnaround times, but would require additional spare battery packs at likely added costs.

Hydrogen planes

Hydrogen has the highest energy per mass of any fuel. The gas weighs almost nothing, and one kilogram of hydrogen contains a vast amount of energy – the equivalent of one gallon of gasoline, or 2.8 kilograms. This makes it an efficient and lightweight energy carrier. However, hydrogen's low ambient temperature density results in a low energy per unit volume.

Using hydrogen to fuel plans can be accomplished through 1) the use of hydrogen fuel cells or 2) the combustion of hydrogen in-flight. Similar to electric batteries, hydrogen fuel cells are an option for short-haul flights (less than 1,900km) and have a longer range than electric batteries.

For longer-flights, engines powered by hydrogen combustion are an alternative, and could have a range up to 10,000 kilometers. However, storage of liquid hydrogen requires very low temperatures (around -253°C) in special tanks that ultimately would be four times the size of the equivalent jet fuel tank. This would call for a complete redevelopment of aircraft systems. Given the above, hydrogen-powered aircrafts likely remain an option for short-haul flights.

There are also complications in transporting hydrogen and storage on-site at airports. Facilities to liquefy hydrogen and distribute to terminals either by truck (for small airports) or by pipeline (for major airports) require significant investment.

Airbus targeting launching commercial hydrogen planes by 2035

However, this is not stopping manufacturers from trying. Airbus is testing three hydrogen prototype aircraft, including a two-turbofan model with a capacity of 120-200 passengers and a range of over 2,000 nautical miles, a potential successor to the A320. There is also a two-turboprop model, with a capacity of less than 100 passengers and a 1,000 km range.

The table in Exhibit 25 below summarizes the key statistics across electric, hydrogen and SAF relative to conventional jet fuel on climate impact, aircraft design, aircraft operations and airport infrastructure. Overall, SAF offers major advantages compared to electric and hydrogen propulsion systems. This is especially the case for long-haul flights, where in many cases a viable electric or hydrogen alternative is still decades away. However, there will be a market to focus on extremely short-haul travel, especially given the higher fuel use during take-off and descent relative to cruise altitudes, as highlighted earlier in Exhibit 6.

Exhibit 25: Comparison Of New Fuels And Propulsion Technologies

Comparison to jet fuel	Battery-electric	Hydrogen fuel cell	Hydrogen turbine	SAF
Description	Energy stored in batteries as power source	Hydrogen in fuel cells to combine with oxygen to produce electrical power	Hydrogen for combustion in conventional engines	Drop-in fuel produced sustainably
Climate impact	~100% reduction	75-90% reduction	50-75% reduction	30-60% reduction
Aircraft range	500-1,000km under today's battery technology	Feasible only for commuter to short-haul segments (<1,900km)	Up to 10,000km	Only minor changes
Aircraft operations	Same or shorter turnaround times	1-2x longer refueling times for up to short-haul	2-3x longer refueling times for medium and long-haul	Same turnaround times
Airport infrastructure	Fast-charging or battery exchange system required	Liquid hydrogen distribution and storage required	Liquid hydrogen distribution and storage required	Existing infrastructure can be used
Limitations	Low energy density (heavy for equivalent amount of energy) and battery does not get lighter as energy is consumed	Fuel tank 4x the size of equivalent jet fuel tank due to greater volume-to-energy ratio and need for special tank for ultra-low temperature (-253°C) storage	Fuel tank 4x the size of equivalent jet fuel tank due to greater volume-to-energy ratio and need for special tank for ultra-low temperature (-253°C) storage	Insufficient supply due to early stage of commercial production of SAF

Note: Green shading = major advantages, yellow shading = major challenges. Source: World Economic Forum and CIBC World Markets Inc.

Implications For The Canadian Aviation/Aerospace Sector

We cover six Canadian aviation/aerospace companies – AC, BBD, CAE, CHR, CJT and TRZ – and they are all committed to achieving net-zero GHG emissions by 2050 (CAE became carbon neutral in 2020). It is clear that all these companies are incorporating sustainability in their operating decisions. Some examples include:

Fleet modernization – both AC and TRZ are in the process of introducing new and more fuel-efficient aircraft into their fleets, such as the A321XLR, and taking advantage of the pandemic downturn to retire/return older planes. The fuel efficiency improvement from introducing a more modern aircraft can be in the double-digit percentage range.

Operational efficiency – Ways to reduce GHG emissions through operational means include reducing empty-weight of the aircraft, flying at optimal altitudes and speeds, and using only one engine to taxi, among others.

Electrifying ground service – Electrifying ground service vehicles is another strategy some airlines have taken up to reduce their carbon footprints. For example, 60% of CHR's ground service vehicles run on batteries.

That said, there is also a recognition that new breakthrough technologies that could help to achieve net-zero targets (i.e. change in aircraft configuration, use of electric/hydrogen energy) could take decades before they are commercially viable. As such, the Canadian aviation/aerospace names we cover are turning to SAF to meet their GHG emissions targets.

- AC is a founding member of Canadian Council for Sustainable Aviation Fuels (C-SAF) and pledged to invest $50MM in SAF and other low carbon aviation fuel (LCAF) development by 2030.
- BBD recently signed a multi-year agreement to purchase SAF to cover all of its flight operations (production testing, certification flights, customer demonstration flights and after-service check flights) starting in January 2023.
- TRZ is a partner of SAF+Consortium and will be testing SAF on its fleet.
- CJT is considering adopting SAF but recognizes the limited supply of the greener fuel.
- CHR is in the business of aircraft leasing and indirectly supports the use of SAF when its lessees use SAF.
- CAE does not mention SAF but it is considering retrofitting its training aircraft with electric propulsion systems given they typically fly short, predictable missions.

