ECONOMIC ANALYSIS OF USING ALTERNATIVE FUELS FOR CIVIL AVIATION

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Use of alternative fuels in aviation is currently very topical issue. Many of the technical problems associated with the use of alternative fuels are already solved. Unresolved economic issues associated with the use of alternative fuels for civil aviation preventing their further use. Article provides a basic analysis of the economic problems that accompany the use of alternative fuels for civil aviation.

K e y w o r d s: alternative fuels, costs, production, distribution, raw materials, volatility

1 INTRODUCTION

Alternative fuels have been considered in establishing the first jet engine. However, in economic terms, this period is the only usable fuel showed a fuel produced from oil. At present the situation concerning the long run oil prices, rising oil prices are only confirmed. It is therefore necessary to seek alternatives to conventional fuels. There are two main concerns that motivate the aviation industry and the use of alternative transportation fuels instead of traditional oil and it is cost and environmental impact. From 2003 until mid-2008, rising oil prices on the world market led to a corresponding increase in prices of petroleum products including aviation fuel. The high price of aviation fuel has contributed to the bankruptcy of several airlines and is one of the factors that motivate other airlines using alternative fuels. In all economic sectors, including aviation, there is increased pressure to reduce greenhouse gas emissions. Alternative fuels derived from biomass and renewable energy sources offer the potential to reduce life cycle greenhouse gas emissions and thus reduce the impact of aviation on global climate change. Alternative fuels, if available in sufficient quantity, would reduce world oil demand, in consequence, reduce the world price of crude oil and products made from it.

2 OVERVIEW OF THE COSTS

Access to financing for aviation biofuels represents one of the biggest hurdles to the commercial deployment of sustainable biofuels. Financing solutions are being developed (US Government, IDB, etc.) and FT and HEFA production facilities are operational. However, additional work remains on harmonization of sustainability, and life-cycle analysis (LCA) criteria.

The successes of alternative aviation fuel to airlines affect the two main factors. The first relates to safety and it is determined by strict certification of aviation fuel, which still managed to complete two types of fuel (FT and HRJ / HEFA). And the second is the money thus strictly speaking the economics of alternative fuels. It is possible that the viability of various alternative fuels will be for different types of fuels and a technology is crucial. Accordingly, as is increasing while airlines are experimenting with alternative fuels is clear that interest in these fuels is in the future will only increase. Although currently there is no need for aircraft operators to use bio-fuels, there are many reasons to consider their use in the future:

- benefits to the environment to climate change;
- green business image;
- increased energy independence;
- interplay and potential savings with respect to the emission limits and trading system;
- financial subsidies associated with the use of renewable energy;
- recovery of valuable carbon credits by investing in the cultivation of certain biofuel plants.

These points are certainly many airlines for a big attraction. However, surveys of aviation biofuel economy in 2010, has revealed a wider, more uncertain range of costs. The mid-range of current cost estimates for BTL and HRJ are approximately US$ 1.20-1.40 per liter, which is roughly double the current jet kerosene price, even including carbon costs.

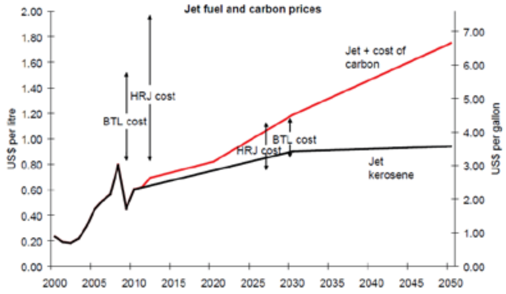

Figure 1. The changing economics of aviation biofuels

There is optimism that this range of costs can be brought lower by technology improvements, scale and learning. Most forecasts, for instance by the International Energy Agency, are for rising crude oil prices. Policy-makers also still appear on course to make energy users pay for carbon emissions, in one way or another. As a result of these developments, aviation biofuels may become economical in approximately 20 years based on current projections.

