Decarbonizing Aviation System in Alberta using Bio-jet Fuel

Challenges and Opportunities

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ABSTRACT. This white paper summarizes challenges and opportunities for decarbonizing the aviation sector via switching to more energy dense biofuel to reduce atmospheric CO_2 concentration. Unlike automobiles and other light transport vehicles, airplanes face technical, safety and infrastructure challenges for being powered by electricity derived from renewable sources such as wind and power, hydrogen or fuel cell technology and will need a more energy-dense renewable fuel (i.e. bio-jet fuel).

BACKGROUND

Three common pillars identified by signatories of Paris Agreement, are energy efficiency, decarbonizing electricity generation and fuel switching. Aviation sector is one of the decentralized emitter of greenhouse gases (GHG) in the world. Decarbonizing transportation system can be achieved via fuel switching. Given this sector's growing contribution to global CO_2, aviation could play a key role in meeting the global climate targets. While major airlines continue to demand the use of narrow range of hydrocarbon jet fuel for the foreseeable future, some European airlines and aircraft manufactures have committed to voluntary CO_2 reduction targets.

Although automobiles and other light transport vehicles have the potential to be powered by electricity derived from renewable sources such as wind and solar, some types of transport, such as long-distance trucking, maritime and airplanes will need a denser biofuel. According to a 2015- report from the Canadian Airport Council, Canadian passenger traffic forecast estimates a market growth to about 216 million passengers by 2033, a 50 % increase compared to 122 million in 2013 (see FIGURE 1). Emissions of passenger aircraft per passenger kilometer vary extensively because of differing factors such as the size and type aircraft, the altitude and the percentage of passenger or freight capacity of a flight, and the distance of the journey and number of stops in route. On average, the emissions vary from 114 g CO_{2eq} per km for long distance flights to ~ 260 g CO_{2eq} [1]per km for short distance flights.

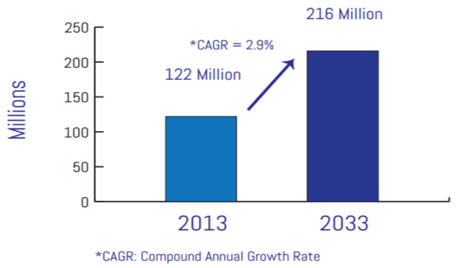

FIGURE 1: Expected size of the total Canadian passenger market over a 20-year period (Canadian Airport Council)

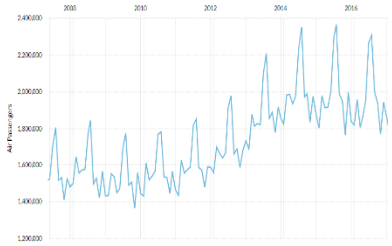

FIGURE 2: Total monthly number of passengers travelling through airports in Alberta (Alberta Government website

FIGURE 2, taken from Alberta Government website, depicts the total monthly

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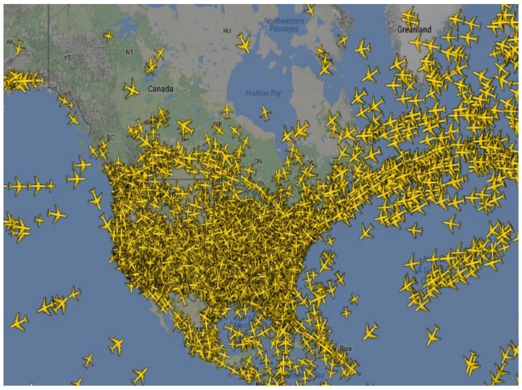
number of passengers travelling through the Edmonton International (YEG), Calgary International (YYC) and Fort McMurray International (YMM) airports. This includes domestic, trans-border (Canada-U.S.), and international flights; a 30% increase over a decade.

Petroleum fuels power nearly all-commercial aircraft. However, there is a push to explore alternatively powered planes to dramatically reduce or eliminate emissions. Electric aircraft are currently very small and are powered by batteries or photovoltaic solar panels. However, the weight and duration of power are obstacles. Electric hybrid planes will likely be utilized before full electric airplanes. Decarbonizing the aviation sector via switching to more energy dense biofuel could, however, play an important role in reducing atmospheric CO_2 concentration in the province and across the country while transitioning to Future Energy System.