Exhibit 26: Industrials – Initiatives To Reduce GHG Emissions, 2022 (Detailed)

Coverage	Initiatives To Reduce GHG Emissions
AC	**Net-Zero By 2050** - Long-term target of net-zero GHG emissions by 2050 - Set 2030 absolute mid-term GHG net reduction targets: ▪ 20% GHG net reductions from air operations by 2030 compared to AC's 2019 baseline ▪ 30% GHG net reductions from ground operations by 2030 compared to AC's 2019 baseline ▪ $50MM investment in SAF as well as carbon reductions and removals **Operational Efficiencies & Fleet Modernization** - AC permanently retired older and less fuel-efficient aircraft from its fleet and is replacing them with more fuel-efficient aircraft with a projected fuel efficiency gain of up to 17% for typical transcontinental flights and up to 23% on transatlantic flights - Electrify fleet of ground support vehicles; as of 2021, 43% of fleet is powered by less carbon intensive means like electricity **SAF Adoption** - $50MM investment in SAF and other low carbon aviation fuel (LCAF) development by 2030 **New Technologies** - AC will evaluate the viability, safety and performance of new electric, hydrogen or hybrid operational technologies - AC signed a purchase agreement for 30 hybrid aircraft (ES-30) that run on electricity and SAF from Sweden-based Heart Aerospace **Other** - Carbon reductions and removals ▪ AC offers voluntary programs that allow travelers and corporate customers to offset GHG emissions associated with their flights
BBD	**Net-Zero By 2050** - Achieve net-zero GHG emissions by 2050 - Announced an objective of 25% reduction in GHG emissions by 2025 relative to 2019 (In 2021, achieved 9% reduction compared to 2019 level by replacing existing equipment, retrofitting buildings and improving efficiency) **SAF Adoption** - To use SAF in all of BBD's flight operations from January 2023 ▪ Production testing flights / Certification flights / Customer demonstration and delivery flights / After-service flights
CAE	**Net-Zero** - Reached carbon neutrality in 2020 by buying Renewable Energy Certificates (RECs) in the countries where it operates and funding GHG reduction projects such as wind energy and forest preservation **New Technologies** - CAE is considering retrofitting its fleet of 200+ trainer aircraft with electric propulsion systems given they typically fly short, predictable missions
CHR	**Net-Zero By 2050** - Strive to achieve net-zero GHG emissions by 2050 ▪ Currently focused on quantifying emissions within the Chorus Group **Operational Efficiencies & Fleet Modernization** - Focus on driving efficiency for flight operations by optimizing speed and distance flown, reducing thrust on takeoff, using the thrust of only one engine to taxi, etc. - Reduce Ground Service Equipment (GSE) emissions by electrifying (currently 60% of Jazz's GSE has been converted to electric power) - Potential order of up to 200 electric vertical take-off and landing (eVTOL) aircraft and development of a global network of eVTOL operators
TRZ	**Net-Zero By 2050** - Committed to net-zero GHG emissions by 2050 **Operational Efficiencies & Fleet Modernization** - Fuel efficiency initiatives such as single-engine taxi and empty aircraft weight reduction - Make buildings more energy efficient - Fleet renewal where older A310 fleet was replaced with newer generation A321neoLR which emits 15% less **SAF Adoption** - TRZ is a partner of SAF+Consortium that seeks to transform carbon dioxide emitted by industries into an alternative fuel that has the same chemical properties as kerosene, while reducing carbon footprint by 80% over its life cycle ▪ TRZ will be responsible for testing SAF on its fleet of aircraft **Other** - Evaluating the use of carbon offsets for both regulatory compliance (e.g., CORSIA) and for voluntary reductions by allowing customers to purchase carbon offsets or SAF

Source: Company reports and CIBC World Markets Inc.

AC Stands Out Amongst Its Airlines Peers

Among the airlines we cover, we believe AC leads the pack when looking at the various initiatives it is undertaking towards its goal to become carbon-neutral. Exhibit 27 compares the aviation/aerospace companies we have under coverage across a number of sustainability initiatives.

Exhibit 27: Industrials – Initiatives To Reduce GHG Emissions, 2022

Initiatives	AC	TRZ	CHR	CJT	BBD	CAE
Net-Zero By 2050	✓	✓	✓	✓	✓	✓
Operational Efficiencies	✓	✓	✓	✓	N/A	N/A
Fleet Modernization	✓	✓	✓	✓	N/A	N/A
GHG Emissions Disclosure	✓	✓	✗	✗	✓	✓
SAF Adoption	✓	✓	N/A	✗	✓	✗
New Technologies	✓	✗	✗	✗	✓	✓

Note: Please refer to Appendix 4 for details

Source: Company reports and CIBC World Markets Inc.

We would make the case that AC stands out amongst global airline peers as well when considering the following:

