CBSCI
Canada's Biojet
Supply Chain Initiative

Policy Tools for Enabling Biojet 2019

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About CBSCI

CBSCI is helping to enable a low carbon future for Canadian aviation by generating hands-on experience with biojet integration in the co-mingled fuel supply of Toronto's Lester B. Pearson International Airport.

CBSCI research activities include investigating and defining the components of a future domestic biojet supply chain, including potential feedstock sources, biojet production, delivery logistics, and enabling policy framework.

CBSCI has primary funding from the Green Aviation and Research Development Network (GARDN), a Business-led Networks of Centres of Excellence of Canada. Additional project funding is provided by Air Canada, BioFuelNet Canada, and IATA.

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1. Introduction

Efforts to address greenhouse gas (GHG) emissions from commercial aviation are underway at provincial, federal, and international levels. Across jurisdictions, multiple policy tools are being considered and implemented with the aim to decouple aviation emissions from sector growth, and encourage the commercial deployment of biojet. These policy tools range from prescriptive measures such as regulations requiring lower aviation fuel emissions through use of lower carbon aviation fuels to less direct approaches such as carbon pricing. Also included are voluntary measures and support of research and development activities.

Given the reliance in Canada on air transport for domestic and international travel, aviation-focused policies impact Canadians. In order to identify policy mechanisms that might be used to help Canada address aviation emissions, a range of applicable policy tools are reviewed. These include carbon pricing, both clean and low carbon fuel standards, renewable fuel mandates, tax credits, capital support and loan guarantees, voluntary measures, and research and development investments. Following a brief review of climate commitments and aviation fuel use in Canada, policy recommendations are summarized. Each tool is later discussed in more detail, with use of international and Canadian examples. Recommendations reappear within their respective sections.

2. Paris Agreement Commitments and the *Pan-Canadian Framework*

Under the Paris Agreement, Canada has committed to reducing its GHG emissions by 30% below 2005 levels by 2030. Canada's 2015 emission level was 722 MT and the target emission level in 2030 is 523 MT, requiring 199 MT emission reductions in 2030 (Government of Canada 2017). The specific target GHG reductions and current emission levels are subject to update and recalculation as Canada determines how it will incorporate land use, land-use change and forestry (LULUCF) activities in its GHG reporting (Climate Action Tracker 2018).

Announced in December 2016, the *Pan-Canadian Framework on Clean Growth and Climate Change* (PCF) is Canada's national plan to meet its 2030 emission reduction target. The framework takes an economy-wide approach to reducing emissions that includes carbon pricing, complementary policies across governments, and regular reporting on progress (Government of Canada 2018). The measures outlined in the PCF are expected to achieve 86 MT of annual reductions by 2030. An additional 89 MT of reductions will come from measures announced prior to December 2016 that include federal action on hydrofluorocarbons (HFCs), heavy duty vehicles, methane, and provincial actions. Beyond the PCF, to achieve Canada's Paris Agreement target the remaining reductions will come from 'additional measures such as public transit and green infrastructure, technology and innovation, and stored carbon (forests, soils, wetlands)' (Government of Canada 2017).

The PCF contains two measures that will most directly impact aviation fuels used in Canada: carbon pricing (under the *Greenhouse Gas and Pollution Pricing Act,* 2018 - GGPPA), and the *Clean Fuel Standard* (CFS - under the *Canadian Environmental Protection Act,* 1999).

3. Aviation Fuel in Canada

The primary aviation fuels used in Canada are kerosene-based turbine fuels (Jet A and Jet A-1). Total consumption is split between international (68%) and domestic use (32%) (Transport Canada 2017). In 2017, Canada produced approximately 7.0 BL and imported 2.4 BL (Statistics Canada 2018).

Canadian airlines continue to increase the efficiency of fuel use through fleet renewals and upgrades, more efficient air operations, and other measures. The fuel efficiency rate reported for 2017 was 33.31 litres per 100 Revenue Tonne-Kilometres (RTK)—a metric that combines both passenger and cargo traffic. This translates to an average fuel efficiency improvement of 1.87 percent per year between 2008 and 2017, and a cumulative improvement of 15.6 percent (Transport Canada 2017).

Using Argonne National Laboratory's LCA model, GREET, the lifecycle well-to-wake (WTW) emissions associated with conventional aviation fuels are approximately 87.5-88 g CO2e/MJ (Wang et al. 2016). The most recent national emission figure of 722 MT of CO2e in 2015 (ECCC 2017a) suggests that aviation GHGs contribute more than 3% of Canada's total domestic emission profile—higher than the global average of 2% (as reported in IATA 2017a). Canada's geography and climate create stronger demand for aviation, helping to push it higher than global averages.

4. Summary of Policy Recommendations for Addressing Aviation GHG Emissions

Aviation environmental policy is currently in an active state of development at provincial, national and international levels. The included recommendations are offered into a dynamic policy and regulatory environment, with regulatory processes currently underway with approaching milestones.

Recommendations that impact Canada's ability to achieve International Civil Aviation Organization (ICAO) targets are addressed in the section on voluntary measures. The recommendations pertain to policy tools that are examined in more detail in sections 5 - 11.

CARBON PRICING ON AVIATION FUELS:

Policy Recommendation 1. Exempt biojet from the carbon charge under GGPPA and provincial policies. At present, the carbon charge is applied to biojet under the *Greenhouse Gas Pollution Pricing Act.* If a carbon charge is applied to renewable fuels, it erodes any economic signal for fuel switching to lower carbon options. As currently written, the GGPPA exempts the carbon charge on biofuels in blends above 10% and 5% in gasoline and diesel fuels, respectively. Renewable natural gas, in any quantity, is not subject to the carbon charge. This approach to exemption, as used in the GGPPA, is similar in structure to Alberta's exemption that was adopted in 2017. Biojet should be given the same treatment as renewable natural gas: a full exemption from the carbon charge.

PR 2. Reassess the current patchwork approach to carbon pricing of aviation fuels. Canadian governments at both federal and provincial levels should collectively reconsider the existing diverse approach to carbon pricing on aviation fuel. Currently applied carbon taxes do not provide a sufficient signal to motivate the use of low carbon fuels and are an unavoidable cost to the sector. To date, carbon pricing systems in Canada have failed to create a market price signal based on the GHG emissions of fuels used in Canada. In BC and AB , the carbon charge applies equally to both low and high carbon fuels.

PR 3. Consider a consistent national approach to carbon pricing applied to aviation fuels across the country, maintaining sector competitiveness and removing distortions between intraprovincial and interprovincial routes. A single approach to carbon pricing for aviation fuels would eliminate the current inconsistently applied carbon pricing among provinces. As air travel is an essential service for many communities, special care must be taken to ensure that the imposition of a carbon tax does not lead to route cancellations, particularly for vulnerable communities. The application of the carbon charge can be moderated through a similar structure as the current Output-Based-Pricing-System (OBPS) which applies to stationary facilities in emission-intensive and trade-exposed sectors based on their emission efficiency. An approach to an aviation-specific OBPS would incorporate tonne-kilometer performance of each airline to temper carbon charge impacts on sector competitiveness and reward investments in efficiency.

PR 4. 'Recycle' (re-invest) any carbon charge revenues to support aviation sector decarbonization, including the use of biojet. The carbon charge on aviation fuels used in domestic flights may range from approximately $133M in 2019 to $333M in 2022 as the carbon charge increases from $20/tonne to $50/tonne, $0.05 to $0.13 per litre, respectively. The total financial impact will depend on how the charge is applied across aviation fuel use and whether interprovincial flights are subject to the charge. Despite this uncertainty in application, it is evident that the carbon charge alone will not be sufficient to create an incentive for biojet use; the price premium of biojet is greater than the maximum carbon charge of $0.13/litre in 2022, and biojet fuels are not currently exempt from the carbon charge. If carbon charges are implemented for aviation fuels, the revenue should be strategically directed towards activities that address aviation emissions, such as funding collective biojet purchases, blending incentives, research and development activities, and developing domestic offsets that can be eligible for use under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

ENABLING BIOJET VIA THE CLEAN FUEL STANDARD:

PR 5. Design the CFS so that biojet use creates compliance credits to positively enable blending economics. A functioning CFS compliance credit market allows sector operators to work with other CFS participants to maximize the value and liquidity of credits that may accrue from sector activities. Biojet production and blending economics are enhanced by the ability to generate and sell credits into a CFS compliance credit market that has frequent transactions. Credits should be generated without the creation of debits, or 'C02e Exceedances', from fossil jet fuel use. The compliance credit market should allow the participation of brokers and non-obligated parties in order to increase liquidity.

PR 6. Allow a multiplier or 'factor' approach to CFS credit generation for biojet used in domestic aviation to address the higher production cost of biojet vs other renewable fuels and the nascent state of commercial biojet production. Allow the multiplier to be used for a limited duration and quantity. The use of a multiplier for biojet production has been proposed as a means to bridge the price and production cost gap by incentivizing biojet use without a specific aviation fuel mandate. This structure is useful in the CFS because there are no specific blend requirements for aviation fuels. HEFA biojet, currently the most available biojet fuel, is produced from a similar technology platform as renewable diesel but with additional processing requirements, and thus a higher cost of production. Also, jet fuel historically sells at a discount to diesel, making the further processing required to produce biojet even less attractive without inducements (Davidson 2014). A multiplier structure can be used for a limited duration and volume to ensure that it does not result in an overall lower amount of renewable fuels used.

PR 7. Design the CFS to discourage fuels derived from feedstocks that negatively impact biodiversity, critical species habitats, and cause the conversion of land with high carbon stocks. Prohibitions on detrimental feedstock supply chains can enhance social acceptance of biojet and the CFS. Incorporating environmental sustainability into the CFS design reduces reputational risk to airlines that choose to use biojet. The perceived longevity and stability of the CFS is important to attracting investment in biojet supply chains. Therefore, policy design that protects the social license of the CFS is worthwhile. Additionally, ensuring that CFS eligible fuels and feedstocks also comply with CORSIA will help ensure that domestically produced biojet qualifies for international use.

AVIATION FUELS IN THE RENEWABLE FUELS REGULATIONS:

PR 8. Volumetric biojet use obligations are not recommended. Application of a renewable fuel standard (RFS) to fuel used for domestic flights could put Canadian airlines at a disadvantage relative to US and international carriers. The apparent simplicity of a volumetric blending obligation for aviation fuel is counterbalanced by the large financial cost it would add to aviation fuels. Increased cost and subsequent consumer price impacts make an RFS policy structure a less appealing option. Even though the RFS has been effective in enabling biofuel capacity creation, implementing volumetric requirements specific to the aviation sector in Canada would have profound implications for the industry due to the international nature of aviation and lower elasticity of demand compared with road transportation.