Recent research presented by Massachusetts Institute of Technology (MIT) at the 2016 IEA Bioenergy workshop in New Zealand refers to alternative aviation fuel as an "infant industry". A single-time data point of total flights running on conventional fuels, taken from the MIT presentation, is compared with alternative fuel flights in the following figures, confirms the early-stage of alternative fuel in the aviation sector (FIGURE 3).



Friday, Oct 21-2016, 10:25 am EDT (Data from Planefinder - Massachusetts Institute of Technology (MIT) presentation

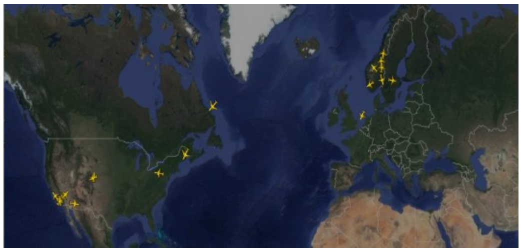


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FIGURE 3: Total flights running on conventional fuels compared with alternative fuel flights

LIFECYCLE CO_2 EMISSIONS

In our view, GHG emissions can be reduced by 1 to 2% annually through improved fuel efficiency, aircraft redesign, airport modifications, new and efficient navigational system, etc. However, significant reduction in GHG emissions requires airlines to use more sustainable alternative jet fuel such as bio-jet in the long-term. The use of bio-jet reduces net life-cycle carbon emissions as it enables reusing and recycling carbon that is already in the biosphere to create the fuel. Biomass derived jet fuels have the potential to reduce life cycle emissions compared to conventional fossil jet fuel, since biomass-based hydrocarbons absorbed CO_2 from the atmosphere when they grew, and the CO_2 emitted during jet fuel combustion is equal to the absorbed during its growth. Bio-Jet can be derived from sustainable global bio-resources and engines of the aircraft don't require modifications for the use of the same. Life-cycle analyses of bio-jet determine the extent to which their production and use would reduce carbon emissions on a life-cycle basis compared to conventional fossil jet fuel. Life-cycle analyses take into account all emissions associated with producing final fuel from its initial form e.g., planting of oil seed corps, or conversion of municipal waste, as well as aircraft emissions. The biomass credit is the primary difference between biomass and fossil fuels in terms of their carbon emissions. However, there can be emissions associated with acquiring a feedstock, with fuel production, with feedstock and fuel transportation, as well as with land-use change attributable to the production of biomass-based feedstock. Similar CO_2 emissions are also associated with the production of fossil fuels. Argonne National Laboratory has conducted life-cycle analysis of bio-based aviation fuel pathways and compared them with petroleum-based jet fuels. The study concludes that renewable (bio-jet) jet fuel can reduce GHG emissions by as high as 50% compared to conventional fossil jet fuel, provided the right feedstock and conversion technology are used. Additionally, according to a report from Utrecht University, the use of bio-jet reduces net life-cycle carbon emissions as it enables reusing and recycling carbon that is already in the biosphere to create the fuel. FIGURE 4 compares life-GHG emissions in g_{CO2eq}/MJ jet fuel for fossil fuel and bio-jet fuel produced using various conversion technology pathways. As shown, most pathways yield greenhouse gas emissions reductions exceeding 60% compared to fossil jet fuel. However, some fail to reach a 50% reduction threshold due to high greenhouse gas emissions associated with feedstock cultivation (e.g. fertilizer) or hydrogen consumption.