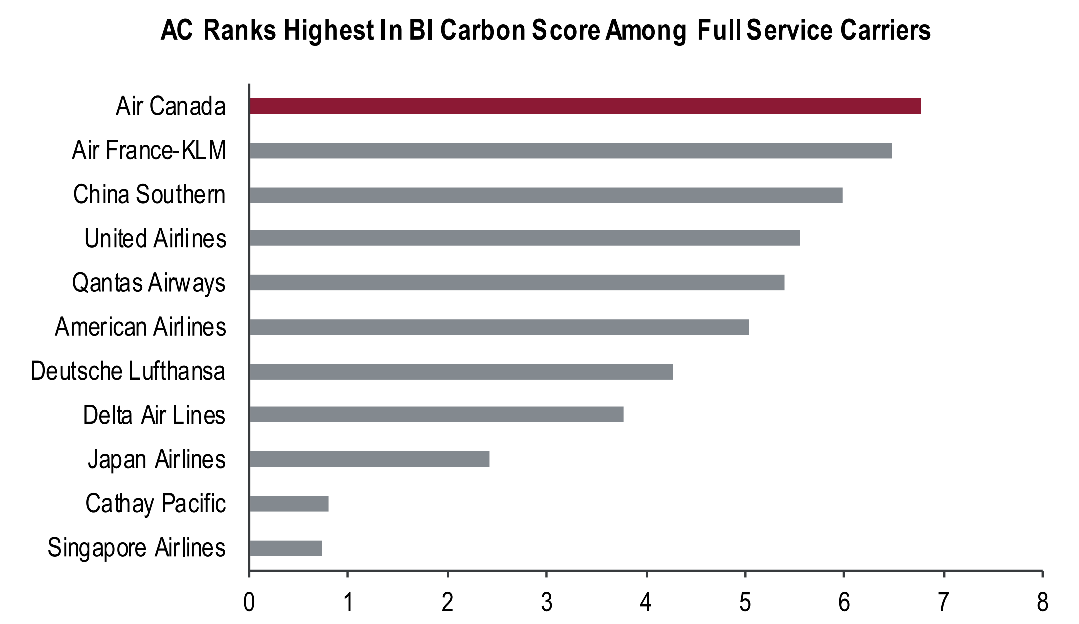
- AC became a founding member and the first Canadian carrier to join the Aviation Climate Taskforce (ACT) that was formed to tackle the challenge of rising carbon emissions from commercial aviation. AC is also a signatory of the Clean Skies for Tomorrow Coalition whose mission is to accelerate the deployment and use of SAF technologies to reach 10% of global jet aviation fuel supply by 2030.
- AC is investing in new aircraft technologies and removing CO_2 directly from the air. In September 2022, AC announced a $5MM investment in Heart Aerospace and a purchase order for 30 battery-powered ES-30 aircraft from the Swedish start-up. The 30-seater ES-30 is powered by four electric motors using lithium-ion batteries as a primary source of power and two SAF-powered turbo generators as reserves. In November 2022, AC announced a $6.75MM investment in Carbon Engineering, a Canadian climate solutions company that seeks to advance its Direct Air Capture (DAC) technology that pulls CO_2 directly out of the air at large, industrial scale.
- AC leads other full-service carriers on emissions per kilometer flown based on pre-pandemic, 2019 data. As Exhibit 28 shows, AC's direct (scope 1) CO_2 emissions per passenger km came in at 87, lowest among major full-service carriers in the world. Bloomberg Intelligence's carbon transition score tells a similar story, with AC ranking the highest among global full-service carriers (Exhibit 29). The current score is based on carbon reduction trend (40% weight) and current carbon intensity (60% weight).

Exhibit 28: Airlines – Direct (Scope 1) CO_2 Emissions Per Passenger KM

	2017	2018	2019	2020	2021
Air Canada	89	86	87	134	144
United Airlines	93	90	90	131	167
Qantas Airways	101	98	97	101	174
Southwest	98	96	98	145	99
Delta Airlines	103	103	98	146	114
American Airlines	97	97	106	134	111
Deutsche Lufthansa	115	118	116	170	154
The Emirates Group	126	122	123	120	397
Japan Airlines	139	132	125	385	335
Cathay Pacific Air	140	138	134	349	1,359
Singapore Airlines	148	161	157	1,483	407

Source: Company reports and CIBC World Markets Inc.

Exhibit 29: Airlines – Bloomberg Intelligence Carbon Transition Scores, Q3/22



Source: Bloomberg and CIBC World Markets Inc.

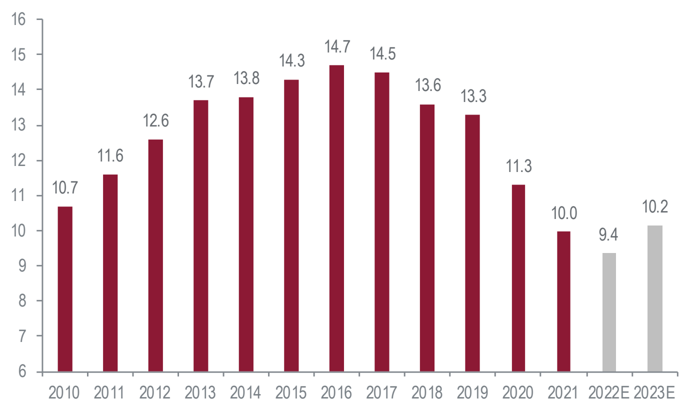
- AC's fleet investments will drive continued fuel efficiency improvement. AC permanently retired older aircraft consisting of certain B767 and A320s and E190s from its air passenger fleet, replacing them with B737MAX and A220 aircraft. These newer models are expected to generate ~20% less CO_2 and ~50% less nitrogen oxides than the aircraft they are replacing. In addition, in 2024, AC will be adding A321XLRs to its fleet. Introduction of new, more fuel-efficient aircraft to its fleet has resulted in a marked improvement in AC's fuel efficiency pre-pandemic. AC's fuel consumption (in liters) per 100 revenue passenger miles (RPM) declined from 7.31L in 2010 to 6.07L in 2019, representing a 17% decline over this period.

Exhibit 30: AC – Fleet, 2010 – 2023E

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022E	2023E
Wide-body														
787	0	0	0	0	6	12	21	30	35	37	37	37	37	39
777	18	18	18	22	23	23	25	25	25	25	25	24	24	24
767	30	30	30	27	21	17	14	10	6	5	0	1	6	7
A330	8	8	8	8	8	8	8	8	8	13	16	16	17	18
Narrow-body														
737 MAX	0	0	0	0	0	0	0	2	18	24	24	31	40	40
A320 Family	89	89	89	81	69	74	75	75	73	69	52	39	34	34
A220	0	0	0	0	0	0	0	0	0	1	15	27	33	33
E-Jet Family	60	60	60	45	45	37	25	25	19	14	0	0	0	0
Rouge														
767	0	0	0	2	8	15	20	24	25	25	0	0	0	0
A320 Family	0	0	0	8	20	24	25	25	28	39	39	39	39	39

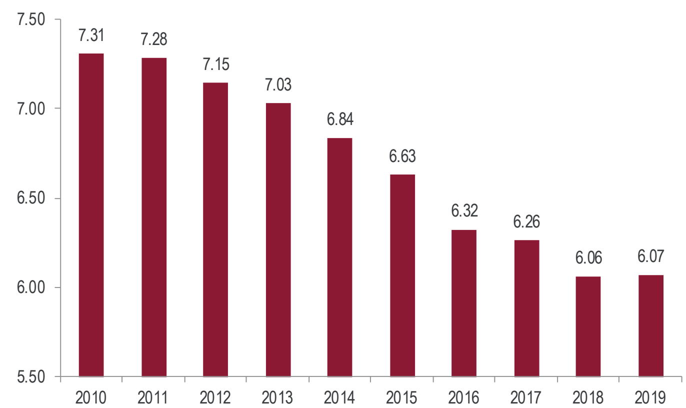
Source: Company reports and CIBC World Markets Inc.