ATTRACTING BIOJET INVESTMENT IN CANADA:

PR 9. To attract capital investment, Canada must signal intent to expand Canada's biojet production capacity through comprehensive, long-term targeted measures. As a component of a broader strategic plan to increase clean fuel production and use in Canada, biojet can be a key driver for economic growth and green jobs. To realize these economic benefits, conducive conditions must be created for Canadian businesses and communities to make responsible investments in an emerging sector that can remain competitive in an expanding global market for clean fuels. The federal government can support this by clarifying eligibility for renewable fuels and biojet production/use projects in existing programs and funding entities (Export Development Canada, Business Development Canada, Sustainable Development Technology Canada, etc.)

PR 10. To help establish biojet production capacity and supply chain infrastructure development, leverage industry funds via loan guarantees and capital grant programs using clear criteria to guide project choice. The loan guarantee/capital grant structure allows for non-dilutive funding at more attractive terms than would be otherwise available for capital intensive projects in new sectors. If competitive with programs in other jurisdictions, a capital cost support program would help attract investment in Canada. As capital support and loan programs require the federal government to choose recipients for support rather than basing support upon achieving biojet production (i.e., a producer credit), the criteria used to assess applicants should be developed to select projects with high likelihood of viability.

PR 11. Implement a biojet producer credit program to create domestic biojet capacity. A producer credit is a policy structure Canada has experience with at both federal and provincial levels, though not yet as applied to aviation fuels. It has proven effective and is understood by capital markets and project developers. A producer credit program can allow Canada to become a biojet exporter in addition to having Canadian-made biojet used on international flights departing from Canada. The producer credit should be performance-based (e.g., based on carbon intensity reduction) and long-term (e.g., extending to at least 2030).

PR 12. Permit accelerated capital cost allowance for biojet production facilities. For Canada to attract capital to build and operate advanced biofuels refineries, we recommend full eligibility for biofuels production assets, including biojet, within the Class 43.1 and 43.2 provisions of the Income Tax Regulations that pertain to accelerated capital cost allowance (ACCA) and flow-through treatment. Given the timeline for biojet buildout, we recommend the extension of ACCA to 2030. Current eligibility for fossil fuel assets under Class 43.1 and 43.2 provisions disadvantages liquid biofuel production.

INCENTIVIZING BIOJET USE THROUGH BLENDING INDUCEMENTS:

PR 13. Exempt biojet from the federal excise tax on aviation jet fuel ($0.04/litre) to improve the economics of its use. Biojet should be afforded similar treatment as ethanol and biodiesel were during their first years of use. The excise tax exemption can be removed once production and use are established.

PR 14. Explore refundable tax credits accessible by airlines and aviation fuel suppliers when blending biojet in Canadian airports for domestic and international use. Blender credits for biojet are a realistic option within airport fuel systems to promote biojet use and investment in enabling infrastructure. It would help fuel blenders bridge the gap between higher priced HEFA and fossil jet. This could be implemented in addition to relief from excise taxes on the biofuel component of the fuel mix (biojet + aviation fuel).

ENSURING ICAO POLICY WORKS FOR FUTURE CANADIAN BIOJET:

PR 15. Ensure Canadian feedstocks and production pathways will be recognized under CORSIA. Work is ongoing within the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) to develop the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA will utilize sustainability criteria as developed by the CAEP and have performance against it certified by a CORSIA approved sustainability certification scheme. Currently, CORSIA eligible fuels are defined as having 10% GHG reductions below the ICAO global average jet fuel carbon intensity of 89 g CO2e/MJ. As the LCA tool to determine GHG values and the actual sustainability criteria are still under development, Canada must ensure that its various biojet feedstocks will be deemed eligible. Any prohibitions on agriculture or forestry biomass eligibility will negatively impact Canada's ability to supply biojet for use under CORSIA.

PR 16. Align compliance reporting requirements between CORSIA and domestic systems (e.g., GGPPA, CFS) to minimize total administrative cost. Creating congruence between compliance options in both ICAO and CFS can help the aviation sector find the most efficient way to reduce emissions while minimizing administrative burden. Where possible, similarity in reporting approaches should be pursued.

PR 17. Align the fossil jet fuel carbon intensity value used in the CFS with ICAO's global value. Initial model work done by Environment and Climate Change Canada (ECCC) for the CFS uses 83 g CO2e/MJ as the interim proposed CI value for aviation jet fuel. ICAO's global average value is 89 g CO2e/MJ for fossil jet fuel. While there are reasons for value divergence (different crude slates, refinery efficiency, LCA model approaches, etc.), there should be a technical rationale for using a different value under the CFS than ICAO's value.

PR 18. Consider developing domestic offset projects for use under the CORSIA system. Canadian airlines will participate in ICAO's CORSIA system to offset emissions from international flights. These offsets can be sourced from Canadian projects, thereby leading to domestic economic benefits and higher-quality offsets.

ENHANCING PROVINCIAL POLICIES:

BRITISH COLUMBIA

PR 19. Designate jet fuel as 'opt-in' within the expanded BC LCFS as announced in the CleanBC plan. The government of British Columbia should update the *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* to schedule aviation fuels. Once updated, BC can take a similar approach to the EU REDII and the California LCFS: i.e. recognize the ability to generate credits through biojet use and assign aviation fuel a zero CI reduction target.

PR 20. Enable biojet development activities to be eligible under the Part 3 credit program. BC's Part 3 credit program can be a useful tool for funding infrastructure and development activities that can create LCFS credits. Biojet projects should be considered once aviation fuels are eligible under the BC LCFS.

PR 21. Exempt biojet blended in BC airports from carbon tax charge. Currently the BC carbon tax applies equally to fossil fuels and renewable fuels. This oversight removes any incentive to lower the carbon tax charge through the use of renewable fuels. Exempting biojet (and all biofuels) from the carbon tax in BC would redress the current tax structure failures that impair adoption of low carbon biofuels. BC can consider the Alberta approach of eliminating the carbon tax on all renewable fuels that are either used in excess of their mandated blending obligation (e.g., 5% in gasoline, 4% in diesel) or when used in any quantity when there is no blending obligation such as biojet.

ALBERTA

PR 22. Exempt biojet blended in AB airports from the carbon levy. Alberta's current implementation of the carbon levy provides relief for renewable content when blended above 10% in gasoline and above 5% in diesel. This levy adjustment creates an economic signal for higher blends of renewable fuel to be used. This same treatment should be applied to biojet fuel blended in any quantity.

FOSTERING BIOJET-RELATED RESEARCH, DEVELOPMENT AND INNOVATION:

PR 23. Continue to connect biojet-related research, development, and deployment activities through the continuation of the Clean Growth Hub established in Budget 2017. The biojet supply chain involves many stakeholder groups and government departments, therefore the 'whole of government' approach implemented through the Clean Growth Hub is useful. The Clean Growth Hub vehicle can inform the emerging biojet supply chain on what types of R&D and innovation funding is available. Also, the aviation sector can help shape future programs of the Clean Growth Hub that reduce GHG emissions from aviation fuel use.

PR 24. Ensure that the results of innovation can be commercially implemented in a biojet sector that has market access. Programs that enhance technical understanding and innovation will be most impactful if they can be used in a sector that has an economic foothold in the fuel supply chain and the ability to invest in improvements. Market access, achieved through fuel regulations like the Clean Fuel Standard and the BC Low Carbon Fuel Standard, is fundamental to creating viable business conditions for biojet production benefitting from targeted innovation programs.

ENCOURAGE VOLUNTARY MEASURES TO REDUCE AVIATION EMISSIONS:

PR 25. Utilize a collaborative approach between government and industry for aviation environmental policy. Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation (Action Plan) demonstrates that airlines and the federal government can work together to pursue voluntary measures that reduce emission intensity. This collaborative approach should be maintained and utilized for establishing measures the Canadian aviation sector can pursue for further reducing emissions towards domestic and international targets. The Action Plan working group should serve as a forum to identify and address cross cutting impacts from aviation policy at provincial, federal, and international levels.

PR 26. Use the Action Plan working group to consider how to direct carbon charge funds that may be collected from the aviation sector. If carbon charge funds are collected from the aviation sector, they should be deployed toward environmental initiatives within the aviation sector. The stakeholder group formed through the duration of the Action Plan process is positioned to offer strategic guidance for the use of carbon charge funds. A potential use could be the collective purchase of biojet fuel, with the credits for its use allocated on a pro rata basis determined by the amount of carbon charge paid.

PR 27. Consider voluntary actions as pre-compliance activities when setting baselines under any future regulations. Future regulations considered for use in the sector should reference progress already achieved under voluntary measures such as the Action Plan. This would serve to recognize and transition voluntary activities under the Action Plan into compliance within any future legislated requirements. If voluntary actions are not recognized in subsequent regulations or are incorporated into the baseline against which future reductions must occur, it removes the rationale for future voluntary action and proactive engagement.

Sections 5 - 11 review the policy tools in added detail, provides the current status of their implementation, and assesses their ongoing usefulness in Canada.

5. Carbon Pricing

5.1 Policy tool description

Carbon pricing is a broad category. There are two general types of carbon pricing systems: emissions trading systems (ETS) and carbon taxes.

An ETS, sometimes referred to as a cap-and-trade system, limits the total level of GHG emissions and allows those participants with lower emissions to sell their extra allowances to larger emitters. The system creates supply and demand for emissions allowances, thereby establishing a market price for GHG emissions. The emission limit (which can be structured as an absolute 'cap' or as a GHG intensity schedule) helps ensure that the emission reductions will take place to keep the emitters, in aggregate, within their allocated carbon budget or emission limits.

A carbon tax – sometimes referred to as a carbon price, carbon charge, or carbon levy – directly sets a price on carbon by defining a tax rate on GHG emissions or on the carbon content of fossil fuels. It differs from an ETS in that the emission reduction outcome of a carbon tax is not pre-defined though the carbon charge rate (World Bank 2014).

Governments can adjust the impacts of carbon pricing systems by providing carbon charge rebates, exemptions, and free or discounted emissions allowances.

5.2 International examples of carbon pricing

As of late 2017, approximately 21 nations have some form of carbon pricing in place or under consideration.[1] In the EU, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, the Netherlands, Poland, Portugal, Slovenia, Sweden, and the UK, now have some form of carbon pricing in place to augment the European Emissions Trading Scheme (CPLC 2018; Carl and Fedor 2016). Iceland and Norway also have a carbon price in place, while South Africa, Japan, Mexico, Colombia and Brazil either have or are considering similar instruments. In Canada, the provinces of British Columbia, Alberta, Ontario, and Quebec have or have recently had carbon pricing systems in place.[2] Few of the carbon taxes in place specifically apply to aviation, although Finland and Japan both identify domestic air travel as subject to their tax (Carl and Fedor 2016).

As of March 2018, there are approximately 19 emissions trading systems (ETS) active around the world, along with five programs currently scheduled for implementation. Of these, the EU's Emission Trading Scheme is the largest single program in the world, covering 28 EU member states as well as three nations through the EU's Free Trade Association (Iceland, Liechtenstein, and Norway). A deal has recently been reached to operate Phase 4 of this program from 2021-2030 (ICAP 2018).

