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The market development of aviation biofuel: Drivers and constraints

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ABSTRACT

Aviation biofuel is technically viable and nearing the commercial stage. In the last ten years, biofuels have moved from relative obscurity to a point where certain types of fuel have become fully certified for commercial use in up to 50% blends with standard jet fuel and commercial partnerships between airlines and biofuel producers are being established. Yet despite numerous successful test flights, aviation biofuels have yet to become widely commercialised. Drawing on the findings of in-depth interviews with leading global aviation biofuel stakeholders undertaken between October and December 2011, this paper identifies and examines the perceived factors that are affecting the market development of biofuels for aviation. The paper illustrates that market development is being driven by the combined effects of rising jet fuel prices, the potential future impact of emissions legislation and concerns about fuel (in)security. However, commercialisation is being constrained by high production costs, limited availability of suitable feedstocks, uncertainty surrounding the definition of the sustainability criteria, and a perceived lack of both national and international political and policy support for aviation biofuel. The implications of these findings for commercial aviation and the future development of global market for aviation biofuel market are discussed.

1. Introduction

The need to develop commercially viable alternatives to traditional fossil-based liquid fuels for commercial aircraft is intensifying. The rising price of crude oil, potential new carbon emissions legislation, the negative environmental externality effects resulting from fossil-fuel consumption (including, but not limited to, atmospheric pollution and anthropogenic climate change), and growing global demand for air travel have collectively motivated research into sustainable fuel alternatives (Köhler et al., 2014; Nair and Paulose, 2014). Liquid biofuels are at the forefront of these developments as they have the potential to confer significant economic and environmental benefits and can be 'dropped in' to existing infrastructure. Worldwide, research and development into new types of alternative fuel has grown significantly during the last 10–20 years as a result of the use of mandates, tax breaks, subsidies and advantageous funding arrangements between biofuel producers and national governments (Panoutsou et al., 2013). This has resulted in commercial markets for liquid biofuels being established in Europe, North America, South America, Asia, Asia Pacific and Africa (Köhler et al., 2014).

Until recently, biofuels were predominantly used by the road transport sector as direct and more environmentally friendly substitutes for conventional petrol and diesel (see Freedman, 2014). Although the rail and maritime sectors have also begun to experiment with biofuels as a way to reduce the carbon intensity of their operations (Florentinus et al., 2012), some of the most dramatic developments have occurred within the commercial aviation sector. The aviation industry faces a unique and increasingly acute set of environmental and energy challenges and many airlines are currently pursuing biofuels as a means to reduce their oil dependency, lower their greenhouse gas emissions and improve their environmental performance. As the unprecedented high price of oil of $147USD a barrel in 2008 demonstrated, the air transport industry is particularly vulnerable to rising and volatile oil prices. Fuel constitutes a major component of an airline's operating cost. In the last 10 years, fuel costs have doubled to account for 28% of airline operating expenses in 2013 (PWC, 2013). As a result of the high oil price, a number of airlines worldwide were forced to declare bankruptcy during 2008 and hundreds of thousands of passengers had their travel plans disrupted. In addition to fuel price concerns, the air transport industry is also under increasing public and political pressure to address its environmental impacts (see Bows-Larkin and Anderson, 2013). In response, the industry is making a concerted effort to reduce greenhouse gas emissions (particularly of carbon dioxide) by investing in more fuel efficient technologies

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and environmentally friendly operating practices (Budd and Budd, 2013) as well as in alternative fuels sources to reduce emissions (Winchester et al., 2013a).

IATA has set a target for the global aviation industry to achieve carbon neutral growth by 2020 and reduce CO_2 emissions by 50% relative to 2005 levels by 2050 (IATA, 2009). In the US the Federal Aviation Administration (FAA) aims for 1 billion gallons of jet fuel to come from alternative renewable sources from 2018, representing 1.7% of predicted fuel consumption of US carriers (FAA, 2011; Winchester et al., 2013b). Moreover, alternative jet fuels can both qualify under the Renewable Fuels Standard in the US, and under the EU Renewable Energy Directive, although there is no specific mandate for jet fuel. Crucially, the industry has few short-term technological options at its disposal which would confer the required emissions reductions while simultaneously reducing oil dependency and protecting growth (Blakey et al., 2011; CCC, 2009). While some efficiency gains can be delivered through fleet renewal and enhanced air traffic management procedures such as continuous decent approaches and precision area navigation (P-RNAV) these measures will not, by themselves, be sufficient to deliver the drastic reductions in emissions which are required and additional interventions are required. At present, virtually all of the world's commercial aircraft are powered by engines that burn Jet A/A1 fuel and produce a range of pollution species as by-products of combustion and incomplete combustion. Although alternative propulsion technologies, such as hydrogen fuel cells and solar power, have been proposed and subjected to a degree of testing, and they are not yet certified for commercial use. Liquefied natural gas has also been produced as a future aviation fuel since it offers lower fuel burn and emissions and potential cost and availability benefits (Stephenson, 2012). One of the most attractive short-to-medium term options for the air transport industry is, however, to continue to operate existing engines and aircraft but use lower carbon fuels. As this will show, although certification for 50% blends of FT biofuels achieved in 2009 and HEFA fuels in 2011, many challenges to widespread commercialisation remain (IATA, 2013). The paper begins by reviewing the current state of aviation biofuel testing and research worldwide. This is followed by a description of the data collection method that was employed, an examination of the key findings, and a discussion surrounding their implications for commercial aviation and the continued development of aviation biofuels.