Exhibit 31: AC – Average Fleet Age, 2010-2023E



Note: 2020-23E are CIBC est. Source: Company reports and CIBC World Markets Inc.

Exhibit 32: AC – Fuel Consumption (L/100 RPM), 2010-19



Source: Company reports and CIBC World Markets Inc.

Appendix 1: Revolutionary Technologies In Configurations

Exhibit 33: Revolutionary Technologies In Aircraft Configurations

Technology	Description and benefits	Readiness level, potential for entry into use
Canard	The canard configuration describes a mostly small foreplane that is placed in front of the main wing of a fixed-wing aircraft. The lifting surface of a canard is mostly used to replace the horizontal tail plane, which is the only drag-producing downward lift surface. Canard foreplanes can also be used for three-surface configurations (foreplane, central wing, horizontal tail plane). With modern flight controls even a no-vertical-tail design could be realised.	Aircraft with canard configurations are mainly found in the military area. A civil canard aircraft could be available around 2035-40, similar to other radically new configurations.
Blended wing body Hybrid wing body	A blended-or hybrid-wing body (BWB/HWB) configuration is a fixed-wing aircraft without clear differentiation between wings and fuselage. Wide airfoil-shaped bodies and efficient high-lift wings enable significant improvements of the lift-to-drag ratio compared with conventional aircraft. As the entire plane is designed to generate lift, high fuel savings are expected.	Flying BWBs exist for military purposes. Numerous research institutes are working on civil BWB designs, for a long time focusing on designs for over 400 passengers, but recently smaller designs of 100-150 seats could also be optimised, with a potential entry into service around 2035, whereas a large BWB could be expected around 2040. A KLM / TU Delft project looks at a flying V configuration and is undergoing scale model flight demonstrations.
Strut-braced wing Truss-braced wing	The strut-braced wing is a concept utilising a structural wing support to allow for larger wing spans without increases in structural weight. By increasing the span the induced drag is reduced and therefore the engine performance requirements can be reduced as well. The high wings allow for larger engine sizes, e.g. open rotors. The increased wingspan may also require a redefinition of current airport compatibility categories or the design of foldable wings.	A strut-braced design with conventional turbofan engines is not an extremely radical design change and could be realised for entry into service in 2030-35. Combination with open rotors could be envisaged for an entry into service (EIS) around 2040.
Box-wing	The box wing configuration, which was proposed first by Ludwig Prandtl in 1924, connects the tips of two offset horizontal wings. For a given lift and wingspan this configuration assures minimum induced drag and offers savings in fuel consumption compared to conventional aircraft.	This configuration has recently been revived in R&T projects and could also be available around 2035-40, similar to other radically new configurations.
Variable camber with new control surfaces	The camber (curvature) of the wing can be changed during flight to optimise lift .	Currently around TRL6, this technology would need to be applied to a new aircraft design.
Laminar flow control technology (natural and hybrid)	Maintaining the air flow over the aircraft surface turbulence-free, through suitable shaping of aircraft surface (natural) or boundary-layer suction (hybrid).	Currently sitting around TRL7, new development progress since 2017, application for new aircraft design.

Source: Air Transportation Action Group and CIBC World Markets Inc.

Appendix 2: Revolutionary Technologies In Propulsion

Exhibit 34: Revolutionary Technologies In Propulsion System

Technology	Description and benefits	Readiness level, potential for entry into use
Open rotor	Also known as unducted fan (UDF), or propfan. The fan nacelle is removed increasing the by-pass ratio beyond what is possible with turbofans. These engines offer great fuel savings compared to current turbofans, but also come with several limitations. The lack of a casing leads to higher noise emissions of the fans and necessitates airframe strengthening for safety purposes in the event of an uncontained engine failure.	While the open rotor concept itself is several decades old, its development was slowed by challenges to reduce noise (which have since been resolved), but also a reduction in the price of oil. Entry into service could take place around 2030.
Electric propulsion	Instead of combustion engines, electric motors drive conventional propellers or sets of multiple small fans. Electric energy is stored in batteries (which, however, have a penalising weight); alternatively, fuel cells are envisaged. CO_2 emissions during operations are zero for full electric aircraft. Lifecycle emissions strongly depend on the primary energy mix for electricity generation. If fully renewable sources are used, they could be close to zero as well. An additional benefit would be the eradication of non-CO_2 effects (such as contrails and NOx emissions). Electric motors are quieter than combustion engines, which could reduce nuisance to airport neighbours and allow increased operations from smaller city airports.	Small full electric aircraft up to 9 seats are already flying (at least for test flights). Electric aircraft up to 19 seats are planned for the later 2020s, and regional aircraft in the 2030s. Norway has the goal of operating all domestic and short-haul flights electrically by 2040.
Hybrid-electric propulsion	Hybrid-electric concepts combine the advantages of both combustion and electric engines. While the combustion and electric propulsion systems can be used in combination during take-off to provide maximum thrust, the combustion engine can be throttled back when the aircraft is in cruise flight or descending. Combustion engines could also be smaller and reduce on-board weight. Hybridisation is a necessary intermediate step for larger airplanes towards a pure electric propulsion system. Probably, the degrees of hybridisation vary with aircraft size, allowing smaller seat categories to be equipped with a higher degree of hybridisation than larger seat categories. Hybrid-electric aircraft on a new airframe body such as the Blended Wing Body can contribute to achieving CO_2 emissions reductions of up to 40%.	Small aircraft (15 — 20 seats) with hybrid-electric propulsion are expected during this decade, regional aircraft in the 2030s and possibly larger ones from 2040.
Hydrogen	Hydrogen is a carbon-free fuel that can be used as a propulsion fuel in two ways: 1) for combustion in conventional engines, replacing jet fuel (including in large aircraft), 2) in fuel cells as an electrical power source. The weight of hydrogen is three times lower than that of an amount of jet fuel with the same energy content, but its volume even in liquid (cryogenic) form is four times larger. Much larger tanks as well as fundamental changes in the aircraft fuel system are therefore needed.	Among the biggest challenges for hydrogen use in aviation are its worldwide availability at large scale, the need to produce 'green' hydrogen, and the existence of appropriate supply infrastructure. With the global move towards renewable energy, the plans for worldwide use of hydrogen as an energy carrier have become much more concrete, and the interest in hydrogen aircraft has risen steeply since 2019. The willingness for strong public funding increased again during the debate about aviation support in the Covid-19 crisis. Technology programmes now envisage EIS around 2035.

