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CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

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Agenda Item 3: Measures to support development and use

ALTERNATIVE AVIATION JET FUEL PRODUCTION AND CERTIFICATION

(Presented by Brazil)

SUMMARY

The conference is invited to consider production technologies that work with the existing biofuels infrastructure and that produce drop-in replacements for petroleum biofuels. Brazil is in an advantaged position to deploy viable alternative aviation jet fuels. The country has acquired invaluable expertise through years of successful ethanol production through the fermentation of sugar cane and commercial aircraft manufacturing. At the same time, there are research institutions and enterprises pioneering research on hydrocarbon production in yeasts, which convert simple sugars, such as sugar cane, into medium and long-chain hydrocarbon precursors via a traditional fermentation platform. The technology platform is suitable for producing hydrocarbon bio-molecules with chemical structures identical to those found in aviation jet fuel.

The conference is invited to consider measures beyond the need for improved international collaboration for certification and product testing. Therefore, the conference is invited to approve the conclusion/recommendation in paragraph 3

1. INTRODUCTION

1.1 THE NEED FOR ALTERNATIVE AVIATION JET FUELS

1.1.1 Governments around the world have signalled that the airline industry will be one of the first to be regulated under global cap and trade. Aviation has no foreseeable new technology to power flight beyond hydrocarbon fuels. As assessed by Amyris[1], the 250 billion litre (70 billion gallon) jet fuel

[1] **Amyris** is an integrated technology and marketing company using an advanced microbial technology platform to produce and market a variety of renewable products. Its production platform uses yeast capable of fermenting different types of feedstock into renewable hydrocarbons for the diesel, jet fuel and chemical markets, starting with

market is fast becoming an area of intense innovation as biofuel producers are developing renewable jet fuels with equivalent performance while reducing total 'well to wake' carbon emissions on a cost competitive basis.

1.1.2 Commercial airline profitability has long been troubled by the volatility of jet fuel pricing. The uncertainty of fuel pricing along with the recent global financial crisis has resulted in dramatic negative consequences on aircraft manufacturers. The introduction of a viable alternative jet fuel would not only avoid or minimize the potential of carbon tax on jet fuel, but also provide a supplemental fuel source which may stabilize aviation jet fuel pricing.

1.1.3 The jet fuel market is structurally able to rapidly adopt alternative fuels due to the relative concentration of off-take partners (1,679 major airports) and leading associations like the *Commercial Aviation Alternative Fuel Initiative* (CAAFI) coalition co-sponsored by the Aerospace Industries Association (AIA), Airports Council International - North America (ACI-NA), the Air Transport Association of America (ATA) and the Federal Aviation Administration (FAA), who support the uptake of alternative jet fuels.

1.2 Climate Regulation impact on industry

1.2.1 Legislation passed by the European Union in 2008 includes an aviation Emissions Trading Scheme (ETS). This scheme will add a carbon tax to all aviation fuels, requiring airlines to compensate for carbon emissions starting in 2012. This legislation will levy fuel taxes on flights originating from the Americas bound for European destinations. The *Air Transportation Action Group* (ATAG) estimates that the carbon tax will equal approximately 9 euro per passenger per trip - further increasing costs for the fragile commercial aviation industry.

1.3 Jet Fuel

1.3.1 The aviation jet fuel market is segmented according to the performance characteristics required by aircraft engine manufacturers (turbine and piston) and end users, inclusive of the military sector. The four dominate fuel classifications include:

- Jet A/A1: The most common aviation fuel utilized by the commercial airline industry
- JP-8: Similar to Jet A with the addition of an icing inhibitor, corrosion inhibitors, lubricants, and antistatic agents. JP-8 is used predominantly by the armed forces around the world
- JP-5: Is similar to JP-8 with a higher flashpoint specification. JP-5 is used predominantly by the armed naval forces around the world.

