International Civil Aviation Organization

WORKING PAPER

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CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

Mexico City, Mexico, 11 to 13 October 2017

Agenda Item 1: Developments in research and certification of aviation alternative fuels

ESTIMATED PRICES OF AVIATION ALTERNATIVE FUELS

(Presented by the ICAO Secretariat)

SUMMARY

Aviation alternative fuel (AAF) prices remain above conventional aviation fuel (CAF) prices by a significant, but steadily declining premium. Incentives and policy support will be required in the short-to-mid-term to ensure the development and scale-up of fuel production facilities. This working paper provides information on estimated prices of several types of AAF reported in published literature, and possible means of reducing costs associated with future sustainable aviation fuel (SAF) production.

Action by the conference is in paragraph 4.

1. INTRODUCTION

1.1 As predicted at the first Conference on Aviation and Alternative Fuels (CAAF/1) Working Paper 12 (CAAF/09-WP/12), significant evolution in research, development, and deployment of aviation alternative fuels (AAFs) has taken place. Since 2009, five types of conversion processes for AAF production have been approved by ASTM International, an international standards setting organization, confirming the safety and viability of these fuel blends. Those conversion processes approved by the ASTM for the production of AAFs are: Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene (FT-SPK); Synthesized paraffinic kerosene produced from hydroprocessed esters and fatty acids (HEFA-SPK); Synthesized iso-paraffins produced from hydroprocessed fermented sugars (SIP-HFS); Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources (SPK/A); and Alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK).

1.2 Additional details regarding these approved conversion processes are described in CAAF/02-WP/07,as well as details of additional conversion processes that are going through the approval process.

1.3 Currently, AltAir Fuels, in Los Angeles, U.S., is the only commercial scale facility that is regularly producing AAF. This facility produces fuel with the HEFA-SPK conversion process. Commercial scale batches of AAF have been supplied by three additional producers: Amyris in Brazil has produced batches of AAF with the SIP-HFS conversion process, Gevo in the U.S. has produced batches of AAF with the ATJ-SPK conversion process, and Neste has produced batches of AAF with the HEFA-

SPK conversion process. Additionally, several new production plants using Fischer-Tropsch (FT) conversion process are under construction (e.g., Fulcrum, RedRock, SG Preston).

1.4 Despite these initiatives, several challenges still hinder further expansion of the AAF industry, as described in CAAF/02-WP/11. These challenges include higher production costs for AAF, which makes it difficult to compete with conventional aviation fuels (CAFs), especially considering current low crude oil prices. Thus, incentives and policy support will be required in the short-to-mid-term to ensure the development and scale-up of AAF production facilities. However, as production experience increases, AAF production costs are expected to fall.

1.5 This paper reviews AAF estimated minimum fuel selling prices (MFSP) by means of a bibliographic review of references that provide such values, in order to provide awareness to the Conference on the relative costs associated with current AAF production.

2. ESTIMATED MINIMUM FUEL SELLING PRICES OF SUSTAINABLE AVIATION FUELS

2.1 Several techno-economic analyses (TEAs) that estimate MFSPs of different types of AAFs are available in the literature. However, there remains significant scientific uncertainty regarding the applicability of these studies, as their results vary strongly and might even be contradicting. Specific challenges identified for these TEAs are their comprehensiveness and comparability, as financial and technology readiness assumptions are not consistently employed over the broad range of studies available in the literature.

2.2 Large uncertainties are associated with the strong impact of yields on economics and sustainability, intellectual property protection impeding the understanding of scaled processes, and the understanding of state-of-the-art technologies. For example, some studies have used scaling and de-risking by assuming the “n-th” plant approach. This approach implies that the analysis does not describe a pioneer plant but several plants using the same technology being already in operation. Therefore, this approach reflects a mature technology, but the evaluation of near-term and early-adopter economics, which are important for identifying scale-up risks and challenges for a technology, are omitted. Available cost estimates for pioneer plants are mostly coming from historical earning effects from the chemical industry, whose applicability to the specific case of AAFs is unclear. Consequently, there is a need to employ a consistent methodology for TEAs, to develop appropriate TEAs for pioneer plants, and a need for guidance and support for this development.

