CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

Rio de Janeiro, Brazil, 16 to 18 November 2009

Agenda Item 2: Technological feasibility and economic reasonableness

TYPES AND COSTS OF SUSTAINABLE ALTERNATIVE FUELS FOR AIRCRAFT

(Presented by the Secretariat)

SUMMARY

There are currently no sustainable alternative fuels for aircraft in commercial production; however, this is expected to change in the near future. Planning is underway for producing new fuels with low life-cycle emissions. When these fuels enter the market, their costs will be high and they may require subsidies or production incentives in order to make them economically viable. As industry gains more experience producing these fuels their costs will decrease, as will their life-cycle greenhouse gas (GHG) emissions. In the long-term, industry may design new aircraft and engines to take advantage of unconventional aircraft fuels with extremely low life-cycle CO_2 emissions.

New sustainable alternative fuels for aircraft may be better suited for regional and local production in countries around the world in light of the variety of potential feedstocks. Once refined into fuel, the feedstock used is irrelevant to the aircraft. Most of the feedstocks studied to date also produce by-products that may be of value locally. Communities may be able to develop new businesses or other sources of income from alternative fuel production. To meet these objectives, significant investment will be needed in regions where States desire to become producers of sustainable alternative fuels for aircraft.

The conference is invited to endorse the conclusions in paragraph 7 and recommendations in paragraph 8.

1. INTRODUCTION

1.1 Sustainable alternative fuels for aircraft are an important mitigation strategy for the aviation industry, yet these fuels do not exist commercially today. Before new fuels can enter the market, there are a number of developments that must take place first. As industry gains experience producing and using these fuels, costs will eventually decrease and production will rise, thus enabling these fuels to become a significant component of worldwide aircraft fuel production.

1.2 Since there is no unique resource or production capability needed to produce these fuels, production of sustainable alternative fuels for aircraft may occur in countries around the world, providing valuable new businesses for developing countries.

2. SHORT-TERM (TO 2012)

2.1 In the short-term, sustainable alternative fuels for aircraft may be available in limited quantities and have a life-cycle CO_2 footprint equal to, or less than, conventional jet fuel. It will be necessary to blend these alternative fuels with conventional jet fuel at up to a maximum of 50% to produce a drop-in fuel. Drop-in jet fuels are completely interchangeable with conventional jet fuel, and so will not require modification of fuel handling and distribution systems, including gauges, meters, fuelling vehicles, and hydrant systems, as well as aircraft engines, once the fuels have been blended.

2.2 GHG emission reductions in the short-term will be limited as sustainable alternative fuels for aircraft are initially introduced. For example, assuming the lifecycle CO_2 footprint of sustainable alternative fuels for aircraft provides a 20% reduction compared with conventional jet fuel, and a 50% fuel blend makes up 10% of the total jet fuel market, the GHG emissions reduction would be 1% compared to forecast emissions without the new fuels. However, reductions in particulate matter and sulphur oxides will be more significant. Achieving air quality benefits from the use of these fuels is independent of production life-cycle considerations.

3. MEDIUM-TERM (2013-2020)

3.1 In the medium-term, it is possible that sustainable alternative fuels for aircraft will be available in much larger quantities. The significant research and development activity currently underway is expected to lead to a number of commercial scale production facilities. The Commercial Aviation Alternative Fuels Initiative (CAAFI) is currently seeking to ensure that at least 10 alternative jet fuel production facilities are built and in operation within five years[1]. Also, these new fuels will have been certified for greater use in blends, possibly up to 100% alternative fuel, thus moving from drop-in blend fuels to drop-in neat fuels according to industry roadmaps. During this time, the fuels may have reached cost parity, especially if the value of their carbon reduction benefits are accounted for.

3.2 As the aviation industry increases its use of sustainable alternative fuels for aircraft, ongoing efforts will be applied to reduce the life-cycle impacts of these fuels. These may include:

a) thoroughly exploring and identifying feedstock resources;
b) enhancing resource quality;
c) improving oil recovery and extraction;
d) finding markets for co-products;
e) creating higher value co-products;
f) improving the efficiency of converting raw biofuels to jet fuel;
g) reducing the length and number of transport links;

[1] Altman, Richard. 2009. "Landmark Synthetic Jet Fuel Specification Action Creates Opportunities for Airports." *International Airport Review*, Issue 4, pp 62-64.

h) continuing to conduct performance studies, fuels testing, and flight testing;
i) enhancing efficiency of existing finance mechanisms and developing new mechanisms that are needed to open new resources;
j) resolving technical barriers to using 100% sustainable alternative fuels for aircraft; and
k) modifying fleets and transport systems as necessary to use 100% sustainable alternative fuels for aircraft.

These efforts will reduce production costs, both directly and as a result of improving co-product value, improve the fuels' life-cycle footprint, and reduce overall fuel transportation costs due to standardization.

4. LONG-TERM (BEYOND 2020)

4.1 In the long-term, the aviation industry may explore more radical fuels that require redesigned engines and airframes. Fuels such as liquid hydrogen and liquid methane might be used to significantly reduce GHG emissions.[2] Managing these cryogenic liquids on an aircraft will require heat exchangers to vaporize and heat the fuel prior to use on-board[3], and the fuel supply infrastructure will need to be substantially redesigned or replaced. While new aircraft designs and new fuel production pathways may be required, these new approaches may result in more energy efficient and environmentally benign air travel.