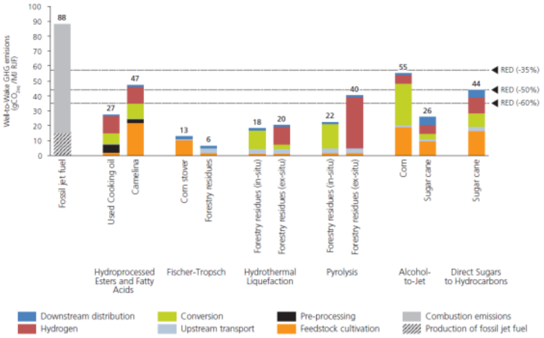

FIGURE 4: Well to Wheel Lifecycle GHG emissions (report from Utrecht University)

On a well-to-wheel basis the bio-jet can significantly reduce GHG emissions compared to conventional jet fuel (if emissions from land use change can be avoided) and achieving such a target requires increase in bio-jet production and consumption by the aviation sector. Expanding the commercial supply of bio-jet fuel, market access has been slow to develop and remains available only in small volumes primarily due to high costs and lack of public-policy support and, also the technical challenges.

BIO-JET FUEL in CANADA

As aviation is international in nature, Canada should take the lead the global policies specific to bio-Jet as it is crucial to encourage larger-scale commercialization and use of the same. Technological development of advanced bio-fuels should be done through multi-stakeholder alliance including equipment manufacturers, airlines, fuel producers and airports. Carbon offsets continue to contribute to global emission reductions and it not clear whether it will accelerate the bio-jet development.

Although bio-Jet has been produced on a limited scale, the transportation fuel industry is very competitive, making it very difficult for producers of bio-jet to be economically competitive with fossil fuel, particularly due to low oil prices. Besides the capital cost of building large-scale production facilities, the difficulty of establishing new supply chains, the projected operating costs associated with proven feedstock and the technical difficulties with conversion processes are all posing challenges to market access. In addition, the oil industry has been conservative in its engagement and support of alternative jet fuel development. As fossil-derived jet fuel is likely to be much cheaper to produce for quite some time into the future, effective policies will be required for all aspects of bio-jet fuel development, from encouraging production of feedstocks through to the production and use of the bio-jet fuel itself.

Traditional biofuels such as ethanol and biodiesel cannot be used to power airplanes due to their low energy density and their tendency to freeze at low temperatures (-30°C or lower). In the short term, most commercial bio-jet fuels will likely come from oleo chemical feedstocks, such as tallow, used cooking and palm oils. However, in the mid-to-long term, cellulosic feedstocks will likely supersede these lipids/fats as the main source of bio-jet fuel because they are not in direct competition with food, are in large supply, and will likely be less expensive. With the support from companies such as Boeing, Bombardier, Air Canada, West Jet and NORAM and from the funding agencies Green Aviation Research and Development Network, NSERC, International Energy Agency (IEA) and BiofuelNet, The Forest

Products Biotechnology/Bioenergy group at University of British Columbia have been assessing the potential of producing bio-jet fuel from forest residues. According to IEA Bioenergy – Task 39, the group is coordinating the efforts of a few companies, researchers and partners to determine whether a bio-jet production facility could be commercialized in British Columbia using local forest residues.

CURRENT TECHNOLOGY PATHWAYS

To fully understand the current biomass-to-jet fuel development, it is necessary to have an overview of the state of technology for all the bio-jet pathway technologies. It should be noted that the aviation sector uses specific fuel classified as Jet A1 in most regions. All jet fuel must meet strict specifications with American Society of Testing and Materials (ASTM), most common standards worldwide, including renewable and sustainable fuels. However, certification of a bio-jet technology through ASTM standard specification can take years and includes rigorous testing and evaluation. The different main technology pathways certified by ASTM standard is given below (for more details on conversion technologies, read the article published by Han et al. in 2017):