Through the Western Climate Initiative (WCI), Québec along with one US state, California, are engaged in a combined ETS system. British Columbia and Manitoba are also members of the WCI, although neither province has opted to pursue a cap-and-trade program. The US has active, smaller-scale ETS programs that focus on electrical power generation, including the Regional Greenhouse Gas Initiative (RGGI), which

1. The term 'carbon pricing' is used to refer to a range of related and similarly named instruments that seek to put a price on carbon emissions such as carbon taxes, carbon levies, as well as cap-and-trade systems. This does not imply equivalency of systems.

2. At the time of writing, Ontario has dismantled its carbon pricing program.

spans nine states in the northeast of the country, and the Massachusetts ETS. China has implemented a national ETS and has eight subnational programs underway in various provinces and cities. Kazakhstan, Korea, New Zealand, and Switzerland also have ETS programs (ICAP 2018). Aviation is included in the EU's program, China's national and several provincial programs, Korea's program, and Switzerland's program which is linked to the EU program.

The EU ETS applies carbon pricing on aviation fuels in the form of requiring EU Allowances for flights between EU nations. Under the EU ETS, both domestic and intra-European flights have been subject to carbon pricing since 2012 (EU 2014; EU 2008; EU 2003). This has not led to widespread commercial adoption of aviation biofuels beyond demonstration flights, largely due to low availability and the higher relative cost for HEFA or HVO biojet compared to petroleum-based, fossil jet fuels (EASA 2018). Historically, low carbon prices have not helped to bridge the price differential between biojet and fossil jet as EU ETS prices have averaged €6.40/T CO2e (approximately C$10) between 2012 and 2018 (Markets Insider 2018).

The EU ETS intends to move forward with pricing GHG emissions associated with international flights that originate or terminate within the EU. In 2008, Directive 2008/101/EC was introduced to address these emissions beginning in 2012 (EU 2008), but it was temporarily halted to allow for ICAO to develop its Market-Based-Measures systems. At the time of this report, the EU ETS covers solely intra-European flights while ICAO progress on international flights continues. The EU Parliament continues to work on this issue; it is expected that a cap on international aviation emissions will be set as of 2021 at a level 10% below the average allocation of emissions in this sector over 2014-2016, and that this cap will decrease at the same rate as the overall EU ETS in years following (EU 2018). The EU Member States oversee the allocation of allowances to aircraft operators based on their efficiency in transporting passengers and cargo. The calculation uses a benchmark value established by the European Commission and the EEA joint Committee. Free emission allowances are allocated to approximately 500 aircraft operators (EU 2016).

A number of additional jurisdictions are scheduled to implement ETS programs, including one additional Canadian province Nova Scotia, Mexico, Taiwan, Ukraine, and the state of Virginia in the US. The states of Oregon and Washington in the US are considering ETS programs. As these states are long-term members of the Western Climate Initiative it may be anticipated that they will eventually join California and Québec in an ETS trading bloc. Brazil, Chile, Colombia, Japan, Thailand, Turkey, and Vietnam are also considering ETS programs (ICAP 2018). At present, the ETS programs described for these jurisdictions do not include aviation (ICAP 2018).

A recent global review of carbon taxes found that approximately 72% of carbon tax revenues ($15.6B US) are either refunded to consumers through relief of other taxes, or used in general taxation funds; by comparison, 70% of cap-and-trade revenues ($4.6B US) are earmarked for green spending (Carl and Fedor 2016). This review highlighted that cap-and-trade systems tended to bring in less money overall, but that these funds were more likely to be applied to new technology development; carbon taxes were sometimes used to address deficits in national or subnational budgets, although they could also be applied in a revenue neutral fashion as in British Columbia until 2017 (Carl and Fedor 2016).

5.3 Carbon pricing in Canada

FEDERAL

The Federal Government of Canada, as part of the Pan-Canadian Framework, committed to have a nation-wide price on carbon. The federal carbon pricing backstop system on fuels was enacted via the Greenhouse Gas Pollution Pricing Act in June 2018.

The initial price schedule began 2018 at $10/T CO2e and rises to $50/T CO2e by 2022 (ECCC 2017b). The start date was subsequently moved to 2019 at the rate of $20/T CO2e. The price on carbon will be applied to all fossil fuels in backstop jurisdictions on April 1, 2019, including aviation fuel for domestic use. Currently, the tax only applies to intra-provincial flights. The federal program is meant to provide a backstop for provinces and territories without carbon pricing programs and to ensure that provincial carbon pricing maintains a minimum level. The federal carbon pricing system is only applied to 'listed provinces.' Provinces 'listed' as 'backstop jurisdictions' are those that the federal government deems to not have carbon pricing measures comparable to the minimum federal requirements; this includes both carbon taxes applied to fuels and to industrial facilities. The federal system is able to complement provincial systems that fall short of national targets. In October 2018, the federal government announced that the fuel charge will apply in Manitoba, New Brunswick, Ontario and Saskatchewan beginning April 2019, and, in July 2019 in Yukon and Nunavut (Environment and Climate Change Canada 2018).

For aviation fuels, the following carbon charge schedule and estimated financial impact is included below in Table 1.

The financial impact calculation assumes that the carbon charge is applied to all domestic flights. This calculation approach follows ECCC's statement that:

"The introduction of carbon pricing in all Canadian provinces and territories eliminates these inter-jurisdictional competitiveness concerns and presents an opportunity for this important source [aviation emissions] of GHG emissions to be covered across Canada. The federal government will engage with provincial and territorial governments and stakeholders to ensure that this emission source is properly covered, through a consistent national approach, and to determine which role the backstop should play in this regard, including in jurisdictions that have a carbon pricing system in place." (Environment and Climate Change Canada 2017)

The estimated financial impact from the carbon charge presents the opportunity to use the funds strategically towards activities that lower aviation sector emissions.

Table 1: Carbon charge schedule and estimated financial impact

	2019	2020	2021	2022
Federal Carbon Charge Rate ($/Tonne)	$20	$30	$40	$50
Aviation Turbo Fuel Carbon Charge Rate ($/L)	$0.0516	$0.0775	$0.1033	$0.1291
Estimated Domestic Fuel Consumption (BL)	2.58	2.58	2.58	2.58
Financial Impact of Carbon Charge ($M)	$133	$200	$267	$333

** Includes interprovincial flights. Calculation maintains 2017 domestic fuel usage levels*

PROVINCIAL CARBON PRICING SYSTEMS:

BRITISH COLUMBIA

There is explicit allowance within the PCF to permit individual jurisdictions to employ carbon taxes like British Columbia, levies and output-based pricing as in Alberta, or cap-and-trade systems such as Quebec's. British Columbia's carbon tax was implemented in 2008 at $10/tonne and increased by $5/year to $30/T by 2012. It was initially designed to be a revenue neutral tax, meaning that all funds collected would be returned to the people of BC through other tax reductions (BC Ministry of Finance 2018). Revenue neutrality of increases to the BC carbon tax, beyond the first $30/T, was eliminated in the 2017 BC Budget. BC imposes a $0.0783/L levy on jet fuel used for intraprovincial travel but does not apply this levy to fuel used for flights that leave the province, whether for other Canadian or international destinations (BC Ministry of Finance 2018). BC raised their overall tax rate to $35/T as of April 1, 2018; the tax will continue to rise in $5/T increments annually to $50/T in 2021, meeting the federal PCF target price (BC Government 2018). Consumers pay the full carbon tax on low carbon biofuels; the overall tax rate is adjusted to reflect the target RFS blend level of 5% in diesel – note that the RFS is actually 4%. This results in neat biofuels such as biodiesel being taxed as if they are 95% fossil diesel and neat fossil diesel being taxed as if it were 5% renewable.

ALBERTA

Alberta introduced their carbon levy program in 2017 at $20/T, rising to $30/T in 2018 (Alberta 2018). Alberta charges a levy of $0.0775 on aviation jet fuel used for intraprovincial flights only, which is slightly below British Columbia's current rate. Alberta's current plans are to raise the carbon tax rate in line with federal legislation, which would see the price rise to $40/T in 2021 and $50/T in 2022 (Wood 2017). Alberta's carbon price increases are uncertain until the current impasse over the Trans Mountain Pipeline is resolved. As in British Columbia, consumers in Alberta pay carbon taxes on biofuels as part of a fuel mixture (Arnold 2016). Alberta's system includes the ability to be relieved from the carbon levy for biofuel blends above 5% and 10% in the diesel and gasoline pools, respectively. There is currently no consideration for carbon levy relief for renewable content blended with aviation fuels.

CAP AND TRADE IN ONTARIO AND QUEBEC

Ontario and Québec have both implemented cap-and-trade systems to reduce GHG emissions. The Québec system was implemented in 2013 and linked to California's cap-and-trade market in 2014 (Québec 2018). Ontario's system was implemented in 2017 and linked to the Québec and California emission allowance markets as of 2018 but has since been revoked by Premier Ford's Progressive Conservative government through Bill 4, the Cap and Trade Cancellation Act, 2018. The first joint auction between the three jurisdictions was held in February 2018 (Ontario 2018). Under the combined program, the highest carbon reserve price found across the three jurisdictions is to be applied in the joint auctions (ICAP 2018). Aviation fuels, and all biofuels, are excluded from cap-and-trade, potentially due to problems isolating intraprovincial, interprovincial, and international travel. This potential complication has been offered as a reason why aviation fuels are excluded in the California cap-and-trade system (Kwan 2015). At present it is unclear how the federal pricing backstop would be applied in jurisdictions that have cap-and-trade programs in place but do not apply them to aviation fuel.

EXEMPTION FOR LOW CARBON FUELS

The GGPPA exempts the carbon charge on biofuels in blends above 10% and 5% in gasoline and diesel fuels, respectively. Renewable natural gas, in any quantity, is not subject to the carbon charge. The carbon charge will, however, be applied to biojet. The approach used in the GGPPA is similar in structure to AB's exemption that was adopted in 2017.

Canada's move to adopt a federal price on carbon is poised to have a significant impact on domestic aviation. Existing carbon pricing systems each treat aviation emissions differently: Ontario and Québec's systems do not cover aviation while British Columbia and Alberta do but applied solely to intraprovincial flights. The intraprovincial approach raises fuel costs for regional carriers who may only operate within provincial boundaries. None of the systems in place contain a clear path to exempt biojet from the carbon price.

5.4 Carbon charge of future biojet production - Output Based Pricing System

At the industrial facility level, carbon pricing systems impose an "output-based" carbon price on the GHG emissions of products. Similar to the cap-and-trade design, the output-based pricing system (OBPS) develops a baseline emissions intensity standard for specific products such as crude oil, forestry products, etc. Initially, at least 70%, in Alberta, to 80-90%, federally, of emissions are exempted from the carbon charge. Furthermore, the exemption level decreases over time with higher exemptions in the 90-100% range available to certain Energy-Intense Trade-Exposed sectors. Facilities that operate below the industrial baseline have reduced exposure to the carbon tax. Compliance can be met through facility improvements, onsite emission reductions, offsets, or by effectively paying the carbon price each year.