Source: Air Transportation Action Group and CIBC World Markets Inc.

Appendix 3: Evolutionary Technologies

Exhibit 35: Evolutionary Technologies

Technology	Description and benefits	Readiness level, potential for entry into use
Geared turbofan engines	Contains a gearbox between the fan and the compressor which each rotate at the most efficient speed, improving the propulsive efficiency of the engine.	In operation (as an option on the A320neo, A220, Embraer E-Jet).
High pressure-ratio core engines	Engines that operate at higher pressure, reducing engine weight and improving thermal efficiency.	Will enter service with the GE9X engine on the Boeing 777X aircraft in 2022. Technology also now available for other engine designs.
Very high bypass ratio engines	A larger fan allows the engine to exhaust more air at a lower speed (increasing bypass ratio), improving the propulsive efficiency.	In operation (e.g. the GEnx, Trent1000, LEAP and PW1000 engines). This level of bypass ratio, or slightly higher, has become the standard for large commercial aircraft. Additional increases in bypass ratio are possible with new aircraft designs configured to accommodate larger engines - understanding there is a trade between engine efficiency (larger is good) vs. engine weight and drag (smaller is good) that limits the optimum ratio.
Composite structures for wing and fuselage	Large metal aircraft structures replaced by lightweight composite materials.	In operation on many aircraft, but with extensive use on new models such as the Boeing 787, Airbus A350. Application could be extended to even more parts of the aircraft.
Wingtip devices	Small structures mounted on the wingtips to improve aerodynamics.	In operation on most aircraft today, but improved models are continually being developed to improve efficiency further. Some older aircraft without such devices can have them retro-fitted.
Riblets	Small grooves on the aircraft surface which reduce the drag caused by flying through the air (inspired by shark skin).	Have been tested to be efficient, but some endurance issues remain before being able to enter into operation, could be available soon also for retrofit at TRLB.
Active load alleviation	Gust and manoeuvre load forces are reduced by suitable flap deflection; this allows less massive wing structure.	Technology available, mass benefits can be used for a new aircraft design.
Structural health monitoring	Sensors detecting damages in the aircraft structure, this allows less massive structures.	Technology available, mass benefits can be used for a new aircraft design.
Fuel cells for onboard power	More efficient onboard electrical power generation by fuel cells instead of engine-driven generators.	The technology has been under active development for some years, with renewed interest. Main challenge is that fuel cells can add weight and also require hydrogen.
Advanced fly-by-wire systems	Digital flight control systems enabling advanced flight control and navigation.	Continuous improvement.

Source: Air Transportation Action Group and CIBC World Markets Inc.

Appendix 4: ESG Snapshots

Exhibit 36: AC – Select Environmental And Social Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	YES	YES	YES	YES	YES
Net-zero Targets (Y/N)	YES/NO	NO	NO	NO	YES	YES
Gross direct (Scope 1) GHG emissions:						
Electricity, heating, cooling and steam generation	tCO_2e	32,231	33,885	34,534	27,698	24,752
Transportation of materials, products, waste, employees and passengers	tCO_2e	12,172,889	12,836,386	13,170,133	5,005,854	4,887,972
Fugitive emissions	tCO_2e	242	651	520	562	534
Biogenic CO_2 emissions (SAF)	tCO_2e	58	195	0	0	0
Scope 1 Emissions	tCO_2e	12,205,362	12,870,922	13,205,187	5,034,113	4,913,258
Scope 2 Emissions (Electricity)	tCO_2e	19,748	14,303	10,647	10,139	7,144
Scope 3 Emissions	tCO_2e	1,588,734	1,650,321	1,611,501	574,983	572,090
GHG emissions intensity	kg of CO_2e / 100 RTK	80.65	78.00	79.62	107.15	95.08
Reductions in GHG emissions:	tCO_2e	54,383	14,119	23,339	10,698	5,991
Other Emissions						
Total fuel consumption from non-renewable sources	GJ	176,992,971	186,639,418	191,480,096	73,086,147	71,301,774
Total fuel consumption from renewable sources (aircraft biofuel)	GJ	847	2,850	0	0	0
Total electricity consumption	GJ	609,432	559,432	561,227	532,580	453,896
Total energy consumption within the organization	GJ	177,603,250	187,201,700	192,041,324	73,618,726	71,755,671
Absolute energy consumption (numerator)	litres	4,704,583,337	4,960,628,693	5,091,678,821	1,932,886,660	1,888,466,020
Organization-specific metric (denominator)	100 RTK	150,617,866	164,202,274	165,100,915	46,570,663	51,277,912
Energy intensity ratio	litres / 100 RTK	31.24	30.21	30.84	41.50	36.83
Waste Generated	metric tons	N/A	6,432.75	6,295.51	3,635.90	4,199.23
Waste Diverted from Disposal	metric tons	N/A	2,251.95	2,619.27	2,121.91	2,339.60
Waste Directed to Disposal:	metric tons	N/A	4,180.79	3,676.24	1,514.00	1,859.63
Social Select Metrics						
Diversity Targets	YES/NO	YES	YES	YES	YES	YES
Executive Vice Presidents:						
Female	%	N/A	N/A	35.7%	28.6%	15.8%
Minority	%	N/A	N/A	7.1%	7.1%	5.3%
Persons with disabilities	%	N/A	N/A	0.0%	0.0%	5.3%
Indigenous	%	N/A	N/A	0.0%	0.0%	0.0%
Senior Leaders:						
Female	%	N/A	N/A	40.2%	38.5%	38.5%
Minority	%	N/A	N/A	14.3%	14.7%	15.2%
Persons with disabilities	%	N/A	N/A	0.4%	0.5%	1.6%
Indigenous	%	N/A	N/A	0.9%	0.9%	0.8%
Management:						
Female	%	N/A	N/A	52.3%	52.9%	53.0%
Minority	%	N/A	N/A	26.5%	24.2%	30.1%
Persons with disabilities	%	N/A	N/A	1.1%	0.9%	2.4%
Indigenous	%	N/A	N/A	0.8%	0.5%	0.8%
Total:						
Female	%	N/A	N/A	50.9%	46.7%	48.6%
Minority	%	N/A	N/A	29.9%	23.1%	31.4%
Persons with disabilities	%	N/A	N/A	1.2%	1.3%	2.0%
Indigenous	%	N/A	N/A	1.4%	1.3%	1.3%