- Fischer-Tropsch (FT) Conversion of syngas to synthetic kerosene (jet): According to an article published by Want and Tao in 2016, Fischer-Tropsch conversion was the first bio-jet pathway to obtain certification in 2009. Syngas is a mixture of carbon monoxide and hydrogen processed in a Fisher-Tropsch catalytic reactor to produce long-chain paraffinic hydrocarbons, which are converted into jet fuel with typical refinery finishing processes. Common methods of producing syngas including gasification of solid forms such as biomass residues, municipal solid waste, etc. and conversion of biogas to syngas. In the gasification process feedstock is heated in a high energy, reduced oxygen environment such that feedstock does not combust but is thermally deconstructed into its elements such as hydrogen, carbon monoxide, nitrogen, water vapor, hydrogen sulfide, carbon dioxide and other compounds. The gasified output is normally cleaned of particulate matter, sulfur, and other impurities. Syngas is also used in various industrial units as fuel or for hydrogen production. Commercial Aviation Alternative Fuels Initiative (CAAFI) stated the blend limitation of the bio-jet produced by this process is a maximum of 50% with the conventional fossil fuel jet.
- Hydroprocessed Esters and Fatty acids (HEFA): Honeywell Green Jet Fuel made from UOP Renewable Jet Fuel process, is an example of HEFA conversion path. Lipids from plant and animal sources converted to synthetic paraffinic kerosene (jet). The technology was ASTM-certified in 2011. Waste fats, oils and greases or plants derived oils are cleaned and treated with hydrogen to produce jet fuel. This hydro-processing route uses large amounts of hydrogen. Other approach for converting to jet fuels involves a combined approach of novel reaction chemistry and innovative catalyst and reactor design, presented by Exelus Technology. In this process water (rather than hydrogen) is used to break-down triglycerides into free fatty acids and glycerol. In the next step, glycerol is reformed to generate 7 moles of hydrogen which are then used in the final step. As for the feedstock, some plant derived oils, such as soybeans are so expensive and other options are potentially more competitive. Example include waste fats and non-food corps especially those grown on land that is not suitable for growing food corps, such as sorghum, are potentially more competitive. Commercial Aviation Alternative Fuels Initiative (CAAFI) stated blend limitation of this bio-jet is a maximum of 50% with conventional fossil fuel jet.
- Synthesized Iso-Paraffinic (SIP): According to an article published by Want and Tao in 2016, SIP fuel is known as direct sugar to hydrocarbon route, certified in 2014. SIP bio-jet is produced biologically through fermentation of sugars by microorganisms to create hydrocarbon

molecule. Then it is treated with hydrogen to make bio-jet. Commercial Aviation Alternative Fuels Initiative (CAAFI) stated a maximum of 10% is the limitation in blending of this bio-jet with conventional fossil fuel jet.

- Fischer- Tropsch (FT) conversion of syngas to synthetic kerosene and aromatics: This process is similar to the earlier FT, but it includes the addition of production process that also produces aromatics. ASTM was certified in 2015. Commercial Aviation Alternative Fuels Initiative (CAAFI) stated blend limitation is a maximum of 50% with conventional fossil jet fuel.
- Alcohol to Jet based on Isobutanol (ATJ): As described in the article published by Want and Tao in 2016, ATJ process involves the fermentation of sugars to alcohols such as ethanol and butanol. The alcohol is then converted to pure hydrocarbons in the jet fuel range through a process of dehydration, oligomerization, hydrogenation and fractionation. According to a number of private corporations, such as Byogy Renewables, Inc. and Gevo, Inc., and the Commercial Aviation Alternative Fuels Initiative (CAAFI), blend limitation is 30% (max) with conventional fossil fuel jet.

The bio-jet blending with conventional fossil jet fuel up to a maximum allowable blending level as tested and approved by ASTM. In future, some alternative jet fuel may qualify as fuels without any blending limit, but has not been the case to date. HEFA technology accounts for the vast majority of existing bio-jet. A number of HEFA facilities are currently operating at a commercial scale, and they predominantly produce HEFA diesel, rather than bio-jet. According to a report by Nordon in 2016, only AltAir Fuels has dedicated bio-jet production capability, mainly because of the policy drivers in the state of California, and because of the company's agreements with airlines. Other major HEFA producers include Neste (with manufacturing locations in Rotterdam, Singapore, and Finland), Diamond Green Diesel (Louisiana), REG (Geismar, Louisiana), and ENI (Italy).

Companies such as Swedish Biofuels and Devo demonstrate the ATJ processes. However, the usage of SIP and ATJ bio-jet is limited because this route is expensive and also the intermediates, such as butanol and farnesene, are worth more as chemical feedstock or for applications in the cosmetics and pharmaceutical industries.