2.3 Still, TEAs provide an indication of the AAF selling prices to be expected. In Figure 1, the MFSP estimated by a selection of TEAs for several AAF pathways is shown (squares) and compared to a three-year averaged price of a typical conventional aviation fuel (solid line). For studies providing a range of MFSPs for a single pathway, the mean value is shown here. For estimating the CAF price, the U.S. Gulf Coast Kerosene-Type Jet Fuel Spot Price was selected and averaged from 2013 to 2015, resulting in approximately 0.78 \$/kg[1].

2.4 In the first Conference on Aviation and Alternative Fuels, in 2009, the production costs for AAF were estimated to range from 2 to 5 times the cost of CAF in some cases (CAAF/09-WP/12). The recent TEAs presented in Figure 1 show that now some pathways are approaching price parity with CAF. Despite this trend of declining production costs, until more significant fuel quantities are available, the cost of AAFs will remain highly uncertain. Therefore, subsidies or incentives might help to initially encourage production and help overcome the risks involved in moving from pilot scale to commercialization. With the startup of further commercial scale production facilities, costs are expected to come down. New, more competitive sources of feedstocks will be identified, production yields will increase, and the value of co-products will improve as new markets are identified.

2.5 Concerted Research and Development (R&D) efforts are one of the main drivers of better TEA performance over time. As shown in Figure 2, over a nine-year period of R&D, the US Department of Energy has improved the state of technology (SOT) for one possible biofuel production pathway, fast pyrolysis, such that the projected cost of fuel at full-scale production using this pathway has decreased by 75%[12]. This general downward trend in costs is also expected for many of the AAF fuel production pathways described in CAAF/2-WP/7, although specifics will vary.

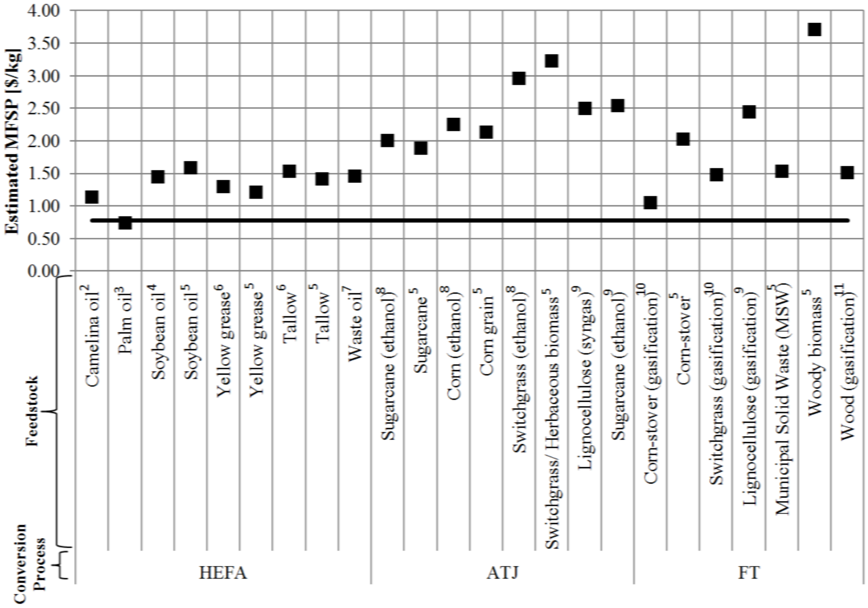

Figure 1: Estimated minimum fuel selling prices (MFSPs) of various pathways for AAF (squares) compared with a three-year average price of U.S. Gulf Coast Kerosene-Type Jet Fuel (solid line)[1].