Source: Company reports and CIBC World Markets Inc.

Exhibit 37: AC – Select Social & Governance Metrics, 2017 – 2021 (cont'd)

ESG Item	Units	2017	2018	2019	2020	2021
Social Select Metrics (cont'd)						
Occupational Health and Safety Performance:						
Fatalities	number	0	0	0	0	0
Total Injury Rate - per 100 FTE	rate per 100 FTE	19.67	17.34	17.30	15.44	13.78
Lost Time Injuries (LTI)	number	872	1,063	1,164	561	869
LTI - per 10,000 Flights	per 10,000 Flights	17.27	18.34	21.05	28.71	48.90
Lost Time Injury Days	number	33,351	36,609	45,375	52,285	50,970
Alberta WCB Assessment Reduction	%	98.0%	95.0%	89.0%	80.0%	90.0%
Flight Safety Performance:						
Accidents	number	1	1	0	0	N/A
Events and Incidents	number	2	3	5	8	N/A
Audit Results:						
IATA (IOSA) Operational Audit	number	2	N/A	3	N/A	3
IOSA Audit - Observations	number	2	N/A	7	N/A	7
Health Canada Potable Water Audit	number	0	0	Postponed	Postponed	N/A
PIR OHS Safety Audit	%	98.0%	95.0%	89.0%	80.0%	
Total Injuries (including fatalities):	number	5,211	5,850	6,062	2,804	3,530
Lost Time Injuries:	number	872	1,057	1,164	561	869
Governance Select Metrics						
Board Gender Diversity:						
Female	%	28.0%	28.0%	25.0%	33.3%	33.0%
Minority	%	N/A	N/A	0.0%	8.3%	8.3%
Persons With Disabilities	%	N/A	N/A	0.0%	0.0%	0.0%
Indigenous	%	N/A	N/A	0.0%	0.0%	0.0%
Separation of Chair and CEO	YES/NO	YES	YES	YES	YES	YES
Dual-class ownership?	YES/NO	YES	YES	YES	YES	YES
CEO Compensation	CAD	9,005,849	11,551,850	12,871,900	9,258,983	3,717,000

Source: Company reports and CIBC World Markets Inc.

Exhibit 38: BBD – Select Environmental, Social & Governance Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	YES	YES	YES	YES	YES
Net-zero Targets (Y/N)	YES/NO	NO	NO	NO	YES	YES
Energy consumption:						
Energy Consumption	GJ	4,600,739	4,259,082	2,625,958	2,159,193	1,921,632
Fuel (renewable and non-renewable) Consumed	GJ	2,458,201	2,236,372	1,541,854	1,279,273	1,166,178
Natural gas (non-renewable)	GJ	1,914,269	1,846,055	1,219,499	1,010,760	857,904
Kerosene (non-renewable)	GJ	448,577	304,909	304,768	252,528	295,392
Other fuels (non-renewable)	GJ	95,353	85,407	17,587	15,986	12,882
Electricity, Steam and Hot Water	GJ	2,142,537	2,022,710	1,084,104	879,920	755,455
Electricity (non-renewable and renewable)	GJ	1,873,647	1,768,530	1,084,104	879,920	746,137
Renewable electricity	GJ	662,665	893,514	689,337	619,256	556,802
Energy intensity	GJ per million USD of Revenue	283	270	351	333	316
Greenhouse gas emissions (GHG) (Scope 1 and 2):	tCO2e	280,332	252,214	141,261	108,632	93,515
GHG Emissions - Scope 1	tCO2e	148,927	133,751	92,200	76,877	71,140
GHG Emissions - Scope 2	tCO2e	131,405	118,463	49,062	31,755	22,375
GHG emissions intensity	tCO2e per million USD of Revenue	17	16	19	17	15
Ozone depleting substance emissions	tCO2e	1,024	571	489	763	770
Water withdrawal:						
Water withdrawal	cubic meter	1,742,807	1,673,168	1,218,489	923,253	638,897
Municipal water utility withdrawal	cubic meter	1,685,721	1,621,317	1,214,342	918,419	638,897
WASTE GENERATED (HAZARDOUS AND NON-HAZARDOUS):						
Waste generated (hazardous and non-hazardous)	metric tonnes	53,693	55,348	18,043	12,924	12,076
Hazardous Waste:	metric tonnes	7,691	8,218	5,685	3,791	3,723
Non-hazardous Waste:	metric tonnes	46,001	47,130	12,358	9,133	8,353
Valorized Waste (hazardous and non-hazardous)	% of total waste	84.0%	84.0%	73.0%	69.0%	69.0%
Social Select Metrics						
Diversity Targets	YES/NO	YES	YES	YES	YES	YES
Lost time incident rate	per 200,000 work hours	0.37	0.47	0.94	0.72	0.81
Lost time severity rate	per 200,000 work hours	14.70	17.10	35.10	35.30	36.10
Fatalities	employees and contractors	2	0	0	0	0
Incident rate	rate	1.10	0.97	1.80	1.49	1.78
Workforce represented in formal joint management-worker health and safety committees	%	91.0%	91.0%	85.0%	86.0%	82.0%
Percentage of underrepresented groups:						
Canada	%	N/A	N/A	N/A	N/A	13.4%
US	%	N/A	N/A	N/A	N/A	28.4%
Percentage of women	%	N/A	N/A	N/A	20.4%	20.2%
Percentage of women in management	%	N/A	N/A	N/A	24.7%	25.3%
Voluntary turnover	%	N/A	N/A	N/A	4.2%	7.2%
Total Employee Turnover	number	7,273	12,177	N/A	3,792	3,509
Total Voluntary Employee Turnover	%	6.0%	7.0%	N/A	4.0%	7.0%
Governance Select Metrics						
Board Gender Diversity	%	28.6%	35.7%	35.7%	33.0%	33.0%
Board of Directors	number of director	14	14	14	14	14
Female	number of director	4	5	5	4	4
Male	number of director	10	9	9	10	10
Separation of Chair and CEO	YES/NO	YES	YES	YES	YES	YES
CEO Compensation	USD	10,630,900	7,621,300	N/A	2,955,500	6,111,400
Dual-class ownership?	YES/NO	YES	YES	YES	YES	YES

