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Drivers and barriers to the adoption and diffusion of Sustainable Jet Fuel (SJF) in the U.S. Pacific Northwest

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A B S T R A C T

Sustainable Jet Fuel (SJF) represents an important component of the airline industry's strategy to simultaneously reduce GHG emissions while meeting a growing demand for international air travel. SJFs also have the potential to provide fuel supply diversification and security, enhance fuel price stability and provide regional/rural economic development benefits. This paper measures and ranks perceived drivers and barriers to an economically viable SJF industry in a unique U.S. region, the U.S. Pacific Northwest (PNW), through personal interviews with key aviation fuel supply chain stakeholders conducted from June to September 2015. In addition to providing a fertile arena for this first effort to systematically assess these drivers and barriers, the U.S. PNW is unique due to the region's long strategic focus on aviation innovation and its importance to the regional economy, the seminal efforts in the region to outline a path forward on SJF beginning in 2010, and the relatively small population spread over a large geographic area with a limited number of "hub" airport nodes which geographically concentrates aviation fuel demand and distribution. Nineteen stakeholder interviewees acknowledge that, in order for regional SJF adoption-diffusion to occur, airline jet fuel buyers must drive the process, particularly as they deal with greenhouse gas (GHG) emission issues and related policy considerations. Important perceived barriers to SJF industry scale-up in the U.S. PNW include the high production costs of SJF and related issues, such as fuel logistics and quality control in the transport, storage, and blending of SJFs. Perceptions around chain-of-custody issues, such as blending, tracking, and crediting of SJFs and future SJF market share projections for the year 2030 were also examined. Incorporating stakeholder input into discussions about adding blended SJF into the U.S. aviation fuel supply provides needed insight for the biofuels industry, policymakers, and researchers.

1. Introduction

Volatile crude oil prices, political and public pressure on carbon emissions, more stringent environmental targets, a continued interest in fuel security, and a growing global demand for air travel have collectively driven research toward Sustainable Jet Fuels (SJFs) (Gegg et al., 2014). SJFs are hydrocarbon-based, "drop-in" fuels derived from non-petroleum sources (Ibarrola, 2015). To be drop-in, SJF must be fully compatible with existing aircraft and fueling infrastructure, and meet the same safety and reliability standards as conventional petroleum-based jet fuel (Zuckerman et al., 2015).

SJFs can reduce aviation emissions, provide supply diversification and security, enhance price stability and provide regional/rural economic development benefits (Macfarlane et al., 2011; Wyman, 2013; Miller et al., 2013; Maniatis et al., 2013). Hileman and Stratton (2014) add to these considerations the ameliorating effect of competition for energy sources due to unique aviation fuel requirements necessitating a safe, liquid, high energy density fuel to be carried aloft. To date, the aviation industry has progressed toward SJF goals in terms of research and development, certification of approved production pathways, flight demonstrations, off-take agreements, and global buy-in (CAAFI, 2014). Remaining barriers include capital availability, supply chain development and cost competitiveness with petroleum-derived jet fuel (CAAFI, 2014).

Several interdisciplinary research projects and public-private-partnerships are examining the viability of sustainable aviation

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biofuels with initial emphasis in the PNW states of Washington, Oregon, Idaho, and Montana. These groundbreaking efforts were initiated in 2010 through the Sustainable Aviation Fuels Northwest (SAFN) project, whose final report outlined specific actions that were needed to create a sustainable aviation biofuel industry in the region. This foundational effort has led to further activities in the region: two Coordinated Agriculture Projects funded by the U.S. Department of Agriculture (the Northwest Advanced Renewables Alliance [USDA-NARA] and the Advanced Hardwood Biofuels Northwest [USDA-AHB]); the establishment of the Federal Aviation Administration's Aviation Sustainability Center (ASCENT.aero), and the Washington Aviation Biofuels Working Group (Nararenewables.org; Macfarlane et al., 2011; Wyman, 2013; FAA-ASCENT.aero). The geographic context, as well as the prominence of the aviation industry, and regional interest in SJFs as evidenced by numerous public-private partnerships to create a viable industry, makes the PNW region an interesting case to examine these important SJF issues.

This research effort represents USDA-NARA and FAA-ASCENT research collaborations undertaken to better understand regional stakeholder perceptions, utilizing semi-structured interviews with key aviation fuel supply chain stakeholders. This study provides a relative ranking of the drivers and barriers to a sustainable aviation biofuel industry in one U.S. region, the Pacific Northwest, and examines key downstream SJF fuel blending, tracking and crediting issues. This contextual analysis provides insights for the SJF enterprise to consider, as informing an action plan to ameliorate potential obstacles to scale up.

2. Background

Approximately 23 billion gallons of jet fuel were consumed by the combined jet-powered aviation enterprise of the U.S. (commercial, business, and military) in 2015 (CAAFI, 2016). SJF is expected to be more easily diffused into the aviation sector, as opposed to the ground transportation sector, due to its drop-in nature and the concentrated and comparatively smaller scale of airport operations (ATAG, 2012). In the U.S. alone, there are about 160,000 gas stations, whereas 381 U.S. airports handle approximately 99 percent of all commercial passengers (ATAG, 2012; FAA, 2015a). Worldwide, 190 airports handle over 80 percent of the world's aviation fuel (ATAG, 2012).