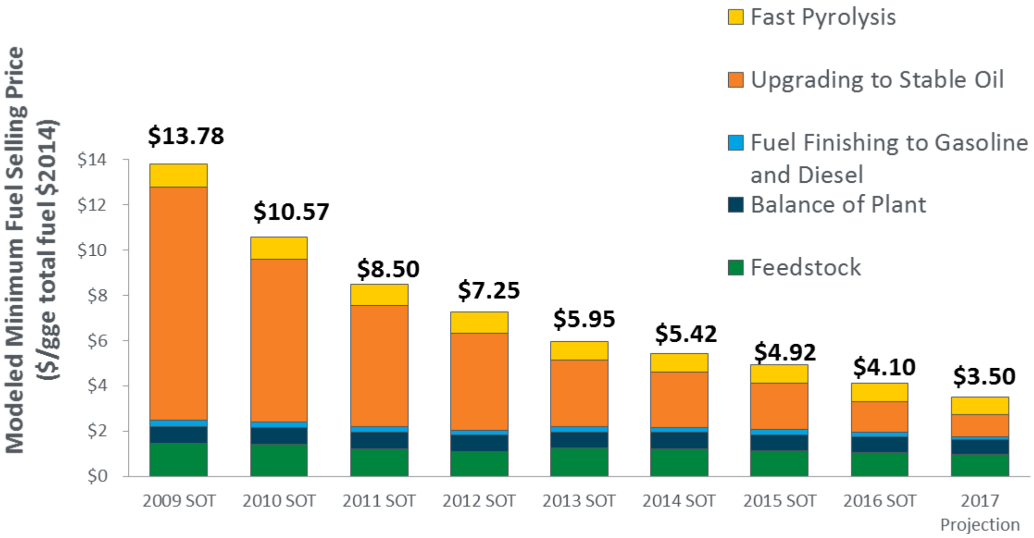

Figure 2: Modelled minimum fuel selling price (MFSP), in commercial deployment, of fast pyrolysis fuel using the current state of technology (SOT) at each year from 2009 to 2017[13].

2.6 Despite the uncertainties in TEAs, the general understanding is that the main production cost drivers for AAFs are: feedstock cost and composition, capital cost of a proposed process, overall yield of conversion, quality and composition of the produced AAF, operating expenses, financial requirements, logistics, initial resources, and current production costs of the AAF pathway[13]. Some of these costs can be directly or indirectly reduced by the following technology-related initiatives:

a) utilizing brownfield facilities i.e., existing infrastructure that is un- or under used such as older petroleum refineries or existing alternative fuel production facilities;
b) co-location with existing infrastructure e.g., locating AAF production near conventional fuel production to leverage hydrogen production and blending facilities;
c) thoroughly exploring and identifying feedstock resources, with the objective of increasing the volume available for sustainable aviation fuels (SAFs);
d) improving renewable oil recovery and extraction processes;
e) creating higher value co-products;
f) improving the efficiency of processes that convert feedstocks and intermediates to SAF;
g) development of advanced technologies for SAFs production;
h) reducing the distance and number of transport links;
i) continuing to conduct performance studies, fuels testing, and flight testing.

3. CONCLUSION

3.1 To reach greater commercial production of SAFs, price parity compared with CAFs has to be approached, as fuel is the main operating cost for commercial airline operators. However, current low crude oil prices makes it difficult for SAF to compete with CAFs. Therefore, financial mechanisms will likely be necessary in order to reach the goal of price parity for SAFs, since they reduce the risks associated with the volatility in oil prices. Possible financial mechanisms for the development of SAF projects are presented in CAAF/2-WP/10.

3.2 In order to advance the goal of price parity for SAFs, it is important that analyses are carried out to evaluate different policy options for stimulating SAF production. The cost and effectiveness of various policy options can be significantly different, thus it is important to identify which policy options can stimulate SAF production in the most cost-effective way for States. The set of qualitative metrics presented in CAAF/2-WP/11 can serve as the basis for evaluating the feasibility, effectiveness, and practicality of policies under specific national contexts and conditions.

4. ACTION BY THE CAAF2

4.1 The CAAF2 is invited to:

a) recognize the reduction in AAF production costs since CAAF/1 in 2009;
b) agree on the need to pursue price parity between SAF and CAF;
c) recommend States to promote collaborative initiatives amongst States, and with industry, in supporting global efforts to reduce SAF prices, including the technology-related initiatives identified in paragraph 2.6; and
d) agree on the need for financial mechanisms and policies to ensure the competitiveness of SAF, particularly during a period of low oil prices.

— END —

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