Source: Company reports and CIBC World Markets Inc.

Exhibit 39: CAE – Select Environmental & Social Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	NO	NO	NO	NO	NO
Net-zero Targets (Y/N)	YES/NO	NO	NO	NO	NO	NO
Energy Consumption within the organization	MWh	247,876	292,560	263,737	260,533	239,448
Natural gas	MWh	20,358	15,507	9,996	7,193	9,248
Electricity	MWh	175,454	186,253	194,847	192,883	165,282
Diesel, heating oil, propane, fuel for aircraft and cars, hot and chilled water	MWh	52,064	90,800	58,894	60,457	64,918
Energy indirect (Scope 2) GHG emissions						
Scope 1	tCO2e	18,625	28,424	19,699	18,590	20,996
GHG emissions (Scope 1 and 2 location based)	tCO2e	78,383	90,104	84,141	78,595	71,442
GHG emissions (Scope 1 and 2 market based)	tCO2e	86,042	84,975	76,772	71,904	65,730
Energy indirect GHG Emissions (Scope 2 location based)	tCO2e	59,757	61,680	64,441	59,645	50,445
Energy indirect GHG Emissions (Scope 2 market based)	tCO2e	67,417	56,551	57,072	52,954	44,733
Other indirect (Scope 3) GHG emissions	tCO2e	N/A	N/A	N/A	14,520	3,876
Emissions intensity	MWh/million USD revenue	91.65	103.62	77.25	76.29	80.30
GHG Emissions Intensity (location based)	tCO2e/$million revenue	22.1	N/A	N/A	N/A	N/A
GHG Emissions Intensity (market based)	tCO2e/$million revenue	24.93	N/A	N/A	N/A	N/A
Water withdrawal by source	cubic meter	89,156	344,798	328,848	315,307	N/A
Water Consumption Intensity	cubic meter / revenue	32.97	N/A	N/A	N/A	N/A
Social Select Metrics						
Diversity Targets	YES/NO	NO	YES	YES	YES	YES
Diversity of Employees	%	N/A	18%	20.0%	21.0%	27.1%
Incidents of discrimination and corrective actions taken	number of incidents	N/A	N/A	N/A	N/A	0
Number of foreign agents hired	number	N/A	N/A	N/A	N/A	9
Employees by Gender:						
Number of employees (female)	number	1,735	1,931	2,408	2,610	2,427
Number of employees (male)	number	6,951	7,704	9,356	9,554	8,960
% of female employees	%	20.0%	20.0%	20.0%	21.0%	21.0%
% of male employees	%	80.0%	80.0%	80.0%	79.0%	79.0%
Employee Turnover						
Employee Turnover Number	number of employees	442	1,064	1,029	1,522	1,651
Employee turnover rate	% of total employees	6.0%	13.0%	10.0%	14.0%	16.0%
Incident Frequency Rate (IFR)	rate	0.55	0.39	0.54	0.52	0.33
Lost Time Injury Frequency Rate (LTIFR)	rate	0.25	0.16	0.24	0.21	N/A
Number of observations of hazardous situations	number	N/A	N/A	N/A	N/A	261
Rate of observations of hazardous situations	number	N/A	N/A	N/A	N/A	2.28
Number of near misses	number	N/A	N/A	122	125	69
Near Miss Rate (NMR)	rate	N/A	1.21	0.92	1.06	0.60
Customer health and safety (Flight safety):						
Number of voluntary reports	per 10K flight hours	N/A	41.0	39.3	61.6	91.5
Number of incidents >$50K in damage	per 10K flight hours	N/A	0.39	0.33	0.39	0.29
Live flight aviation safety reviews - external		N/A	1	10	19	7
Live flight aviation safety reviews - internal	per training location	N/A	1	13	13	12
Governance Select Metrics	**Units**					
Board Gender Diversity	%	N/A	18.0%	20.0%	20.0%	20.0%
Separation of Chair and CEO	YES/NO	YES	YES	YES	YES	YES
CEO Compensation	CAD	6,500,841	6,924,180	7,545,220	7,423,461	7,406,238
Dual-class ownership?	YES/NO	NO	NO	NO	NO	NO

Source: Company reports and CIBC World Markets Inc.