The OBPS system will likely impact investments in Canadian biojet production that compete with imported biojet fuels produced under different, or absent, carbon pricing systems.

5.5 Assessment

To date, carbon pricing systems have not supported the blending of biojet. By not providing a clear path towards carbon tax relief, the carbon pricing system is blind to biojet's potential. Compliance with multiple carbon pricing systems is administratively inefficient, with smaller regional carriers that mainly operate on intraprovincial routes being negatively impacted. Both British Columbia and Alberta have instituted higher carbon prices on intraprovincial jet fuel use than the prices observed in the EU, but the aviation demand in these provinces is much smaller than found across the EU. The carbon cap-and-trade scheme in Québec and, until recently, Ontario do not currently include aviation fossil fuels, nor do they have a mechanism to value the emission reductions from biojet blended into aviation fuels.

The federal system is unclear on its future application to interprovincial flights. There is as yet no agreement among Canadian provinces to apply taxes to interprovincial flights, and thus the carbon pricing structures currently in place only apply to intraprovincial flights in British Columbia and Alberta. There is no international experience with carbon prices in the C$30-50 range on aviation fuels, and the threshold for biojet uptake, as opposed to offset credit purchase, is not well defined. If biojet's carbon price is assessed as if it were fossil jet fuel, similar to British Columbia's current approach, then carbon pricing becomes a significant obstacle to biojet's development in Canada.

5.6 Relevant policy recommendations

Exempt biojet from the carbon charge under GGPPA and provincial policies. At present, the carbon charge is applied to biojet under the *Greenhouse Gas Pollution Pricing Act.* If a carbon charge is applied to renewable fuels, it erodes any economic signal for fuel switching to lower carbon options. As currently written, the GGPPA exempts the carbon charge on biofuels in blends above 10% and 5% in gasoline and diesel fuels, respectively. Renewable natural gas, in any quantity, is not subject to the carbon charge. This approach used in the GGPPA is similar in structure to AB's exemption that was adopted in 2017. Biojet should be given the same treatment as renewable natural gas: a full exemption from the carbon charge. *(Sect 4, PR 1)*

Reassess the current patchwork approach to carbon pricing of aviation fuels. Canadian governments at both federal and provincial levels should collectively reconsider the existing diverse approach to carbon pricing on aviation fuel. Currently applied carbon taxes do not provide a sufficient signal to use low carbon fuels and are an unavoidable cost to the sector. To date, carbon pricing systems in Canada have failed to create a market price signal based on the GHG emissions of fuels used in Canada. In BC and AB, the carbon charge applies equally (at the same rate) to low carbon fuels and high carbon fuels. *(Sect 4, PR 2)*

Consider a consistent national approach to carbon pricing as applied to aviation fuels across the country, maintaining sector competitiveness and removing distortions between intraprovincial and interprovincial routes. A single approach to carbon pricing for aviation fuels can eliminate the current inefficient approach that inconsistently applies carbon pricing between provinces. As air travel is an essential service for many communities, special care must be taken to ensure that the imposition of the tax does not lead to route cancellations, particularly for vulnerable communities. The application of the carbon charge can be moderated through a similar structure as the current Output-Based-Pricing-System (OBPS) that applies to stationary facilities in emission-intensive and trade exposed-sectors based on their emission efficiency. Applying a performance-based OBPS to the aviation sector could incorporate tonne-kilometer results of each airline to temper carbon charge impacts on sector competitiveness and reward investments in efficiency. *(Sect 4, PR 3)*

'Recycle' (re-invest) any carbon charge revenues to support aviation sector decarbonization, including the use of biojet. The carbon charge on aviation fuels used in domestic flights may range from approximately $350M in 2019 to $950M in 2022 as the carbon charge increases from $20/tonne to $50/tonne ($0.05 to $0.13 per litre, respectively). The total financial impact will depend on how it is applied across aviation fuel use and whether interprovincial flights are subject to the charge. Despite this uncertainty in application, it is evident that the carbon charge alone will not be sufficient to create an incentive for biojet usage, as the price premium of biojet is greater than the maximum carbon charge of $0.13/litre in 2022, and biojet fuels are not exempt from the carbon charge. If carbon charges are implemented for aviation fuels, the revenue can be collected and directed towards activities that address aviation emissions strategically, such as funding collective biojet purchases, blending incentives, research and development activities, and developing domestic offsets that can be eligible for use under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). *(Sect 4, PR 4)*

Exempt biojet blended in BC airports from carbon tax charge. Currently the BC carbon tax applies equally to fossil fuels and renewable fuels. This oversight removes any incentive to lower the carbon tax charge through the use of renewable fuels. Exempting biojet (and all biofuels) from the carbon tax in BC would redress the current tax structure failures that impair adoption of low carbon biofuels. BC can consider the Alberta approach of eliminating the carbon tax on all renewable fuels that are either used in excess of their mandated blending obligation (e.g., 5% in gasoline, 4% in diesel) or when used in any quantity when there is no blending obligation such as biojet. *(Sect 4, PR 21)*

Exempt biojet blended in AB airports from the carbon levy. Alberta's current implementation of the carbon levy provides relief for renewable content when blended above 10% in gasoline and above 5% in diesel. This levy adjustment creates an economic signal for higher blends of renewable fuel to be used. This same treatment should be applied to biojet fuel blended in any quantity. *(Sect 4, PR 22)*

6. Clean Fuel Standard and Low Carbon Fuel Standard

6.1 Policy tool description

The Clean Fuel Standard (CFS) and Low Carbon Fuel Standard (LCFS) are similar policy approaches that regulate fuel carbon intensity (CI) reductions over a specified period of time rather than prescribing specific emission mitigation activities. The CI is calculated using a life cycle assessment (LCA) model and typically reported in grams of CO2e per megajoule (g CO2e/MJ). The CFS/LCFS allows for the generation and transfer of compliance credits, which can be separated from the low carbon fuels they are derived from. This permits some obligated parties to blend higher levels of low carbon fuels and other obligated parties to blend lower levels, while the CI requirements across the jurisdiction are still met via trading of credits among obligated parties (CARB 2017; Scott 2017). Additional fuel types and uses can be included within LCFS/CFS policy's scope.

6.2 International low carbon fuel standards

California was the first jurisdiction to approve a low carbon fuel standard. A 2007 Executive Order called for the CI of California's transportation fuels to be reduced by at least 10% by 2020. The California Air Resources Board approved the *Low Carbon Fuel Standard* (LCFS) in 2009 and implementation began on January 1, 2011 – four years after the Executive Order (CARB 2018b). In 2018, California extended the LCFS to 2030 with a target of 20% CI reductions (California Air Resources Board 2018). California uses the CA-GREET LCA model (a modified GREET model for the California market) to determine the specific CIs for fuel sources within the marketplace and includes the calculation of estimated indirect land use change (ILUC) impacts (CARB 2018b). As of 2019, California's LCFS policy is moving forward allowing biojet blended in California airports to generate compliance credits which can then be sold to obligated parties in the ground transportation subsector (CARB 2018a).

In the EU, an LCFS-type policy called the Fuel Quality Directive (FQD) was implemented along with the Renewable Energy Directive (RED). Amendments to the RED require a 6% reduction in CI from a 2010 baseline by 2020 (EU 2009b). Due to concerns about potential ILUC, and the difficulty in obtaining accurate ILUC factors, the European Commission instead proposed limiting the proportion of food crop-based biofuels to 7% of the fuel supply.

6.3 Federal Clean Fuel Standard

The Clean Fuel Standard is poised to have a major impact on Canadian renewable fuel production and use. The CFS is one of the primary federal climate action strategies under the 2016 *Pan-Canadian Framework.* The primary goal of the regulation is to achieve 30 MT of annual GHG reductions by 2030. The CFS will use a partitioned approach, with different targeted GHG reduction requirements for each fuel type (liquid, solid, gaseous). A regulatory design framework was published on December 23, 2017 (ECCC 2017) presenting several key elements of the program. In July 2018, Environment and Climate Change Canada updated the timeline and process for the CFS to delay implementation of regulations for gaseous and solid fuels to 2023, and to proceed with liquid regulations in 2022. In December 2018, ECCC released the CFS Regulatory Design Paper and stated that the final CFS regulation will be published in 2020.

AVIATION ENGAGEMENT IN THE CFS PROCESS

The Canadian aviation sector is participating in the Technical Working Group (TWG) and the Multi-Stakeholder Consultative Committee (MSCC) of the Clean Fuel Standard via the National Airline Council of Canada. At the time of this report's completion, the TWG and MSCC are active as the CFS proceeds through the regulatory development process.

The MSCC is comprised of representatives from key industry associations, academia, environmental non-governmental organizations, provincial and territorial governments and other federal departments. The MSCC meets periodically to provide a forum for ECCC to update all interested parties on progress and for stakeholders to provide advice and input on the draft regulations.

The TWG is a small group of technical subject experts from the affected industries, non-government organizations, and academia who provide technical advice, data, and feedback on the CFS regulatory design.

CFS AND PROPOSED APPROACH TO AVIATION FUELS

In October 2018, Environment and Climate Change Canada presented its 'Provisional Approach to Aviation Fuels' that specifies a potential approach to aviation fuels under the CFS. ECCC specified that aviation gasoline would be excluded from any CFS obligation as it contributes a relatively small quantity of emissions and there has been limited development of lower carbon substitutes.

Importantly, ECCC confirmed that producers and importers of fossil jet fuel would have reporting requirements for fuels they produce and import for domestic use and that the use of renewable fuel is eligible for credit generation under the CFS. As currently formulated, the CFS contains the flexibility that allows an aviation fuel producer or importer to achieve compliance without being required to reduce the CI of aviation fuel. Instead, obligated parties such as fuel producers and importers, which would include airlines that import aviation fuel, can create credits from blending low carbon fuels in other end use sectors outside of aviation, facilitate fuel switching, or purchase CFS credits from the compliance market.

IMPACTS OF THE PROPOSED APPROACH TO AVIATION FUELS

A concern with the proposed 'Provisional Approach to Aviation Fuels' is that it may not incentivize emission reductions within the aviation fuel sector itself. Rather, the provisional approach may lead to CFS credits being generated from other sources such as ethanol in gasoline, biodiesel/renewable diesel in distillate, etc. as these fuels have existing production capacity and lower production costs. If credits derived from those fuel types are cheaper than biojet, they may be preferred to cover the CFS obligations of jet fuel. This would reduce the economic signal for biojet use as it would rely on obligated parties to pay a premium for biojet as compared to other low carbon fuels or CFS credits. Increases in aviation fuel costs in Canada may harm sector competitiveness and cause consumers to switch to US-based flights to avoid carbon costs. As the CFS regulatory development process continues through to 2020, there will be opportunities for ECCC to consider approaches that address these issues and enable wider biojet adoption.