ASTM certification is a measure of a pathway's progress, as is its fuel readiness level (FRL), an indicator created by the Commercial Aviation Alternative Fuels (CAFF) Initiative. These are important considerations for the eventual commercialization and supply of bio-jet. There are several other ways of producing bio- jet, some which are in the process of achieving ASTM certification and should be included in any assessment. As each new pathway is approved by ASTM will be expanded to provide specification that encompass all the feedstock and conversion processes approved for use in that pathway. For example a fuel blends fossil jet with low percentage of green diesel (hydrogenation derived renewable diesel, or HDRD) is currently in the certification process.

OTHER TECHNOLOGY PATHWAYS

Thermo-chemical routes turn biomass into bio-jet involves the production of three main products, in different ratios: bio-oil, synthesis gas and char. The 2015 PNNL report describes that the two main thermo-chemical routes to bio-jet are gasification and pyrolysis, and hydrothermal liquefaction (HTL). The FT process uses gasification combined with synthesis to produce bio-jet. The 2016 report by Nordon states that several commercial facilities based on gasification-FT are being planned. The pyrolysis route to bio- jet is known as HDCJ (hydro treated depolymerized cellulosic jet).

To date, gasification technologies have experienced high capital costs to both gasify the biomass and convert the resulting syngas to FT liquids or partially oxygenated liquid hydrocarbon products such as mixed alcohol. Current FT technology results in a maximum of about 40% of the final product comprised of bio-jet fuel and middle distillates, requiring the marketing of the other 60% of the output.

The 2015 PNNL report also states that commercial biomass-gasification facilities under construction include those of Fulcrum Bioenergy and Red Rock Biofuels, both in US. Red Rock Biofuels plans to use woody biomass as well as a different FT technology (from Velocys). Fulcrum will use Plasma gasification technology. These pioneer plants should provide invaluable insights and lessons for future investment. Many believe that costs for the FT route could fall considerably as the technology matures.

Pyrolysis and Hydrothermal liquefaction (HTL): According to the 2015 PNNL report, the commercial production of bio-jet via the pyrolysis route is likely to be challenging because bio-crudes derived from fast pyrolysis contain up to 40% oxygen, similar to the biomass itself. This will result in extensive upgrading to produce bio-jet, which is typically achieved through hydroprocessing. The processing costs, as well as the need for external hydrogen, represent a large proportion of equipment and production costs. Further challenges to the hydroprocessing of pyrolysis oils are the costs of and stability of the catalysts that are required.

A potential advantage of the pyrolysis approach to bio-jet production is that it can be done in existing oil refineries, which reduces the need for capital to build a dedicated facility. Similarly, significant savings might be achieved by directly sourcing hydrogen from an oil refinery and, in the longer term, through using existing processing units. Refinery integration strategies should be synergistically beneficial but are likely more technically challenging.

Catalytic pyrolysis or processes such as HTL can produce a bio-oil intermediate with significantly lower oxygen content, at less than 10%. That would be easier to upgrade to produce fuels, including bio-jet. The high-pressure requirements of HTL during the production of biocrude will impact their potential for scale-up. While production of bio-oil via pyrolysis is at a commercial scale, HTL is currently just at the demonstration stage,

Bio-chemical routes: The 2016 report by NREL describes how genetically engineered yeasts convert sugars via biochemical routes directly to renewable hydrocarbons such as farnesene, which can then be upgraded through hydroprocessing to produce Synthesized Iso-Paraffinic (SIP) fuel. It is also known as the Direct Sugars to Hydrocarbons (DSHC) pathway. It received ASTM certification in 2014, provided it is used in 10% max blend with fossil derived jet fuel.