1.4 Product characteristics of Aviation Jet fuel

1.4.1 Jet fuel must satisfy rigorous specifications to operate successfully in flight, including physical properties as well as 'fit-for-purpose' operating criteria. Aircraft, for example, operate at temperatures ranging from greater than 55 ^{o}C at ground level to less than -60 ^{o}C at altitude, and at elevations ranging from sea level up to 45,000 feet. In addition, turbine engine manufacturers are

traditional sugar cane mills. Amyris has its main operations in Emeryville, CA, USA and Campinas, SP, Brazil, where it operates pilot and demo plants using sugar cane as a feedstock. Its investors include Votorantim, Kleiner Perkins Caufield and Byers, TPG Biotech and Khosla Ventures.

increasingly utilizing the fuel prior to combustion as a hydraulic fluid for actuating advanced engine features. This extraordinarily broad range of operating conditions and functions requires special examination of alternative jet fuel cold flow, flash point, distillation, energy density properties, as well as engine system compatibility.

1.5 Certification

1.5.1 Certification of jet fuel is a complex, expensive and lengthy process that requires clear technical standards, international cooperation and industry support. The US standards for all fuels are set by the ASTM International organization. ASTM has recently established a new standard (ASTM D 7566-09) for Aviation Turbine Fuel Containing Synthesized Hydrocarbons. It is essential that international standard setting for alternative jet fuels is established on a harmonized basis with the greatest opportunity for mutual recognition of testing and validation data. It is essential that certification policy be technology neutral, requiring physical properties and fit-for-purpose specifications assessed only on final fuel blends as used and not the blending components.

1.6 Biotechnology as a tool for Alternative jet fuel

1.6.1 Modern biotechnological science provides the precise control and targeting of DNA in microorganisms. An in-depth understanding of microbial physiology allows scientists to precisely influence what molecules microbes produce, such as hydrocarbons. This specialized technology is especially valuable for alternative jet fuel production as the extracted hydrocarbon must have properties capable of satisfying the performance requirements of the finished fuel. Yeast has been used for thousands of years in traditional fermentations. In the late 70's, Brazil implemented a very impressive sugar cane ethanol program on the basis of yeast fermentation. Today, leveraging biotechnology to reprogram the same yeast (*Saccharomyces cerevisiae*) will effectively ferment sugar cane into alternative jet fuel, resulting in one of the most promising means of redefining the aviation jet fuel industry.

1.7 Biomass Derived Jet Fuel

There are research institutions and enterprises (Amyris Biotechnologies and Amyris Brasil Pesquisa e Desenvolvimento, Ltda., for example), pioneering hydrocarbon production yeasts, which convert simple sugars, such as sugar cane, into medium and long-chain hydrocarbons precursors via a traditional fermentation platform. The technology platform is ideal for producing hydrocarbon bio-molecules with chemical structures identical to those found in petroleum derived aviation jet fuel. By simple processing, these molecules have resulting product characteristics satisfying aviation jet fuel requirements.

1.8 Example of Bio-Jet Fuel Tests Performance

1.8.1 Isoprenoid, hydrocarbon biojet fuels are a viable alternative jet fuel in high-level blends with petroleum derived jet fuel serve as an example of fuels to support. These blended fuels have been demonstrated to meet all of the ASTM D1655 and key ASTM D7566 bulk property specifications. Noteworthy is the ultra low sulfur content, lubricity and negligible residues in the jet fuel thermal oxidation test (JFTOT). This class of biojet has demonstrated a best in class freezing point, which is below -70 ^{o}C and approximately 20-25 degrees lower than petroleum derived jet fuel. In combustor rig tests at GE Aviation, these biojet fuels, in a 1:1 blend with petroleum jet fuel, performed equal or better than commercial jet fuel across a wide range of conditions. For any fermentation based biojet fuel, the creation of an ASTM D 7566-09 Annex for Fermentation-Derived Renewable Jet Fuel would be an appropriate standard-setting action. Through the application of advanced biotechnology, biojet fuels and production systems are being designed to provide biofuel blends compatible with the commercial jet fuel distribution infrastructure and engine technology.