BRITISH COLUMBIA'S LOW CARBON FUEL STANDARD

The province of British Columbia is currently the only Canadian jurisdiction that has a low carbon fuel standard. The Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR) has been in place in BC since 2008 and includes both volumetric and CI reduction requirements—5% renewable in gasoline and 4% in diesel with an overall CI reduction requirement of 10% from 2010 levels by 2020. In December 2018, via the CleanBC plan, the province signaled its intent to increase the Low Carbon Fuel Standard targets to 20% below the 2010 baseline by 2030 and to achieve 650 MLY of annual clean fuel production in the province (Government of British Columbia 2018). The RLCFRR offers obligated parties the option to meet up to 25% of their CI reduction requirement using 'Part 3 Agreements', which provide credits to fuel suppliers who undertake actions that promote the uptake of renewable fuels "sooner than would occur without the agreed-upon action" (BC Government 2016).

The Part 3 Agreement structure has the potential to support activities and infrastructure development that would enable biojet production, distribution, and use in BC. Part 3 Agreements are limited to fuels that substitute for those included in the RLCFRR which at present only includes gasoline and diesel. Aviation fuels are not currently part of the RLCFRR; their inclusion would require a change to the enabling legislation for the regulation, the *Greenhouse Gas Reduction (Renewable & Low Carbon Fuel Requirements) Act.*

6.4 Assessment

Low carbon fuel standards, clean fuel standards, and similar type policy instruments, are now being put in place to either enhance or supersede renewable fuel mandates. They may become a primary mechanism of providing a market signal for biojet production and use.

Unlike volumetric renewable fuel mandates, low carbon fuel standards require an assessment of GHG intensity reductions associated with fuel pathways using a variety of feedstocks and production techniques.

6.5 Relevant policy recommendations

Design the CFS so that biojet use creates compliance credits to positively enable blending economics. A functioning CFS compliance credit market can allow sector operators to work with other CFS participants to maximize the value and liquidity of credits that may accrue from sector activities. Biojet production and blending economics will be enhanced by the ability to generate and sell credits into a CFS compliance credit market that has frequent transactions. The compliance credit market should allow the participation of brokers and non-obligated parties in order to increase liquidity. *(Sect 4, PR 5)*

Allow a multiplier or 'factor' approach to CFS credit generation for biojet used in domestic aviation to address the higher production cost of biojet in comparison with other renewable fuels and the nascent state of commercial biojet production. Allow the multiplier to be used for a limited duration and quantity. The use of a multiplier for biojet production has been proposed as a means to bridge the price and production cost gap by incentivizing biojet use without a specific aviation fuel mandate. This structure is useful in the CFS because there are no specific blend requirements for aviation fuels. HEFA biojet, the most common biojet fuel, is produced from a similar technology platform

as renewable diesel, but with additional processing requirements, and thus higher cost of production. Also, jet fuel historically sells at a discount to diesel, making the further processing required to produce biojet less attractive without inducements (Davidson 2014). A multiplier structure can be used for a limited duration to ensure that it does not result in reduced renewable fuel use overall. *(Sect 4, PR 6)*

Design the CFS to discourage fuels derived from feedstocks that negatively impact biodiversity, critical species habitats, or cause the conversion of land with high carbon stocks. Prohibitions on detrimental feedstock supply chains can enhance social acceptance of biojet and the CFS. Incorporating environmental sustainability into the CFS design in a clear way can reduce reputational risk to airlines that choose to use biojet. The perceived longevity and stability of the CFS is important to attracting investment in biojet supply chains. Therefore, policy design that protects the social license of the CFS is worthwhile. *(Sect 4, PR 7)*

Align the fossil jet fuel carbon intensity value used in the CFS with ICAO's global value. Initial model work done by Environment and Climate Change Canada (ECCC) for the CFS uses 83 g CO2e/MJ as the interim proposed CI value for aviation jet fuel. ICAO's global average value is 89 g CO2e/MJ for fossil jet fuel. While there are reasons for value divergence (different crude slates, refinery efficiency, LCA model approaches, etc.), there should be a technical rationale for using a different value under the CFS than ICAO's value. *(Sect 4, PR 17)*

Designate jet fuel as 'opt-in' within the expanded BC LCFS as announced in the CleanBC plan. The government of British Columbia should update the *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* to schedule aviation fuels. Once updated, BC can take a similar approach to the EU REDII and the California LCFS: i.e. recognize the ability to generate credits through biojet use and assign aviation fuel a zero CI reduction target. *(Sect 4, PR 19)*

Enable biojet development activities to be eligible under the Part 3 credit program. BC's Part 3 credit program can be a useful tool for funding infrastructure and development activities that can create LCFS credits. Biojet projects should be considered once aviation fuels are eligible under the BC LCFS. *(Sect 4, PR 20)*

7. Renewable Content Blending Mandates

7.1 Policy tool description

This type of fuel regulation creates an obligation for fuel producers and importers, of generally gasoline and diesel used for transportation, to supply an average renewable fuel content based on the volume of fuel they produce, import, or 'place into market' in the jurisdiction. The regulations typically include provisions that govern the creation of compliance units, allow for trading of these units among participants, and specify record-keeping and reporting to ensure compliance (Environment and Climate Change Canada 2010). Renewable content blending mandates can establish minimum GHG, biomass feedstock eligibility criteria, sustainability performance of fuels, and other modifications that are reflective of their regulatory and political context.

7.2 International renewable content mandates

Multiple countries have implemented renewable content mandates, including 14 countries across North and South America including the US and Canada, 12 countries in Asia and the Pacific, 11 countries in Africa, and 2 countries in Europe aside from the member countries in the European Union (Lane 2018). The Renewable Energy Directive, taken across the entire EU, is the largest single renewable fuel mandate in place worldwide, followed by the Renewable Fuel Standard (RFS) in the US.

EUROPEAN UNION

Presently the EU is transitioning from the 2009 Renewable Energy Directive (RED) to the 2018 Renewable Energy Directive (REDII). The 2009 Renewable Energy Directive (RED) required all EU countries to ensure that at least 10% of their transport fuels come from renewable sources by 2020 (EU 2009a). The RED is part of a broader EU requirement to source 20% of total energy from renewable sources by 2020 and proposes targets of 27% by 2030, with separate obligations established for each member country (EU 2016).

The revisions to the RED developed between 2016¬¬–2018, and adopted by the Parliament and Commission in November 2018, introduce a 7% cap on the contribution of crop-based biofuels to renewable fuel obligations. The European Commission has yet to specify the feedstocks that pose "high indirect land use change risk" versus those which pose a "low risk". This risk-based approach updates the more specific language that referred directly to palm oil in the pre-November 2018 legislation draft.

From 2019 until 2030, the proportion of high risk indirect land use change (ILUC) biofuels to the EU's energy goals are to be gradually phased out (Morgan 2018).

It is yet to be determined what role sustainability certified crop-based biofuels will play in the future of the RED as member states are given flexibility in their implementation approach to the transportation aspect of the Directive, and the Commission has yet to define criteria for ILUC risk.

For aviation fuels, under the RED and REDII, there are no specific renewable blend requirement for this segment of the fuel market. The RED utilized multipliers that can give renewable fuels designated as 'advanced' the compliance benefit of 2x–4x times their use. As biojet is scheduled as an advanced biofuel, concerns were originally raised that aviation biofuels could distort progress towards national renewable energy and GHG mitigation goals; their use can be multiplied when assessing progress towards these targets (EU 2017a). Aviation and marine

fuels are not included in the mandatory fuel volumes under REDII. Fuels supplied to the aviation and shipping industry will receive a multiplier of 1.2x; REDII contains multipliers of 4x for electric vehicles and 1.5x for electric trains.

UNITED STATES

The US Renewable Fuel Standard (RFS), was established under the *Energy Policy Act* of 2005 (RFS1) and expanded under the *Energy Independence and Security Act* of 2007 (RFS2) (USDOE 2005; USDOE 2007). RFS2 mandates 136.3 BL of biofuel be consumed in the US annually by 2022, of which a maximum 56.8 BL can be corn-based ethanol. Blending requirements are established annually by the EPA for cellulosic biofuels, biomass-based diesel, advanced biofuels, and total renewable fuel. Each of these categories has specified GHG performance thresholds and applicable fuel types.

The volumetric blend requirements are set using Renewable Volume Obligations (RVOs). Parties achieve compliance with their RVO by securing sufficient Renewable Identification Numbers (RINs), which are considered the 'currency' of the RFS2 program. RINs, which are assigned to a batch of fuel, are generated by biofuel producers. RINs can stay assigned to the batch or be separated from the physical fuel. Market participants can trade RINs, which are ultimately acquired by obligated parties, such as fuel suppliers, and subsequently retired for compliance (US EPA 2018). Aviation biofuels are eligible to receive D5 RINs under the RFS, but due to the higher cost and lower yield of biojet relative to renewable diesel and supportive RIN values, production preference is favoured towards renewable diesel. The RFS2 does not currently apply to aviation fuels produced or used in the US.

7.3 Canadian renewable content mandates

The primary policy approach used in Canada to increase renewable fuel use has been the use of volumetric renewable content blending mandates. The federal *Renewable Fuels Regulations* (RFR) (SOR/2010-189), established in 2010, requires a minimum renewable liquid fuel content in gasoline and diesel pools. The levels are currently set at 5% for gasoline and 2% for diesel, on a volumetric basis. The federal RFR does not include a mandate for renewable content in aviation fuels (ECCC 2017c), though it allows for aviation biofuels to be used as a compliance option in the distillate pool. There are no GHG performance requirements under the federal RFR, which means that biofuels are not selected based on their carbon intensity (ECCC 2017c). It was recently announced that the federal RFR will be maintained through the introduction of the *Clean Fuel Standard;* in the longer term, however, the volumetric blend provisions will be considered for phase out (ECCC 2018b).

Provincially, five jurisdictions have established their own renewable content mandates. Some of these mandates are higher than the federal RFR in terms of both blend percentage and minimum GHG requirements of eligible fuels. In both Ontario and British Columbia, renewable fuel regulations in 2018 require 4% renewable content in diesel and include a requirement to reduce GHG intensity of fuels below that of conventional petroleum-based products (Province of Ontario 2018; Province of British Columbia 2018). Alberta has an RFS set at the same level as the federal RFR but requires renewable fuels to have 25% lower emissions intensity than fossil fuels (Alberta 2018). In Manitoba and Saskatchewan, renewable fuel regulations require higher renewable content in the gasoline pool, at 8.5% in Manitoba and 7.5% in Saskatchewan (Province of Manitoba 2018; Province of Saskatchewan 2018). In both federal and provincial RFR/RFS regulations, there are currently no requirements for mandatory blending of renewable aviation fuels.