2. Developments in aviation biofuel

The term biofuel refers to any form of renewable energy that is derived from biomass.

Biofuels can be solid (e.g. wood), liquid or gas and can be produced from an array of feedstocks, wastes and production processes. There are two basic forms; primary biofuel and secondary biofuel. Primary biofuels, such as wood chippings and agricultural waste, are the most basic form of bioenergy and require no additional processing (see Naik et al., 2010). Secondary biofuels are made from biomass that has been processed to change its chemical composition. These processes include fermenting sugar crops to produce ethanol, pressing oil rich crops to produce vegetable oil, superheating biomass to create combustible gas and combining different types of liquid or gaseous biofuel together.

However, in order to produce biofuels that have the required chemical and flow characteristics for use in aircraft engines, advanced processing techniques have need to be developed (see Chuck and Donnelly, 2014). The main processes of producing aviation biofuel involve either hydrotreating vegetable oils to make hydrotreated renewable (HEFA) fuels or performing gasification of biomass feedstocks using the Fischer–Tropsch process (FT) (CCC, 2009). Both techniques produce a bio-derived paraffinic hydrocarbon known as Bio-SPK. Crucially, the resulting Bio-SPK not only has similar chemical properties and comparable flow characteristics at low temperatures to standard commercial Jet A/A1 fuel but it also does not contain Fatty Acid Methyl Esters (FAME), water, metal particles or other contaminants. To ensure the safety and performance of Bio-SPK fuels, a lengthy period of testing commenced. Trials on commercial aircraft followed from 2008 onwards and involved different airframe and engine combinations as well as a variety of different feedstocks and blend ratios.

As a result of extensive trials, ASTM (formerly known as the American Society for Testing and Materials, a global leader in the development of international voluntary standards) certification for BtL and HEFA fuels was granted for commercial purposes in up to 50% blends in 2009 and 2011 respectively (ASTM, 2011). The 50% blend limit was established to guarantee the presence of 'aromatics' in the fuel which are essential for the effective operation of engine fuel seals but which are not present in biofuels (Corporan et al., 2011). With ASTM certification achieved, major airlines began to source biofuels and operate scheduled commercial flights powered, in part, by biofuels. KLM operated one of the first revenue biofuel flights in July 2011 when it flew 171 passengers from Amsterdam to Paris in a Boeing 737 part-powered by biofuel derived from waste cooking oil (KLM, 2012). Later that year, Lufthansa conducted a six month trial using biofuel derived from a variety of plant and animal fats to power 1187 flights between Hamburg and Frankfurt (Lufthansa, 2012).

Although all of these trials involved short-term co-operation between airlines, airframe and engine manufactures, airports and biofuels suppliers, one of the main challenges airlines faced was sourcing sufficient supplies of biofuel. To overcome this challenge and reduce vulnerabilities in the supply chain, airlines and biofuel producers began establishing commercial partnerships. British Airways agreed to co-fund, with US firm Solena, the development of the UK's first commercial scale waste-to-liquid aviation biofuel facility in east London which aims to convert 500,000 tonnes of domestic refuse into 50,000 tonnes of aviation biofuel a year (British Airways, 2013) while Virgin Atlantic entered into a partnership with Swedish biofuel company Lanza Tech (Enviro.aero, 2012). In June 2013 it was announced that United Airlines will purchase 15 million gallons of renewable jet fuel over a 3 year period (Lane, 2013). However, despite these (and other) commercial partnerships, barriers to market development remain. This paper reports on the findings of a series of in-depth interviews with major aviation biofuel stakeholders worldwide.

3. Method

25 Aviation biofuel stakeholders based in Europe and North America were identified from extensive literature and internet searches (Table 1). Respondents were drawn from sectors including airframe manufacturers, airlines, environmental consultants and (bio)fuel companies. Initial contact was made via email and interviews, which averaged 1 h in length, were conducted by telephone between October and December 2011. Whilst recognising the methodological limitations of the research undertaken, not least in terms of the limited sample of the stakeholders interviewed, the research presented here contributes to extant debates on the future commercial development of aviation biofuel by examining the perceptions of fuel producers, end users and policy makers.

The semi-structured interview schedule consisted of open-ended questions relating to four key areas that had been identified from the literature as representing gaps in the existing knowledge base. These areas were: the historical development of