3 COSTS OF ALTERNATIVE FUELS ASSOCIATED WHIT THE PRODUCTOIN AND DISTRIBUTION

Production costs are a key measure for the commercial viability of alternative fuels. Current price of aviation fuel is directly dependent on oil prices. Cost-effective development of alternative fuels requires that the cost of fuel price competition with conventional fuels. Alternative fuels with higher production costs than the price of conventional fuels can produce and sell at a profit, without government support (e.g. investment or production subsidies, production mandates, or taxes on fuels made from ordinary oil.)

3.1 The cost of production and distribution of GTL-Gas to Liquid

Estimate the cost GTL complicated series of factors. These include in particular information about their own cost of capital and raw material costs, which is natural gas. On the basis of a set of business interests and opportunities for GTL compression and transportation of natural gas, it is possible to estimate the cost of producing GTL-based jet fuel ranging from \$ 1.40 to \$ 2.50 per gallon.

3.2 The cost of production and distribution of CTL

Based on the analysis Bartis, CAMM, and Ortiz (2008), the estimated cost of CTL production range from \$ 1.60 to \$ 1.92 per gallon.

3.3 The cost of production and distribution of BTL

BTL fuels is far in the development and direction of economic efficiency of production of bio-aviation fuel is best explored. The dominant majority of the analyzes is the combination of biomass with coal as raw material, whose biggest advantage is the reduction of emissions. CBTL fuel (liquid fuel from coal and biomass), biomass, accounting for between 10-30%. The 10,000 barrels of fuel produced per day, which is the maximum that can be made, the estimated cost of 0.52 to 0.62 U.S. \$ (2010) per liter (or between 1.97 to U.S. \$ 2:39 per gallon). Studies suggest that there is an upper threshold of production (the ability to produce biomass only), about 5,000 barrels per day, reducing the level achieved in large-scale cost effectiveness CBTL. The cost of biomass supply to processor will probably be higher than the costs associated with mining and shipping coal. In the production of BTL fuels is expected to BTL plants should be located near a source of raw materials to minimize transport costs of raw materials. BTL materials are typically quite low in energy, which means that the material has low energy density in terms of volume and / or weight.

Given the uncertainty about future prices of biomass, there are two different hypotheses for the evolution of prices of input raw materials:
- optimistic hypothesis, in which raw material price decreases simultaneously with increasing returns, as described in Wit 2008/57;
- the pessimistic hypothesis, which should be raw material costs rise as fast as the price of crude oil. A major contributor to the manufacturing cost of the BTL investment. With the assumption of low-cost raw materials, are dominant throughout the

period, representing more than 40% of production costs. If the increased cost of raw materials is expected that production costs in 2030 will be 36% and 28.5% in 2050 (Figure 2.).