7.4 Assessment

Renewable fuel standards are now expanding beyond straightforward volumetric or energetic mandates to include GHG emission intensity measures and often include sustainability requirements. There has been little progress towards increasing renewable fuel mandates without also putting in place GHG thresholds or CI reduction targets. This is the case in Canada, where the government indicated in 2017 that the existing federal Renewable Fuels Regulation would potentially be replaced with the Clean Fuel Standard. Generally, the effectiveness of a shift away from the volumetric certainty of RFS-type policies is yet to be seen. Blending mandates provided a clear policy signal for development of renewable fuel production capacity with the caveat that they may not provide the clear signal for innovation to lower the CI of renewable fuels, as is the case with the LCFS and CFS policies.

For aviation fuels specifically, a renewable content standard that requires the use of biojet has not been implemented. Without sufficient supply of biojet, any renewable content obligation would not be technically feasible. Furthermore, to the extent biojet fuel supplies expand to meet any proposed blending requirements, scarcity of supply will increase fuel costs for airlines which would then be passed on to passengers, likely leading to use of alternative travel routes, including flying from US cities such as Buffalo instead of Toronto or Bellingham instead of Vancouver.

7.5 Relevant policy recommendation

Policy 8. Volumetric biojet use obligations are not recommended. Application of a renewable fuel standard (RFS) to fuel used for domestic flights could put Canadian airlines at a disadvantage relative to US and international carriers. The apparent simplicity of a volumetric blending obligation for aviation fuel is counterbalanced by the large financial cost it would add to aviation fuels. Increased cost and subsequent consumer price impacts make an RFS policy structure a less appealing option. Even though the RFS has been effective in enabling biofuel capacity creation, implementing volumetric requirements specific to the aviation sector in Canada would have profound implications for the industry due to the international nature of aviation and lower elasticity of demand compared with road transportation. *(Sect 4, PR 8)*

8. Tax Credits and Exemptions

8.1 Policy tool description

This broad category includes any tool that uses the tax system as an enabling mechanism to incentivize low carbon fuel production and/or use. It encompasses financial mechanisms that can modify the depreciation schedule of low carbon fuel assets, create income tax deductions for companies in specific sectors, and modify the excise tax collected on different fuels. Generally, the tax code is perceived as a more stable funding mechanism than program or grant funding.

8.2 International tax credits and exemptions

Adjusted tax treatment of renewable fuels can be an effective means of creating a market signal for their production and use. For example, 'blender credits' can be a direct government payment or refundable tax credit to transportation fuel suppliers for blending lower carbon renewable fuels with fossil fuels. Examples of blender credits include the US Biodiesel Blender's Tax Credit (BTC), which was extended from 2005 to the end of 2017 and provided a refundable tax credit of US$0.27/L for biodiesel blended with diesel, and the US Volumetric Ethanol Excise Tax Credit (VEETC), which expired at the end of 2011 and provided $0.12/L (previously $0.13/L) of ethanol blended in gasoline (USDA 2008; USDOE 2017). As an annually authorized tax program, the US BTC has been allowed to lapse and then been retroactively extended by Congress several times since its inception.

There is ongoing uncertainty in the US about the continuation of the BTC and whether it should be replaced with a producer tax credit (PTC). The preference of PTC over BTC reflects that imported fuels are eligible for the BTC, with over US$900 million in credits generated in 2016 based on imported biodiesel from Argentina and renewable diesel from Indonesia (Kotrba 2017; USEIA 2017). The preference of PTC over BTC diminished following the imposition of anti-dumping and countervailing duties on biodiesel/renewable diesel imported from Argentina and Indonesia.

Refundable producer tax credits could be used to incentivize domestic production of biojet. An example of this mechanism includes the US Second Generation Biofuel Producer Tax Credit, which expired at the end of 2017 and provided a refundable tax credit of US$0.27/L for 'advanced' biofuels (USDOE 2017). While the producer credit approach would ensure that the tax credit benefit is allocated to domestic producers, its structure may not inherently lead to domestic consumption of renewable fuels.

Fuel specific excise tax exemptions can be used to support renewable fuels use as excise taxes constitute a significant portion of the price of transportation fuel. One method that has been used to support consumption of biofuels is a tax rate reduction or exemption applied to improve the economic competitiveness of biofuels relative to the fossil fuel they substitute. For aviation fuels, the Chicago Convention determines that international aviation fuels are exempt from excise taxes. Therefore, there may only be a domestic opportunity to improve the competitiveness of biojet relative to fossil jet using excise or other fuel tax exemption.

8.3 Canadian tax credits and exemptions

Excise tax exemptions are useful to enhance the economics of renewable fuel blending. Exemptions have been provided in limited duration for renewable fuels at both federal and provincial levels. Ethanol was granted exemption from the $0.10/L federal excise tax between 1992–2008. Biodiesel was granted exemption from the $0.04/L federal excise tax between 2003–2008 (Charrière 2009). This same treatment, the relief of the $0.04/L federal excise tax on aviation fuel for biojet, is an option to enhance the economics of biojet use. Canada has not yet utilized the blender tax credit policy structure.

Producer credit programs, such as the federal ecoENERGY for Biofuels Program (ecoEBF) and the Alberta Bioenergy Producer Program, have been previously implemented. The ecoEBF program provided ethanol producers with credits over the 2008–2017 period, ranging from C$0.10/L in 2008/09 to C$0.03/L in 2016/17, while biodiesel producers received credits ranging from C$0.26/L in 2008/09 to C$0.04/L in 2016/17 (NRCan 2016). Producer incentives like the ecoEBF program were a major initiative of the federal government to develop new Canadian biofuel production capacity (Stephen et al. 2013). Over the period, the ecoEBF program was more effective in expanding ethanol production capacity compared with biodiesel or renewable diesel capacity—the latter of which is a similar production pathway to HEFA biojet. The ecoEBF program ended on March 31st, 2017 and was never applied to aviation biofuels.

Alberta's Bioenergy Producer Credit Program, later renamed to the Bioenergy Producer Program, was introduced in 2006 and extended through to 2016. It was further revised in 2017 and currently runs through to March 31, 2020 (Province of Alberta 2018). Alberta's program has supported investment to build Canada's largest biodiesel plant and the first global scale waste-to-ethanol facility, among other projects.

8.4 Assessment

If implemented correctly, producer credits are an effective tool to attract investment in domestic production capacity as these credits, like renewable fuel mandates, can provide a degree of financial certainty for producers which reduces the risk associated with developing new projects. Blender credits incentivize the use of a given fuel are most effective when there exists either production capacity of the relevant fuel or enabling programs like producer credits or capital cost support programs which serve to attract investment. Trade flows and the ability of other countries to supply biojet to the Canadian market must be taken into consideration prior to establishing a biojet blender credit. Tax and funding programs must be consistent with Canada's obligations under World Trade Organization (WTO) rules and international trade agreements.

A producer credit could enable biojet producers in a more direct way than a blender tax credit if there is another mechanism to pull the fuel into the market. A producer-credit can be 'performance-based', tied to the CI of the fuel. In general, producer credits are more effective at reducing domestic GHG emissions from products that are more difficult to export, such as heat, than transportation fuels which are traded globally. Canadian policies have to be globally competitive to attract investment in Canadian assets. In particular, Canada needs to be positioned to compete with investments and trade flows across the Canada –US border.

8.5 Relevant policy recommendation

To attract capital investment, Canada must signal intent to expand Canada's biojet production capacity through comprehensive, long-term targeted measures. As a component of a broader strategic plan to increase clean fuel production and use in Canada, biojet can be a key driver for economic growth and green jobs. To realize these economic benefits, conducive conditions must be created for Canadian businesses and communities to make responsible investments in an emerging sector that can remain competitive in an expanding global market for clean fuels. The Federal government can support this by clarifying eligibility for renewable fuels and biojet production/use projects within existing programs and funding entities (Export Development Canada, Business Development Canada, Sustainable Development Technology Canada, etc.) *(Sect 4, PR 9)*

Implement a biojet producer credit program to create domestic biojet capacity. A producer credit is a policy structure with which Canada has experience at both federal and provincial levels, although not as of yet for aviation fuels. Producer credits are proven effective and are understood by capital markets and project developers. This policy structure can allow Canada to be a biojet exporter in addition to having Canadian-made biojet used on international flights departing from Canada. The producer credit should be performance-based, i.e. based on carbon intensity reduction, and long-term, extending to at least 2030. *(Sect 4, PR 11)*

INCENTIVIZING BIOJET USE THROUGH BLENDING INDUCEMENTS:

Exempt biojet from the federal excise tax on aviation jet fuel ($0.04/litre) to improve the economics of its use. Biojet should be afforded similar treatment as ethanol and biodiesel were during their first years of use. The excise tax exemption can be removed once use and production are established. *(Sect 4, PR 13)*

Explore refundable tax credits accessible by airlines and aviation fuel suppliers when blending biojet for flights from Canadian airports to domestic and international destinations. Blender credits for biojet are a realistic option to promote biojet use in airport fuel systems. It would help fuel blenders bridge the gap between higher priced HEFA compared with fossil jet. This could also be implemented via relief from excise taxes on the biofuel component of the blend (biojet + aviation fuel). *(Sect 4, PR 14)*

9. Capital Support & Loan Guarantees

9.1 Policy tool description

This policy tool category includes government directed mechanisms that reduce the net capital cost of establishing production capacity by providing access to project capital under comparatively favourable terms. Governments can enable a sector's development through assistance with upfront construction costs in the form of non-repayable grants, low or zero interest loans, or loan guarantees.

A loan guarantee is where a third-party lender provides financing at a competitive interest rate and the government guarantees repayment in case of default. Direct government loans and loan guarantee programs lower the cost of financing by reducing repayment risks associated with the loan. Loan and loan guarantee approaches can be combined with other instruments, such as volumetric content requirements, LCFS, or tax credits, that encourage production and consumption of specific fuel types.

9.2 International capital support & loan guarantees

The primary international loan guarantee programs are located in the United States and the European Union.

UNITED STATES

The US government has used loan guarantees extensively to support construction of first-of-kind demonstration and commercial-scale cellulosic and advanced biofuel plants (USDOE 2016; USDA 2017). The US Department of Energy's Loans Program Office helps innovative energy, tribal energy, and advanced auto manufacturing projects overcome hurdles in obtaining loans to help bring new technologies to commercial deployment. The Loans Program Office manages a portfolio of over $30 billion in loans, loan guarantees, and conditional commitments covering over 30 projects. Of this, US $4.5 billion is dedicated for innovative renewable energy and efficient energy projects (USDOE 2018).

EUROPEAN UNION

The EU has multiple programs that enhance viability of renewable fuel projects. Under Horizon 2020, approximately €5.9 billion is directed towards energy projects in the EU's Research and Innovation Programme. Funded projects aid the establishment of clean energy technologies, including smart energy networks, tidal power, and energy storage (EU DG ENER 2018).

The NER 300 program uses proceeds from the sale of carbon allowances to fund demonstration projects for carbon capture and storage (CCS) and renewable energy. To date, €2.2 billion has been awarded to 38 renewable energy projects and one carbon capture project (EU DG ENER 2018).