Exhibit 40: CHR – Select Environmental, Social & Governance Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	N/A	N/A	N/A	YES	YES
Net-zero Targets (Y/N)	YES/NO	N/A	N/A	N/A	YES	YES
Social Select Metrics						
Diversity Targets	YES/NO	YES	YES	YES	YES	YES
Women Workforce	%	N/A	N/A	38.0%	N/A	36.1%
Indigenous Peoples	%	N/A	N/A	2.0%	N/A	2.5%
Persons with Disabilities	%	N/A	N/A	3.0%	N/A	2.0%
Visible Minorities	%	N/A	N/A	16.0%	N/A	15.5%
Diversity in Executive Positions:						
Women Workforce	%	16.0%	14.0%	20.0%	21.0%	24.3%
Indigenous Peoples	%	N/A	N/A	0.0%	0.0%	5.4%
Persons with Disabilities	%	N/A	N/A	5.0%	6.0%	5.4%
Visible Minorities	%	N/A	N/A	0.0%	3.0%	5.4%
Total:						
Women	%	N/A	N/A	38.0%	N/A	36.1%
Men	%	N/A	N/A	62.0%	N/A	63.9%
Lost time Injuries	rate/100 FTE	N/A	2.59	2.89	N/A	N/A
Governance Select Metrics						
Board Gender Diversity	% of directors	25.0%	30.0%	30.0%	30.0%	30.0%
Separation of Chair and CEO	YES/NO	YES	YES	YES	YES	YES
Dual-class ownership?	YES/NO	NO	NO	NO	NO	YES
CEO Compensation	CAD	3,092,607	3,316,344	3,311,045	2,375,094	3,015,353

Source: Company reports and CIBC World Markets Inc.

Exhibit 41: CJT – Select Environmental, Social & Governance Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	N/A	N/A	N/A	N/A	NO
Net-zero Targets (Y/N)	YES/NO	N/A	N/A	N/A	N/A	YES
Fuel Efficiency	ltrs per pound	0.27	N/A	N/A	N/A	0.19
Social Select Metrics						
Diversity Targets	YES/NO	N/A	N/A	N/A	YES	YES
Workforce	#	N/A	N/A	N/A	N/A	1,512
Women Employees	%	N/A	N/A	N/A	13.8%	15.6%
Aboriginal Peoples	%	N/A	N/A	N/A	2.2%	2.2%
Person with Disabilities	%	N/A	N/A	N/A	2.8%	2.8%
Visible Minorities	%	N/A	N/A	N/A	27.3%	29.0%
Female Executive Officers	%	27%	21%	21%	22%	15.0%
Employee Retention	%	N/A	N/A	N/A	N/A	89.5%
Governance Select Metrics						
Board Gender Diversity	%	0.0%	20.0%	20.0%	20.0%	20.0%
Separation of Chair and CEO	YES/NO	NO	YES	YES	YES	YES
Dual-class ownership?	YES/NO	NO	NO	NO	NO	NO
CEO Compensation	CAD	6,894,630	9,413,586	9,732,930	11,888,822	3,148,910

Source: Company reports and CIBC World Markets Inc.

Exhibit 42: TRZ – Select Environmental, Social & Governance Metrics, 2017 – 2021

ESG Item	Units	2017	2018	2019	2020	2021
Environmental Select Metrics						
Emissions Targets (Y/N)	YES/NO	N/A	N/A	N/A	N/A	YES
Net-zero Targets (Y/N)	YES/NO	N/A	N/A	N/A	N/A	YES
Scope 1 International flights	tonnes CO2	N/A	N/A	N/A	N/A	107,671
Scope 1 Domestic flights	tonnes CO2	N/A	N/A	N/A	N/A	15,689
Total Scope 1 flight emissions	tonnes CO2	1,462,488	1,581,461	1,586,538	407,441	123,360
Scope 1 (Other-company vehicles)	tonnes CO2	331	1,093	1,045	681	N/A
Scope 1 (Other-airline hangar)	tonnes CO2	750	1,588	1,523	1,099	473
Total Scope 1	tonnes CO2	1,463,569	1,584,142	1,589,106	409,221	123,833
Scope 2 (purchased electricity in QC)	tonnes CO2	28.83	26.07	28.86	26.97	19.42
Total Emissions	tonnes CO2	1,463,589	1,584,163	1,589,128	409,236	123,834
Unit consumption	liters/100 pax km	2.98	2.95	2.89	3.18	3.15
Unit emissions	kg co2-100 pax km	7.54	7.46	7.31	8.05	7.97
Other GHG Aircraft Emissions						
SOX	tonnes CO2	9,750	10,543	10,577	2,716	822
NOX	tonnes CO2	133	144	145	37	11
CH4	tonnes CO2	1,271	1,374	1,379	354	107
Jet fuel consumed	liters	580,352,500	627,563,750	629,578,591	161,683,066	48,952,381
Energy from jet fuel	megajoules	20,475	22,140	22,211	5,704	3,033
Natural gas consumption	m3	403,461	853,848	818,847	591,123	254,614
Electricity consumption	Kwh	11,785,011	10,742,327	11,751,852	11,015,356	7,994,996
Social Select Metrics						
Diversity Targets	YES/NO	YES	YES	YES	YES	YES
Women Executive Officers	%	18.0%	17.0%	17.0%	17.0%	
Women in Management	%	N/A	N/A	N/A	N/A	41.0%
Governance Select Metrics						
Board Gender Diversity	%	27.0%	36.0%	33.0%	33.0%	45.5%
Separation of Chair and CEO	YES/NO	NO	NO	NO	YES	YES
Dual-class ownership?	YES/NO	YES	YES	YES	YES	YES

Source: Company reports and CIBC World Markets Inc.

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