Production of bio-jet would not be the most profitable use of biochemically processed biomass and sugars. Products such as carboxylic acids, alcohols and polyols can generate higher profits because there are fewer processing steps and require less hydrogen consumption. Less-oxygenated microbial metabolites with potential as drop-in biofuel intermediates are already being sold in the value-added chemicals and cosmetics markets, such as Amyris's farnesene and Gevo's or Butamax's butanol. The market for biochemical drop-in products is highly competitive and growing. Incentives will be required for commercial entities to concentrate on drop-in fuels until the market is saturated. The capital expenditure for biochemical routes to bio-jet is projected to be lower than those for thermo chemical routes, but that benefit may be offset if the minimum fuel sale price is higher.

BIO-DRIVED JET-FUEL TEST FLIGHTS

2008 Virgin Atlantic airline, in the US, tested 20% bio-jet fuel blend, produced from coconut and babassu (OTJ conversion pathway) in a B747. The 2016 report by NREL states that the first commercial-scale biofuel plant in the United States, Dynamic Fuels, a 50/50 joint venture between Syntroleum and Tyson Food, achieved production of 5.4 MM gallons per month of renewable fuels, which equals to 65 MM gallons per year.

2012 Air Canada operated two biofuel flights, one between Toronto and Mexico City as part of a series of commercial biofuel flights that took the secretary general of ICAO to the United Nations conference on Sustainable Development held in Rio de Janeiro; the second flight transported a number of Olympic athletes and officials on their way to the London 2012 Olympic Games. The 2016 report by NREL states that National Research Council of Canada (NRC) also supported a Faclon-20 test flight with 100% bio-jet fuel produced from Carinata.

2015 Canada's Bio-jet Supply Chain Initiative (CBSCI), which is a three-year collaborative project, begun in 2015 with 14 stakeholder organizations to introduce 400,000 litres of sustainable aviation biofuel (bio-jet) into the shared fuel system at Montreal airport. The CBSCI project is a first in Canada and is aimed at creating a sustainable Canadian supply chain of bio-jet using renewable feedstocks.

2017 The number of bio-jet fuel tests flights increased in 2017. In January, some flights left the airport in Oslo, Norway, running on jet biofuel produced from an oilseed crop. An article in Canadian Biomass Magazine informs that in March 2017, United Airlines became the first U.S. airline to use biofuel for regularly scheduled commercial flights leaving Los Angeles International Airport. Three months later, Alaska Airlines flew commercial flights using biofuel produced from renewable isobutyl alcohol.

In early 2017, Air Canada announced its participation in the Civil Aviation Alternate Fuel Contrail and Emissions Research project (CAAFCER), a research project led by NRC to test the environmental benefits of biofuel use on contrails. This project will use advanced sensing equipment mounted on a research aircraft operated by the NRC (National Research Council of Canada) to measure the impact of biofuel blends on contrail formation by aircraft on five biofuel flights operated by Air Canada between Montreal and Toronto in the coming days weather permitting. During these flights, NRC will trail the Air Canada aircraft with a modified T-33 research jet to sample and test the contrail biofuel emissions. The sustainable biofuel is produced by AltAir Fuels from used cooking oil and supplied by SkyNRG.

Swedish Biofuel company, run by a rocket fuel expert and professor, and his daughter, has been developing bio-based jet fuel “SB JP-8” (Swedish Biofuels JP-8) for the last two years. US DARPA (Defense Advanced Research Project Agency) has partly financed the development. Results from early laboratory tests at DARPA are promising - the SB JP-8 fulfill and even surpass quality and specifications of the military jet fuel “JP-8”. According to the Swedish technical weekly Ny Teknik, a test is to be places in the fuel system and engine of the Swedish fighter jet JAS 39 Gripen, summer/autumn 2017. The tests will be done on Gripen’s new General Electric GE 414 engine and is cooperation between the Swedish Defense Materiel Administration (FMV) and the US Air Force Research Laboratory (AFRL). As a base in its biofuel, Swedish Biofuels uses waste fuel oil from ethanol production. The company has registered more than 40 biofuel technology patents.