9.3 Canadian capital support & loan guarantees

Canada has experience with and has been successful in growing the domestic biofuel industry through providing capital support for biofuel capacity build-out. The federal Ethanol Expansion Program, along with provincial government contributions, played a significant role in growing the domestic ethanol industry during 2003-2005 (Canada 2004). The Canadian capital support program utilized non-repayable grants, which are the simplest form of capital support. This means the public—or emitters, if paid by carbon pricing funds—are directly supporting construction costs.

9.4 Assessment

By providing loans directly or by guaranteeing loans, governments can show confidence in the longevity of the policies they have instituted and significantly improve the business case for companies seeking to establish or increase biofuel production capacity.

An issue with capital support and loan guarantees is that the projects selected for development still have to complete financing, construction, and start-up; there is no guarantee that the projects will eventually commission. This is in contrast to a producer credit, which is only payable upon actual production of the eligible fuel product. In the case of HEFA biojet, where there is relatively low technology risk, a loan guarantee program may be utilized effectively. As demand for capital support and loan/loan guarantees may be greater than available funds, the government must assess which projects to select. This contrasts with a producer credit that is only payable once a facility completes commissioning and begins production.

A critique of loan guarantees is that primary lenders do not sufficiently assess risk, which can lead to a higher likelihood of non-performing loans (IMF 2006).

9.5 Policy recommendation

Leverage industry funds via loan guarantees and capital grant programs to help establish biojet production capacity and supply chain infrastructure development using clear criteria to guide project choice. The loan guarantee/capital grant structure allows for non-dilutive funding at more attractive terms than would be otherwise available for capital intensive projects in new sectors. If competitive with programs in other jurisdictions, a capital cost support program would help attract investment in Canada. As capital support and loan programs require the federal government to choose recipients for support rather than basing support upon achieving biojet production, as with a producer credit, the criteria used to assess applicants should be developed to select projects with high likelihood of viability. *(Sect 4, PR 10)*

Permit accelerated capital cost allowance for biojet production facilities. For Canada to attract capital to build and operate advanced biofuels refineries, we recommend full eligibility for biofuels production assets, including biojet, within the Class 43.1 and 43.2 provisions of the Income Tax Regulations that pertain to accelerated capital cost allowance (ACCA) and flow-through treatment. Given the timeline for biojet build-out, we recommend the extension of ACCA to 2030. Current eligibility for fossil fuel assets under Class 43.1 and 43.2 provisions disadvantages liquid biofuel production. *(Sect 4, PR 12)*

10. International and Voluntary Measures

10.1 Policy tool description

Voluntary measures are a means of self-regulation and, when done as an industry, are a way for a sector to establish performance goals, provide means to achieve them, and ways to measure progress. Voluntary measures can be created through collaboration between government, industry, and civil society. Voluntary measures enable a sector to pursue action without being required to do so by regulations.

10.2 International voluntary measures

Significant voluntary commitments to reduce GHG emissions have been made by the international air transport community. The International Civil Aviation Organization (ICAO) is the United Nations agency set up to administer the Convention on International Civil Aviation. ICAO adopted Resolution A37-19 on climate change in 2010, which set the goal of increasing the energy efficiency of the aviation sector by 2% per year between 2012 and 2020, and further defined an aspirational goal of maintaining this level of improvement between 2021 and 2050. The Resolution also set the aspirational goal of carbon neutral growth (CNG) after 2020.

To implement the resolution, the members of ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016. In the pilot phase (2021-2023) and first phase (2023-2026) of operation, CORSIA will operate on a voluntary basis for a subset of all member countries—currently 73 of 192 members, including Canada, the USA, the EU, and China (ICAO 2018a). After 2026, CORSIA will apply to almost all ICAO members, with the exception of very small emitters and select developing countries. CORSIA focuses on emissions associated with international travel, i.e. between two countries. In the first phase, the agreement will only apply to international routes that link participating member states, but as time moves forward the number of routes covered by the mechanism will increase as the participating country list expands (ICAO 2018a). CORSIA is primarily an offsetting mechanism, which will allow aviation companies to purchase offsets for their international travel segments. ICAO endorsed a new international CO2e standard certification requirements in 2016, though the exact criteria used to select eligible offsets for the CORSIA program have not yet been adopted by ICAO (IATA 2018).

The International Air Transport Association (IATA) is the body that represents commercial airlines around the world. In 2010, IATA followed ICAO in crafting a resolution on carbon-neutral growth post-2020 (CNG2020; ICAO 2013). The IATA resolution closely followed ICAO's format, with two important differences: it called for 1.5% average annual fuel efficiency improvements between 2010 and 2020, as compared to the ICAO call for a 2% annual improvement; and it called for carbon neutral growth (CNG) across the industry rather than emphasizing only international travel legs. In 2013, at their 69th Annual General Meeting, IATA endorsed this resolution (ICAO 2013).

In addition to the carbon neutral growth after 2020 strategy, IATA, in partnership with ClimateCare, introduced a carbon offset program in 2010 (IATA 2015. This program has invested in a wide range of projects

including forest protection in Kenya and solar hot water heating projects in South Africa. This offset program may be considered as an option for airlines in countries that are participating in the first phases of CORSIA.

At the current time, it is not clear what penalties are in place for countries that fail to conform with ICAO's resolution, or for commercial partners that do not meet the IATA requirements. Under Article 88 of the International Convention on International Civil Aviation, countries found to be non-compliant with the standards of ICAO can lose their voting powers (ICAO 2018b). ICAO member states are expected to enforce the offsetting requirements of CORSIA on their respective carriers, but the penalty mechanism for non-compliance are not yet clear (ICCT 2017).

10.3 Voluntary measures in Canada

As a member of ICAO, Canada has been working to reduce GHG emissions from aviation related activities. Efforts in this area date back to 2005 when a voluntary agreement was signed between Transport Canada and the Air Transport Association of Canada (ATAC) on the Reduction of Aviation Greenhouse Gas Emissions. This agreement was set out as a Memorandum of Understanding (MOU) between the parties and was the first voluntary agreement of its kind to be based on ICAO's template. The primary goal set out in the 2005 MOU was to reduce GHG emissions on a per unit basis, i.e. GHG intensity, across the ATAC fleet by an average of 1.1% per annum for a cumulative improvement of 24% reduction in GHG intensity, as compared to 1990 levels, by 2012 (Transport Canada 2013). The industry successfully met its goal; from 1990 until 2011, the Canadian aviation industry saw an increase in GHG emissions of 31.9%, but the intensity of these emissions dropped substantially—by 31.6% over the same period, or by 1.8% per year (Transport Canada 2013).

The most significant voluntary measures to date are in Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation (Action Plan) that began in 2012. The Action Plan, developed by a joint industry-government Working Group on Aviation Emissions, set an aspirational goal to improve fuel efficiency over 2005 baseline levels by an average annual rate of 2% per year between 2012 and 2020. This Action Plan highlights multiple secondary measures for Canadian carriers, including the development of alternative fuels and regulatory measures to help address GHG emissions from aviation. By 2016, absolute CO2e emissions rose to 19.5 MT of CO2e per year from 12.6 MT in 2005, representing an average rise of 5% per year (Transport Canada 2017). The sector has become significantly more efficient over this period; emission rates have fallen from 1,044 g CO2e per revenue tonne kilometre (RTK) in 2005 to 866 g CO2e/RTK in 2016, a decline of 15% or approximately 1.4% per year (Transport Canada 2017). ATAC and the National Airlines Council of Canada (NACC) collect data from their membership in support of the Action Plan.

10.4 Assessment

As members of IATA, Canada's major airlines—Air Canada, WestJet, Porter, Air Transat, and Cargojet Airways—have committed to carbon neutral growth beyond 2020 (IATA 2013). It is expected that improvements in efficiency will not be significant enough to offset growth in overall emissions, and that the industry will need to introduce new mechanisms, including biojet, in order to meet its goal of carbon neutral growth. Furthermore, given Canada's dedication to meeting the international goals set by ICAO, governments will need to play a role in achieving them.

Voluntary actions are useful in familiarizing a sector with available options to reduce emission intensity, generally by implementing cost-saving measures like increased efficiency. Once voluntary measures begin adding real costs and competitive distortions to airlines, their attractiveness declines if not similarly implemented by other competing airlines.

10.5 Relevant policy recommendations

Utilize a collaborative approach between government and industry for aviation environmental policy. Canada's Action Plan to Reduce Greenhouse Gas Emissions from Aviation (Action Plan) demonstrates that airlines and the federal government can work together to pursue voluntary measures that reduce emission intensity. The approach that created the Action Plan, coordinated target setting by dialogue between industry and government, should be maintained and utilized for establishing measures the Canadian aviation sector can pursue for achieving domestic and international targets. The Action Plan working group should serve as a forum to identify and address cross cutting impacts from aviation policy at provincial, federal, and international levels. *(Sect 4, PR 25)*

Use the Action Plan working group to consider how to direct carbon charge funds that may be collected from the aviation sector. If carbon charge funds are collected from the aviation sector, they should be deployed toward environmental initiatives within the aviation sector. The stakeholder group formed through the duration of the Action Plan process is positioned to offer strategic guidance for the use of carbon charge funds. A potential use could be the collective purchase of biojet fuel, with the credits for its use allocated on a pro rata basis determined by the amount of carbon charge paid. *(Sect 4, PR 26)*

Consider voluntary actions as pre-compliance activities when setting baselines under any future regulations. Future regulations considered for use in the sector should reference progress already achieved under voluntary measures such as the Action Plan. This would serve to recognize and transition voluntary activities under the Action Plan into compliance within any future legislated requirements. If voluntary actions undertaken by a sector are not recognized in subsequent regulations or are incorporated without recognition into the baseline against which future reductions must occur, it removes the rationale for future voluntary action and proactive engagement. *(Sect 4, PR 27)*

Ensure Canadian feedstocks and production pathways will be recognized under CORSIA. Work is ongoing within the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) to develop the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA will utilize sustainability criteria

as developed by the CAEP and have performance against it certified by a CORSIA approved sustainability certification scheme. Currently, CORSIA eligible fuels are defined as having 10% GHG reductions below the ICAO global average jet fuel carbon intensity of 89 g CO2e/MJ. As the LCA tool to determine GHG values and the actual sustainability criteria are still under development, Canada must ensure that its various biojet feedstocks will be deemed eligible. Any prohibitions on agriculture or forestry biomass eligibility will negatively impact Canada's ability to supply biojet for use under CORSIA. *(Sect 4, PR 15)*

Align compliance reporting requirements between CORSIA and domestic systems (e.g., GGPPA, CFS) to minimize total administrative cost. Creating congruence between compliance options in both ICAO and CFS can help the aviation sector find the most efficient way to reduce emissions while minimizing administrative burden. Where possible, similarity in reporting approaches should be pursued. *(Sect 4, PR 16)*

Consider developing domestic offset projects for use under the CORSIA system. Canadian airlines will participate in ICAO's CORSIA system to offset emissions from international flights. These offsets can be sourced from Canadian projects, thereby leading to domestic economic benefits and higher-quality offsets. *(Sect 4, PR 18)*

11. Research & Development Support

11.1 Policy tool description

Research and development programs help establish and foster innovation by building domestic intellectual capital to enable long-term competitiveness of a sector. Basic research can be conducted at university and government labs, while technology development—including pilot, demonstration and first-of-kind commercial scale deployment—is performed in the private sector, often with university involvement. In some cases, government and university labs have played an active role in early stage technology development.