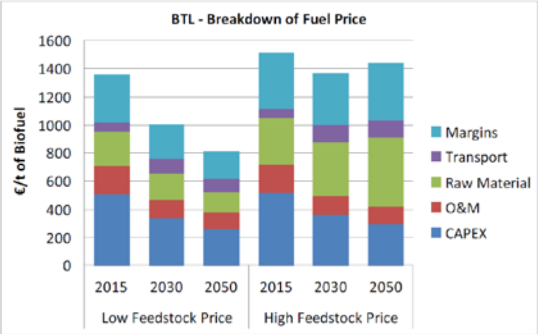

Figure 2. Price breakdown for BTL

3.4 Costs of production and distribution of HRJ

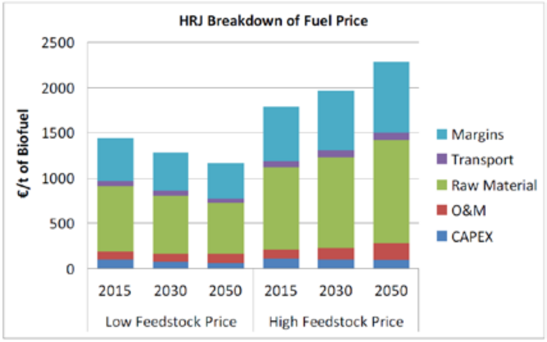

Figure 3. Price breakdown for HRJ

The worst are determined to HRJ fuel costs. Costs of production are estimated HVO (hypothermic treatment of biomass) and FAME biodiesel, which have similar production processes as HRJ. But there is no publicly available analysis of the acquisition budget cost of aviation fuel from vegetable and animal fats. Cost of production HRJ using, as the basic raw material oil from algae remain extremely uncertain, with a wide range of applicability of the acquisition life cycle of oil and carbon waste products. The U.S. National Renewable Energy Laboratory has submitted evidence of numerous studies on the cost of bio-fuels from oil obtained from algae, which are substantially higher than previously reported. The average was around $ 1.59 per liter or $ 6.00 (2010) per gallon, and some studies have operated on a cost so high as 5.00 $ -6.00 $ (2010) per liter or 20.00 $ -60.00 $ (2010) per gallon. It is clear that this technology is in its initial development stage, and therefore it is impossible to make accurate calculations of expected costs. Although there appears to be considerable potential to increase yield and reduce costs for this fuel technology.

4 COST NEED TO MODIFY AIRCRAFT A AIRCRAFT ENGINES BY INTRODUCTION OF ALTERNATIVE FUELS

4.1 The costs in implementing drop - in fuel

The replacement of traditional fossil fuels with alternative fuels type drop - in, there is no need for innovation, adaptation or alteration of aircraft engines and systems.

Drop - in fuels are currently the only existing candidates in aviation. Any alleged advantages of the cost of non-drop-in fuels cannot be compared with the costs that would be needed to create new facilities and changes to existing infrastructure.

4.2 Cost of the introduction of non - drop - in fuel

Potential fuel type non - drop - in hydrogen. The testing was addressed in several companies. Airbus A study of 2004 created a conceptual basis for full compatibility shift from kerosene to hydrogen. The study concluded that a conventional aircraft design can be adjusted to accommodate the larger tanks required for hydrogen fuel. It would, however, increased resistance because of the increased volume of the body, resulting in the increased consumption of energy and of 9-14%. Weight of the aircraft design could increase by approximately 23% and a maximum takeoff weight would be ranged between 4.4% to 14.8% depending on the size of the aircraft configuration and its mission. The use of hydrogen as aviation fuel offers obvious advantages, but also a considerable technical problem. Due to its weight and volume must be on the plane hydrogen stored in liquid form at -253°C (20°C). The volume of fuel is 4 times larger than that of kerosene, which leads to changes in aircraft configuration. The fuel system must be completely new, both with respect to its architecture and its components. While the engine is necessary to make significant changes. The company conducted tests on the Airbus aircraft powered by liquid hydrogen nicknamed Cryoplane (Figure 1). The specific task was to ensure low NO_x emissions. The security level has proved at least as high as in an aircraft with conventional propulsion. Testing also showed that operating costs would be as a result of using this fuel increased by 4% to 5%.

Figure 4. Project CRYOPLANE

Airlines will be ready to go to hydrogen, only if they have a secure economic advantage. The economic advantages of using hydrogen comparison, despite the costs associated with the adjustment of engine and aircraft itself depends mainly on fuel costs.

5 EFFECTS OF ALTERNATIVE FUEL FOR OPERATION OF THE ECONOMICS THE SELECTED TYPE OF AIRCRAFT

For the flight company Etihad Airways from Abu Dhabi to Seattle was to power the Boeing 777-300ER used a mixture of biofuels from sources of recycled cooking oil and traditional jet fuel. A mixture of biofuels supplied by Sky NRG and mixed in a ratio of 50% Jet-A and 50% biofuel (Figure 5.). This year is no different from the normal flight using conventional jet fuel. The only difference and thus the impact on the economic operation of the aircraft is in the price of fuel, which is compared with the aviation kerosene is higher. On the other hand, the use of alternative fuel for the airline a great asset especially in terms of actual image "green" company" and also in terms of reducing emissions in the payments system for emissions trading.

Figure 5. Etihad new Boeing 777-300ER tanking biofuel mixture prior to departure from Paine Field

6 COMMODITI PRICE VOLATILITI

According to Aviation Fuel Solutions, volatility in the biofuels market is caused by rising commodity and food prices, the fluctuating demand for biofuels, as well as increased speculation. This instability is amplified by the growing interconnectedness between energy and commodity markets and the increasing unpredictability of commodity markets.