Key players in this industry have adopted goals of moving to SJFs to assist the aviation enterprise in meeting its self-ascribed goals of achieving carbon neutral growth from 2020. For instance, the Federal Aviation Administration (FAA) has stated a near-term aspirational target of 1 billion gallons of SJF in use by 2018, based on an aggregate of renewable fuel targets for the US Air Force, the US Navy and US commercial aviation industry (GAO, 2014; FAA, 2015c). The Navy recently contracted with AltAir Fuels to supply 77 million gallons of cost-competitive, drop-in, non-food advanced biofuel blends from October 2015 to September 2016 (EESI, 2016; Lane, 2016). The target for the US Navy is for half of total energy consumption, currently about 3.5 million gallons per day, to be derived from alternative sources by 2020 (U.S. Navy, 2016).

More than 20 airlines have flown over 1700 SJF-blend commercial passenger demonstration flights between June 2011 and October 2014 using fuel derived from a variety of feedstocks in different aircraft and engine types (IATA, 2015). Several airlines have also sought SJF supply chain agreements with fuel producers. For example, in 2013, United Airlines announced a purchase agreement with AltAir for HEFA fuel from the Paramount, California refinery. Also, FedEx Express and Southwest Airlines agreed to purchase the entire SJF output (6 million gallons) of Red Rock biorefinery from 2017 through 2024 (Lane, 2015). Other airline efforts include developing direct cooperation either for technology breakthroughs or to set-up production supply chains (ICAO, 2014).

In addition, a variety of multi-stakeholder joint initiatives have formed to promote the coordinated development and commercialization of SJF worldwide. In North America, the industry formed the Commercial Aviation Alternative Fuels Initiative (CAAFI) to pursue SJF. More regionally-focused efforts have also been executed in the U.S., including the Sustainable Aviation Fuels Northwest (SAFN) and Midwest Aviation Sustainable Biofuels Initiative (MASBI). The U.S. Department of Agriculture (USDA) has also initiated several regionally focused efforts through the National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative Coordinated Agricultural Projects (AFRI CAP) program.

2.1. Airline emissions

Aviation currently produces about 2 percent of the world's GHG emissions and is responsible for 12 percent of CO2 emissions from all transport sources[1] (Zuckerman et al., 2015; ATAG, 2015; IATA, 2015; FAA, 2015b; Nair and Paulose, 2014). Due to a growing middle class in the world's developing economies, aviation is growing faster than other transportation modes with the number of passengers expected to grow from 3.1 billion in 2013 to approximately 7.3 billion a year by 2035 (ATAG, 2015; Fahey and Mayerowitz, 2015; Zuckerman et al., 2015). As a result, the aviation industry established aggressive carbon reduction targets in 2009 to reduce GHG emissions by 50 percent by 2050[2] (ATAG, 2015; IATA, 2015). Emission reduction targets may be achieved via operations, infrastructure and technology (including the use of SJF) (Zuckerman et al., 2015; ATAG, 2015; Miller et al., 2013).

2.2. ASTM-approved SJF pathways

Conventional jet fuel for commercial airlines, primarily Jet A in the U.S., is a blend of hydrocarbons produced from petroleum distillation and refinement (CAAFI, 2016). In 2009, the American Society for Testing and Materials (ASTM) International approved the world's first semi-synthetic aviation fuel specification: the “Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons” [D7566]. “Drop-in” fuel specification D7566 was a significant milestone toward promoting the development of SJFs as it allows the use of these certified fuels in all existing engines and aircraft (Altman, 2012). D7566 also allows oil companies, refiners and producers of aviation turbine fuel and new SJF producers to use the D7566 specification in their operations.

Currently, four ASTM-approved production pathways for SJFs include (Table 1): Fischer-Tropsch (FT) (certified in 2009); Hydroprocessed Esters and Fatty Acids (HEFA) (2011); Synthetic Isoparaffin from Fermented Hydroprocessed Sugar (SIP) (certified in 2014); and FT-SPK/A Fischer-Tropsch plus Aromatics (Fall, certified in 2015). In addition, Alcohol to Jet Synthetic Paraffinic Kerosene (ATJ-SPK) passed two levels of ASTM technical balloting and is currently in the final stages of review, with final publication expected by April 2016 (Lane, 2016). Several additional SJF pathways are currently under ASTM review, including: Alcohol to Jet Synthetic Kerosene with Aromatics (ATJ-SKA); CH (lipids); Hydroprocessed Depolymerized Cellulosic Jet (HDCJ); and HEFA+ (wider-cut HEFA with RD) (CAAFI, 2014; ICAO, 2014; Miller et al., 2013;

[1] For comparison, 74 percent of emissions emanate from road transport (ATAG, 2015; IATA, 2015).

[2] Reduction targets used a 2005 level baseline with zero net carbon emissions growth beyond 2020 (ATAG, 2015; IATA, 2015).