11.2 International research & development support

Due to the potential job creation, energy independence, and GHG reduction impacts of biofuels, governments around the world have deployed significant funds to support research and development of conversion technologies, feedstocks, feedstock and biofuel supply chains, and understanding biofuel's environmental impacts.

Countries that are major players in the global renewable fuels sector—such as the US, EU, and Brazil—continue to invest in their domestic research capabilities through long term programs that are linked to agriculture, energy, and innovation areas of budgetary programming.

11.3 Canadian research & development support

In Canada, federal funds for university biofuels research have been made available via the Natural Sciences and Engineering Research Council which provides individual project and network grants. Two Networks of Centres of Excellence (NCE) have funded aviation biofuel projects: two rounds through GARDN, and one with BioFuelNet (GARDN 2017; BioFuelNet Canada 2017). The National Research Council has played an active role in biojet applied research in Canada—particularly in test flights and trials of novel fuels, such as 100% HEFA biojet, and biojet impacts on in-flight aircraft performance, such as contrails formation (NRC 2012; NRC 2017). Other agencies, including Sustainable Development Technology Canada, Emissions Reduction Alberta, and the Ontario Centres of Excellence, have provided support for technology development and demonstration, as well as deployment and scale-up of low carbon technologies.

Budget 2017 established the Clean Growth Hub and announced $2.3 billion to support clean technology in Canada and the growth of Canadian firms and exports. The Clean Growth Hub is a focal point for coordinating the government's clean technology efforts. Select programs that support research and development include the Agricultural Clean Technology Program, Sustainable Development Technology Canada, the Impact Canada Initiative, the Energy Innovation Program, and the Green Infrastructure program's demonstration component. Within these programs, the Sky's the Limit Biojet Challenge is dedicated to advancing biojet in Canada.

SKY'S THE LIMIT CHALLENGE

This program is directly relevant to the advancement of biojet production and use in Canada. It seeks to stimulate the development of biojet supply chains so that Canadian airlines can further reduce GHG emissions. The Challenge consists of two competitions:

1. The Green Aviation Fuels Innovation Competition provides $2 million for each of four teams who develop the most innovative solutions, which, in turn, will support their next endeavour: an 18-month competition to produce the most economical and environmentally sustainable aviation fuel and win the $5-million grand prize.

2. The Cross-Canada Flight Competition offers a $1 million prize to the first participant to fuel a Canadian commercial flight using a minimum 10% blend of made-in-Canada biojet fuel (Impact Canada 2018).

11.4 Assessment

Research and development activities are useful to help a domestic sector find competitive advantage, become established, and progress towards commercial deployment. To keep the beneficial results of research and development progress in Canada, these innovations must be able to access domestic markets. Commercialization of new energy technologies typically follows a four-stage financing and milestone path (Figure 1). In the field of advanced biofuels, including biojet, governments, and in particular the US and Canadian governments, have expanded beyond their traditional role of investment in technology research and have provided support at multiple stages in the commercialization process, including during the 'Roll-Out & Market Volume' phase. This expansion means that governments and the public sector are not only taking on technology risk, which tends to involve relatively small sums of capital in the research and development stage of technology commercialization, but a large amount of operational and market risk. Operational and market risk can dwarf technology risk in absolute financial terms due to the size of capital investments and the quantity of product being produced. HEFA biojet technology is considered to be at the 'Roll-Out & Market Volume' stage of commercialization.

Figure 1 shows the steps needed to finance renewable fuel capacity. The history of biofuels research and development funding shows that even with significant sums provided, large volume commercial production will not occur in the absence of policies designed to enable market access and structural demand.

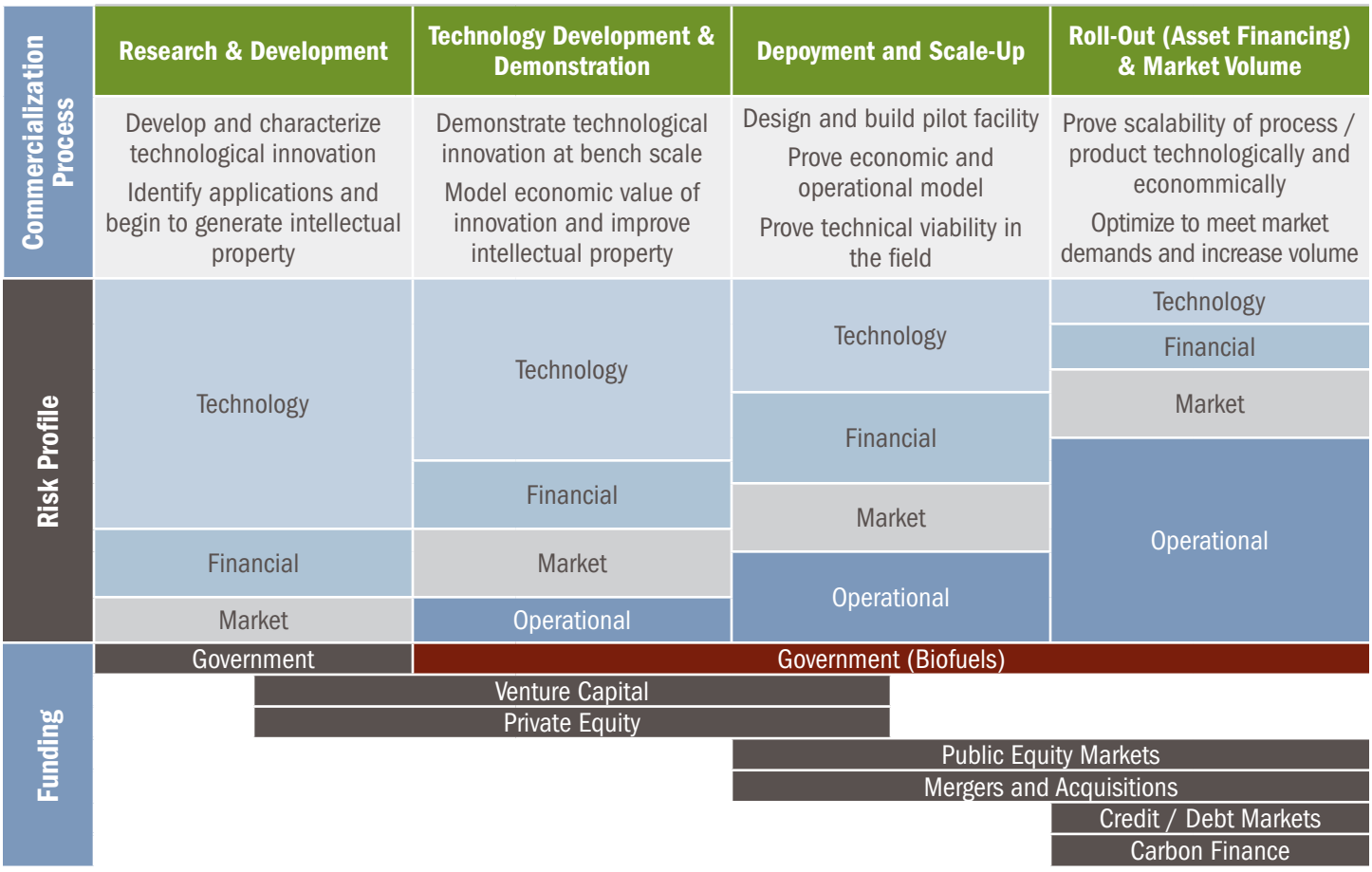

Figure 1: Pathway to technology commercialization - Sources: Adapted from Bloomberg New Energy Finance 2010; SDTC 2010; UNEP 2011

11.5 Relevant policy recommendations

Continue to connect biojet-related research, development, and deployment activities through the continuation of the Clean Growth Hub established in Budget 2017. The biojet supply chain involves many stakeholder groups and government departments, therefore the 'whole of government' approach implemented through the Clean Growth Hub is useful. The Clean Growth Hub can inform the emerging biojet supply chain on what types of R&D and innovation funding is available. The aviation sector can help shape future programs of the Clean Growth Hub that reduce GHG emissions from aviation fuel use. *(Sect 4, PR 23)*

Ensure that the results of innovation can be commercially implemented in a biojet sector that has market access. Programs that enhance technical understanding and innovation will be most impactful if they can be used in a sector that has both the ability to invest in improvements and an economic foothold in the fuel supply chain. Market access, achieved through fuel regulations like the Clean Fuel Standard and the BC Low Carbon Fuel Standard, is fundamental to creating viable business conditions for biojet production which can benefit from the results of targeted innovation programs. *(Sect 4, PR 24)*

12. Conclusion

The recommendations contained in this report reflect the current Canadian situation of heightened activity on the climate change mitigation file, including the range of enabling policy tools to bring about lower carbon fuel options. The next 12 months will be dynamic for renewable fuels policy development in Canada as the regulations under the Pan-Canadian Framework, and specifically the Clean Fuel Standard, are finalized. There will be greater political attention given to 'clean growth' amid upcoming Alberta and federal elections. Both national and regional debates are likely to continue over a range of topics: energy and pipelines; climate policies, carbon taxation, and the use of carbon revenues; and the observed environmental impacts of increased greenhouse gas emissions.

The next year may reveal market risks related to climate action and carbon tax policies as polarized political positions can lead to regulatory instability and reversal risks. Perceptions of forthcoming policy uncertainty and program instability can stall investment decisions.

The next year may also unveil the efficacy of the wide range of 'clean tech' and 'clean innovation' programs and whether these frameworks are useful for attracting real investment in domestic low carbon energy production capacity. Alternatively, these programs may attract political risk if they are ineffective or have high profile failures.

Ultimately, the current period clearly demonstrates that 'climate action' has moved from 'policy development' to 'regulatory action', with specific attention on 'clean growth' stimulus to capture economic benefits from new investment, all while protecting policies from public opposition and reversal.

Establishing a biojet sector in Canada requires the political will to establish a stable regulatory framework that will incentivize its use and fiscal competitiveness to attract domestic production. Complementary programs, developed alongside the regulatory measures of the Pan-Canadian Framework, will be necessary to attract investment capital for domestic biojet production capacity. The fate and future of biojet in Canada, at least at present, is linked to the ability of Canadian governments to continue to develop regulations within the Pan-Canadian Framework that will create strong economic signals for biojet development, production, and use.

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SUGGESTED CITATION:

Canada's Biojet Supply Chain Initiative (CBSCI). 2019. Policy Tools for Enabling Biojet. https://cbsci.ca/reports/.

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