First-generation biofuels like bioethanol and biodiesel rely on commodities such as sugar cane, corn, and rapeseed. Energy producers compete directly with animal-feeding operations and food processors for their respective commodities. Greater integration between oil prices and agricultural commodity prices is likely to result in more pronounced price instability for cereal grains. However, the increase in food prices is not only due to its links to biofuels.

Demand for biofuels is also affected by crude oil prices. If oil prices are high, then biofuels can compete, and the demand for biofuels would therefore increase. A decline in oil prices increases demand for crude oil and reduces the demand for biofuels.

6.1 Biofuels Impact on Land Use

According to a study conducted for the government of the United Kingdom in 2009, the full replacement of jet kerosene by 2050 would require:

- 37 million hectares for new oil crops

(camelina, jatropha, algae).

- 194 million hectares for woody energy crops (for BTL).
- A total 231 million hectares of land which represents 16% of all arable land.

Meeting these challenges will require instruments such as sustainability standards and planning regulation. Second and third generation biofuels are promising, posing less competition for land and water needed for food production, and making a greater contribution to energy security. The feedstocks for these include jatropha and other oil bearing, non-food shrubs that can grow on marginal land with little rainfall. However, questions regarding possible yields and required inputs, as well as the economics of growing these perennial poisonous shrubs for fuel production remain. Some studies have reported that, when jatropha is grown on arid and infertile soil, the oil yields are too low to be economic. It has been said that, "If you grow jatropha in marginal conditions, you can expect marginal yields."

6.2 Risk Assessment

An analysis of biofuel-related risks and their impact on project financing was conducted by Elobio et al in April 2010, with the following results:

- **Technology risk:** Relevant for new technologies which have a short track-record (or even none) in large-scale production operations producing a product of consistent quality, for a longer period of time.
- **Market risk:** Mainly refers to fluctuations in feedstock and biofuel prices and the correlation between the two, or lack thereof.
- **Regulatory risk:** As most biofuel production still requires policy support, it is important whether investors and lenders consider this support as adequate and stable, or insufficient and unreliable.
- **Geopolitical risk:** Relevant for production based on feed stock from regions with an unstable political environment, where export taxes or bans can be adopted without sufficient prior notice.

6.3 Stakeholder acceptance risk.

Refers to negative publicity received by biofuels during the food crisis of 2007/2008, which was seen as real threat to the reputation of finance providers who were associated with biofuel production; has caused some lenders to categorically deny funding to any kind of biofuel projects. Table 1 illustrates the variations in risk levels for key risk factors, for both first and second generation biofuels.

Risk Type	First Generation	Second Generation
Technology risk	Low-medium	High
Market risk	High	Medium
Regulatory/Policy risk	High	Medium
Geopolitical risk	Medium	Low
Stakeholder acceptance	High	Low

Table 1. Risk profile of first and second generation biofuels

6.4 Risk mitigation

Some of the risk mitigation options may include investing in multi-feedstock plants, hedging, and securing long-term contracts. The biorefinery concept maximizes the use of the biomass resource and generates revenue from different markets, lowering the risk of a slump in one of them. Although market risk remains high, these mitigation options make it less uncontrollable and thus, a lesser issue compared with technology risk.

6.5 Bringing Capital to Biofuels Technologies – Bloomberg New Energy Finance

Global investments in biofuels decreased from over $26 billion in 2007, to around $7 billion in 2011. The decrease is mostly a result of the financial crisis of 2008 which made access to capital difficult for a sector that was already overextended. Recently, the situation has been improving, as the focus shifts towards next generation technologies, as follows:

- Venture capital and private equity (VC/PE) investments have dramatically shifted from first generation to next-generation (next-gen) biofuel projects since 2006.