1.9 **Process and Scale-up**

1.9.1 Several biotechnology enterprises are on the final stages of scaling a hydrocarbon platform for deployment as early as 2011, using simple fermentation technology currently deployed in sugar and ethanol mills. Production of sugar-derived biojet fuel could deploy from this initial production base as early as 2012 and ramp to billions of litres, dependent primarily on the basis of technology neutral alternative jet fuel policy. While the deployment initially will focus on sugar cane, potentially any source of carbohydrate can be used as a fermentation feedstock, opening the space for cellulosic feedstock when these become commercially viable.

1.10 **Sustainable Production of Alternative jet fuel**

Sustainability is a politically charged theme ranging from agriculture inputs, to farming practices, and biomass processing. Generally, groups have emphasized that alternative aviation fuels be derived from feedstocks that minimize impact on food supplies are fast growing, do not require excessive inputs, provide socio-economic value to local communities and result in a lower carbon footprint. Implementation of these principles in a technology neutral manner as performance criteria for finished fuels will allow industry to quickly innovate and deliver commercially viable options to market.

1.11 **Sugar Cane as an advanced feedstock for Alternative jet fuel**

Over 180 countries produce sugar from sugarcane and other sugar containing crops for a total 2005 production of 1.5 billion tons of biomass. Sugar cane has the lowest carbon footprint crop in large scale production for transportation fuel (ethanol) today. Direct calculations of carbon emissions estimate a reduction versus petroleum of 80 to 100% depending on growth, harvest and other production practices. Brazil is the largest grower of sugar cane in the world, representing approximately one third (1/3) of the world's existing production capacity, or approximately 570M tons.

1.12 **Production Potential for Brazil**

1.12.1 Today, Brazil utilizes approximately 7M hectares of the total agricultural land of more than 320M hectares (excluding protected areas such as rainforests), or approximately 2.2%, for the production of sugar cane. Of the 7M hectares occupied by sugar cane, approximately half is used for biofuels production (ethanol). Pasture land, much of which is degraded, occupies approximately 180M hectares.

1.12.2 Sugar cane could expand into this degraded pasture land to produce a sustainable feedstock for alternative jet fuel. It is also a crop that has a large potential to increase per area productivity. UNICA reports that Brazilian production practices (such as mandatory mechanization and non-burning of sugar cane in the field before harvesting) are leading the world in sustainability.

1.12.3 The existing sugar cane production infrastructure can be leveraged with new yeast strains for fermentation into renewable jet and rapidly achieve production scale, increasing productivity. Today, Brazil has approximately 400 sugar cane mills transforming feed stock into ethanol, totalling 570Mt. Retrofitting these mills to alternative jet fuel refineries would not be capital prohibitive. The required retrofitting would utilize the existing agricultural and biomass processing equipment and workforce expertise. In 2016, it is estimate that the Brazil will produce 900-1,000 million tons of sugar cane.

Retrofitting 10% of this capacity for the fermentation of alternative jet fuel would provide 5 billion litres, exceeding Brazil's 2008 jetfuel consumption of 3.8 billion litres.

1.12.4 By converting the ethanol mills into 'jet fuel' refineries, Brazil can become a sustainable supplier to the aviation industry, guaranteeing a renewable energy matrix to the world, and strengthen the commercial aviation industry's commitment to reduce CO_2 emissions.

2. CONCLUSION

2.1 The conference is invited to conclude:

a) Current production technologies work with the existing biofuels infrastructure and can produce drop-in replacements for petroleum biofuels.

b) Brazil is in an advantaged position to lead that next generation of biofuels and deploy viable alternative aviation jet fuels. The country has acquired invaluable expertise through years of successful ethanol production through the fermentation of sugar cane and commercial aircraft manufacturing. This expertise provides the Brazilian government a unique opportunity to intensify the movement towards alternative jet fuel commercial up-take.

3. RECOMMENDATION

3.1 The conference is invited to:

a) Consider measures beyond the need for improved international collaboration for certification and product testing detailed herein

b) Encourage States to develop technology and feedstock independent policies based on performance criteria both in production and in use which ensures that the best alternative jet fuels from the best inputs are accepted

c) ICAO, working with States and Industry, facilitate the development of globally harmonized standards and test criteria for all renewable jet fuel types

d) Encourage the development of funding mechanisms to accelerate the production of the volumes of alternative jet fuel required for certification

— END —