5. COSTS

5.1 Today, estimated costs for sustainable alternative fuels for aircraft range from 2-5 times the cost of conventional jet fuel[4] and in some cases, even higher. However, these values are estimates, as the fuels are not commercially available. These estimates also do not include a value for carbon credits. Until more significant fuel quantities are available, the cost of sustainable alternative fuels for aircraft will remain highly uncertain. As a result, these fuels will likely require subsidies or incentives, at least initially, to encourage their production given the risks involved in moving from pilot scale to commercialization.

5.2 The development of new processes for producing sustainable alternative fuels for aircraft can quickly reduce costs of fuels to compete with conventional jet fuel in the mid-term. Over time, as new fuel production becomes commercialized and the processes are improved, fuel costs are expected to decrease. Larger plants will bring economies of scale; capital costs will be reduced through the application of advanced production technologies; operating and maintenance costs will be reduced through process refinement, improved control systems, and greater experience; transportation links will be shortened; and the total value of products may increase. The International Energy Agency has projected costs for 2nd generation biofuel plants producing a biodiesel to fall an average of 2.5%/year

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[2] Daggett, D.L., Hendricks, R.C., Walther, R., and Corporan, E. *Alternate Fuels for use in Commercial Aircraft,* The Boeing Company, published by the American Institute of Aeronautics and Astronautics, Inc. ISABE-2007-1196, 2007.
[3] Walther, R. et al, *Aero Engines for Alternative Fuels, in Hydrogen and Other Alternative Fuels for Air and Ground Transportation,* European Commission, Brussels, published by John Wiley & Sons, 1995.
[4] Caldecott, B. and Tooze, S., *Green skies thinking: promoting the development and commercialization of sustainable bio-jet fuels*, Policy Exchange, research note, July 2009 (notes "…best estimates of current minimum production costs are approximately US$100-130 per barrel …"; Start-up biofuel firm Solix currently producing fuel from algae at $32.81/gallon but expects costs to come down as better design improves production integration. See also Figure 15 in IP/1, *A summary of research and perspectives presented at the ICAO Workshop on Aviation and Alternative Fuels.*

between 2010 and 2030, or be reduced by approximately 40%.[5] Since there are no sustainable alternative fuels for aircraft being produced today, a specific cost reduction curve cannot be developed or confirmed for these fuels. There are, however, many projects in various stages of development whose investors believe they can quickly reach cost parity with conventional fuels, although their financial plans and forecasts have not been made public.

5.3 With most of the feedstocks presently being evaluated, a substantial portion of the mass will end up as a by-product of fuel production. Finding markets for by-products (or co-products) will be important for overall process economics. Some high-value markets are available today for select bio-oils, such as nutraceuticles, which are used as nutritional supplements and feedstocks for pharmaceutical production. These materials represent a small part of the total oil produced, and large-scale fuel production may have a significant impact on their market value. Other by-products, such as meal, may be used for animal feed, solid fuel, or similar low value products; however, these materials will be an important consideration in overall process economics.

6. REGIONAL AVAILABILITY

6.1 Sustainable alternative fuels for aircraft can be produced from a wide variety of feedstocks. Sources of oil-producing plants such as camelina, moringa, babacu, macauba, jatropha, halophytes, and algae are already being evaluated for fuel production. These plants and others can be grown in countries around the world. It is quite likely that different feedstocks can be optimally grown in different countries, suggesting that many regions are candidate production locations. Once refined into fuel, the feedstock used is irrelevant to the aircraft. Additionally, since these feedstocks have a relatively low energy density, especially compared to crude oil, it is uneconomic to ship them over long distances. As a result, sustainable alternative fuels for aircraft may be better suited to production on a local scale.

6.2 The by-products or secondary products from sustainable alternative fuels for aircraft production can become valuable inputs to local economies. These materials, such as animal feed or solid residues that can be used as fuel for cook stoves, may be valued locally even if the bio-oils are shipped out of the region for refining. Communities may be able to develop new businesses or other sources of income from alternative fuel production.

6.3 While sustainable alternative fuels for aircraft can be produced from a wide variety of feedstocks and processes, only those that attract sufficient investment will achieve a market presence. Identifying resources, producing test quantities of oil, certifying the fuels, conducting performance studies, and investing in plot plant production are all expensive. Significant investment will be required in any region where States desire to become producers of sustainable alternative fuels for aircraft.

7. CONCLUSION

7.1 The conference is invited to:

a) note that development of new sustainable alternative fuels for aircraft production processes are able to reduce costs of fuels to compete with conventional jet fuel in the mid-term;

[5] *Energy technology perspectives to 2050,* International Energy Agency, OECD/IEA, Paris, 2008.

b) acknowledge that sustainable alternative fuels for aircraft can be produced from a wide variety of feedstocks for use in global aviation, suggesting that many regions are candidate production locations;

c) conclude that sustainable alternative fuels for aircraft are well suited to production on a local scale because unlike crude oil, the energy density of currently-proposed feedstocks is too low to support economical shipment over long distances;

d) agree that the by-products or secondary products from sustainable alternative fuels for aircraft production are valuable inputs to local economies; and

e) recognize that sustainable alternative fuels for aircraft can be produced from a wide variety of feedstocks and processes, yet, only those that attract sufficient investment will achieve a market presence.

8. RECOMMENDATIONS

8.1 The conference is invited to:

a) recommend that States inform ICAO of any plans to establish alternative fuel production facilities in the short, medium, and long-term;

b) recommend that those plans be incorporated into the High-Level Roadmap on Aviation and Alternative Fuels;

c) recommend that ICAO establish a web site to facilitate the exchange of information between States and International Organizations interested in advancing sustainable alternative fuels for aircraft; and

d) recommend that States and International Organizations share best practices and techniques that can apply to the development and scale up of sustainable alternative fuels for aircraft production through ICAO.

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