- Venture capital and private equity investments in next-gen projects now represent 95% of all VC/PE biofuel investments.
- Most VC/PE investments have gone to advanced biochemical companies in the last five years.
- Several biofuel companies have gone public over the last year. These companies have been next-gen firms using pathway technologies such as pyrolisis, enzymatic hydrolysis, and biobutanol fermentation.
- The US government has played a very strong role in providing financial support to the next-gen sector by carrying companies through the so-called "valley of death", to commercial scale production.
- By 2011, commercial scale next-gen projects were finally being financed and built, mainly in the enzymatic hydrolysis pathways.
- Enzymatic hydrolysis has received the most investments on the next generation pathway technologies; in front of advanced biochemical, gasification and pyrolisis.

6 CONCLUSIONS

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.

BIBLIOGRAPHY

[1] IATA 2011 Report on Alternative Fuels Effective, December 2011:No: 9709-04 978-92-9233-668-4,2011 International Air Transport Association. All rights reserved. Montreal – Geneva: Dostupné na internete: http://www.iata.org/whatwedo/environment/Documents/IATA%202011%20Report%20on%20Alternative%20Fuels.pdf

[2] IATA 2010 Report on Alternative Fuels Effective, December 2010: ,. No: 9709-03 ,ISBN 978-92-9233-491-8,2010 International Air Transport Association, All rights reserved. Montreal — Geneva.

[3] SWAFEA:Sustainable Way for Alternative Fuels and Energy in Aviation, Final Report ,April 2011 Submitted to the European Commission under contract Tren/F2/ 408.2008/SI2.518403/SI2.519012

[4] RUMIZEN,Mark: Qualification of Alternative Aviation Fuel. Montreal, Canada, ICAO Aviation and sustainable alternative fuels-Workshop.2011. [online]. < http://legacy.icao.int/sustaf/Docs/19_Rumizen.pdf >

[5] Technical - economic analysis of suitable alternative fuels [online]. 2006<http://www.mdcr.cz/NR/rdonlyres/F2EF24EF-5E59-42C7-B6C7 A5508CE8F820/0/Technickoekonomicka_analyza_vhodnych_alternativnich_palív_v_dopravecast_1.pdf >

[6] IPCC: Climate Change 2007: Working Group III: Mitigation of Climate Change-Aviation. [online].<http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch5s5-3-3.html>

[7] CRYOPLANE Hydrogen Fuelled Aircraft Submission for the Energy Globe Award 2001 ,Category "Transport",Hamburg,. [online]. 2000-13-10. http://webstaff.itn.liu.se/~clryd/KURSER/TNK027/Kurslitteratur2011/CRYOPLANE.pdf>

[8] SUSTAF:ICAO Review-Sustainable alternative fuels for aviation. Montreal 2011.Chapter 5. [online] < http://legacy.icao.int/sustaf/>

[9] WAAF:ICAO Workshop on aviation and alternative fuels Montreal 2009. [online] < http://legacy.icao.int/waaf2009/>

[10] GREENAIR: Some non-food vegetable oil-based aviation biofuels could be cost-competitive by the end of the decade, finds Bloomberg study.Greenaironline.com.[online].2012-15-02

<http://www.greenaironline.com/news.php?viewStory=142>

[11] ENVIRO: Beginers guideto aviation biofuels:2011.Enviro.areo.[online] Dostupné na internete: <http://www.enviro.aero/Content/Upload/File/BeginnersGuide_Biofuels_WebRes.pdf>

[12] ASHWORTH, Ryan: Aircraft Economics (Programme and Operational**)** Chapter 10. [online]. < http://www.bristol.ac.uk/aerospace/msc/avadi/units/projects/ub2006/group2/economics.pdf>

[13] THE ECONOMIC TIMES:UAE carier Etihad Airwais operates first biofuels poweres flight.Economictimes.com .[online].2012-26-01.<.http://articles.economictimes.indiatimes.com/2012-01 26/news/30666648_1_biofuel-jet-fuel-flight-marks>

[14] CONFERENCE ON AVIATION AND ALTERNATIVE FUELS Rio de Janeiro, Brazil, 18 November 2009. .[online] <. http://legacy.icao.int/caaf2009/>

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