Neste, in Finland, and AltAir Fuels, in California, the two firms capable of making jet biofuels at commercial scale, use animal fat, plant oil, and used cooking oil to produce primarily linear and branched paraffins. To convert fat and oil to hydrocarbons, the companies first deoxygenate and hydrogenate them to make long, linear hydrocarbons, which are then cracked and isomerized to shorter linear and branched C_8 to C_{16} hydrocarbons. This so-called hydro-processed esters and fatty acids (HEFA) process is also used to produce renewable diesel that is chemically indistinguishable from petroleum-derived diesel. Because current aviation biofuels contain only linear and branched paraffins, they have to be blended with petroleum-derived fuels to create a jet fuel with the physical properties specified by ASTM. The renewable fuel at Oslo Airport contains 50% biofuel produced by Neste, and United uses renewable fuel containing 30% biofuel from AltAir Fuels.

BENEFITS, BARRIERS & CHALLENGES

The commercialization of bio-jet offers potential societal benefits by expanding energy sources, reducing GHG and other emissions that impact air quality and economic development. Many of these benefits are the result of agricultural opportunities that are not accessible to food crops. For significant reduction in GHG emissions from flights, second generation feedstock should be utilized, i.e. oils from nonfood crops such as camelina and jatropha grown on no arable land or in rotation with grains, or waste products—such as animal fat, used cooking oil, forestry and agricultural waste, and household trash. Having a variety of feedstocks makes it easier to produce renewable jet fuel around the world because refineries can use the feedstock most available in their region. The majority of the bio-jet could be distributed, located close to feedstock supplies to keep costs and emissions minimum.

An analogous policy tool has been that supporting the development of road transportation fuel in Brazil and Europe. Here, the main policy drivers were energy security and climate-change mitigation. The International Civil Aviation Organization (ICAO) plays a major role in the development of bio-jet as it works with 191-member states and industry groups to reach international aviation standards and recommended practices and policies in support of economically sustainable and environmentally responsible aviation sector.

In the 2016 IEA Bioenergy workshop in New Zealand, the presenter from Massachusetts Institute of Technology (MIT) stated that the need for annual growth in alternative jet fuel production out to 2050 estimated to be on the order of 5-15 Mt/yr (100-300 kbpd) in global biofuel production capacity to achieve between 10 to 20 % emission reduction by 2050. This would require an estimated $6B-$50B capital investment per year. The main economic challenges are feedstock availability and price, lack of multi-stakeholder collaboration, techno-economic factors, accelerated technology development and demonstration projects funding for both small and large start-ups. The technical challenges are not limited to feedstock development, novel conversion technology with lower energy use, fuel testing and certification process by ASTM but also policies like renewable fuel standard, sustainability assessment tools and models. For now, fuel producers lack the funds, policy support, and renewable fuel incentives to build more factories and increase production volumes, though there are signs that the industry is ready to grow.

POLICIES to PROMOTE BIO-JET FUEL COMMERCIALIZATION

By 2050, the global aviation industry aims to combat climate change by reducing net carbon emissions by 50% compared with 2005 levels. That's a commitment to cut one-tenth the emissions projected for 2050. Improved engine efficiency and aircraft aerodynamics will provide some reductions. But transitioning to fully renewable jet fuel is key to meeting the targets suggested by the International Air Transport Association (IATA). The international nature of aviation will require global coordination of policy makers and also involvement of organization like ICAO. According to a research in Penn States' College of Agricultural Science, in north America, for example, several policy initiatives are pushing bio-jet fuel use in the states. One is them is EPA's Renewable Fuel Standard that, through a rather complex system, ultimately provides credits for cellulosic biofuels, up to $2 a gallon. The second is, in certain markets like California and Oregon, a low-carbon fuel standard that provides credit for low-carbon-emitting fuels such as bio-jet fuel.

Policy makers should play an active role to help bio-jet in the same evolutionary pathway like bio-ethanol and bio-diesel. Key policy areas to focus are mandated bio-jet blend like ethanol in gasoline, support commercialization of bio-jet through incentives and tax credits, enhance production and use through the entire supply chain from feedstock supply to distribution with initiatives like European Union Initiative Towards sustainable Kerosene for Aviation (ITAKA) project and industry and consumers play a part in expand the production and use e.g., Fly Green Fund and other corporate programs that encourage customers to cover the price of using premium bio-jet.