Biofuels: a key factor for the future of airline industry

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Abstract

The airline industry is rapidly growing due to increasing demands for safe and fast travels. The lack of alternative fuels to replace the conventional jet kerosene, which is polluting and relies heavily on depleting oil reserves, is threatening the sustainability of the airline industry. By applying Feitelson and Salomon's framework for innovation assessment, we evaluate acceptability of biofuels, as potential candidates for powering aircraft engines. Introduction of biofuels requires feasibility study on multiple facets such as: technical, social and political aspects. These issues will be discussed in this article. We conclude that current global situations is in "conditionally" in the favour of introduction of biofuels in the aviation world, given that certain supportive measures are taken to reassure the society and the airline industry.

Keywords: airline, sustainability, biofuels, innovation adoption

Introduction

Reliance of the airline industry on conventional fuels to power the aircraft engines adds to the vulnerability of this economically crucial sector. There is an urgent need to find a safe, sustainable and feasible replacement for current jet fuel which could be used on existing aircraft fleet. However, the airline industry is not confined with the borders of a country and it has international domain of activity, which introduces legal and administrative challenges. Therefore, any alternative and sustainable jet fuel must gain international acceptance, if it is considered for widespread consumption by airlines. In this study we will not focus on international and legal obstacles. Rather, we focus on more general issues that comes with adoption of an innovative solution in such industries.

Recent studies have suggested some alternatives to the conventional kerosene based jet fuel such as biofuels, hydrogen cells and even solar powered aircraft (Blakey et al. 2011, Lee et al. 2009). Among these alternative fuels biofuels seems to be the most practical option for current aircraft engines. Some studies, such as Wong (2008) and Deurwaarder (2005), claim that biofuels are comparatively less polluting and more sustainable in terms of production and consumption. However, there are some concerns over production of biofuels regarding its need for biomass that are produced from plants that require arable land. This raises alarms over land used for food supplies being converted into cultivations that delivers biomass for oil production.

In this article, the objective is to investigate whether or not biofuels have the kind of characteristics to be a successful predecessor for the conventional jet fuels. To achieve this aim a well-known framework from transport innovation literature is used. This framework discusses the conditions of adoption of an innovation in the society.

Based on this framework, biofuels not only have to qualify for technical and economical requirements, but they should also have social and political approval from the society.

In this paper, a brief description will be given about the airline growth and also the situation about biofuels. Then the framework of innovation acceptance with important pillars such as technical, social and political aspect of biofuel will be discussed. Finally we discuss if biofuels have the potentials to be broadly adopted or not.

1 Airline growth and the need for alternative fuels

Airbus and Boeing, the two leading manufacturers of commercial aircraft, have both independently predicted a yearly growth of about 5.0% (Airbus industries, 2007) (Boeing, 2007) for the airline industry. This means that today's fleet of around 15,750 aircraft will grow to almost 32,000 by 2028 (Airbus Industries, 2009). Nygran (2009) points out to similar growth rates for the airline industry looking from the perspective of revenues obtained from passengers. Figure 1 shows the revenue passenger kilometre (RPK) in previous decades and it also gives a forecast for the coming years.

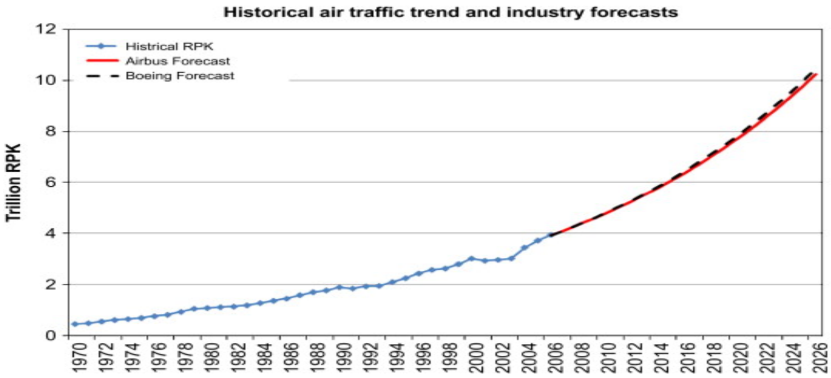

Figure 1 RPK growth in last 40 years and the forecast for coming years (Source Nygren, 2009).

The need for jet fuel will be rising according to these predictions, due to passenger demand and also increasing fleet production that still mainly consumes kerosene based jet fuel. An average of 6.8 million barrels of fuel was consumed per day in year 2007. Some researchers estimated this value to increase to nearly 7.2 million barrels per day in year 2012 (L. Rye, 2010). Fortunately with better airframe designs and more efficient engines, the average consumption of new aircrafts has decreased considerably. However this reduction in fuel consumption is outperformed by the increasing number of aircraft to meet market demand, thus causing the industry to be more dependent on conventional jet fuels. The subsequent problems arising from airlines' dependence on conventional fuels, other than economic instability, is the emissions that are exerted to the atmosphere. The impact of aircraft emissions on the environment is much wider than just the CO_2 pollution. Assessment conducted by IPCC (Inter-governmental Panel on Climate Change) show that along with CO_2, there are other emissions from jet engines such as NO_x, H_2O, sulphate and other particles which have far more harmful impacts on atmosphere than CO_2 (Blakey S, 2011). These facts emphasize the importance of the alternative and sustainable fuels for future survival and growth of the airline industry.

2 Biofuel as an alternative fuel for aircraft

Biofuels, being developed since 1970s, have reached to practical production stages. United States, Brazil and New Zealand are among the leading nations in producing biofuels. Automobile industry is one of the first consumers of biofuels. The reason for early adoption of biofuel by of auto industry over airline sector is that the automotive industries in each country must adapt to the national rules and regulations, whereas the airline industry has more global nature and therefore requires a globally recognized and verified fuel. To achieve this wide recognition, several non-profit organizations have been established, which are mostly funded by federal governments or international bodies. Their aim is to address the idea of renewable fuel sources in global level and further develop the technology and bring together the experts in the field. Renewable Fuels association (RFA), Algal Biomass Organization (ABO), National Renewable Energy Labs, and European Algae Biomass Association are among the major organizations active in this field.

2.1 Various types of biofuels

Charles et al.(2007) distinguish biofuels into two generations. The first and the older generation of biofuels consist mostly of bio-ethanol. Bio-ethanol is primarily introduced for the automobile industry in Brazilian (and to some extent in US) market. This generation of biofuels is produced in large quantities from biomass of crops (e.g. sugarcane and maize), which can supply food to humans (Van der Laak, 2007). These actions have raised criticism from UN's world food program (WFP) who is dealing with increasing hungry populations in underdeveloped countries.

The second generation of biofuel, fortunately, has nothing to do with human food supply chain. Therefore there is less speculation over this generation of biofuels (Charles, 2007). Another advantage of second generation biofuels is that they pollute less when they are burned in jet engines (Charles, 2007). The National Renewable Energy Laboratory (NREL) in the United States claims that one type of algae, which contains high amount of lipid, can produce biofuel three times as much as Soybean (Marsh, 2008).

Algae are developed in huge ponds either covered or exposed to open air. They do not, necessarily, require arable land for their growth. In this respect, a report published by Boeing states that with 38,000 liters (10,000 US gallons) of Algea harvested per acre each year, around 320 billion liters (85bn US gallons) of biofuel can be extracted from algae ponds equivalent to the size of Maryland (12,400 square miles) (Marsh, 2008). According to Rye's estimation of fuel consumption in 2012, the global airline industry will need approximately around 420 billion liters (based on consumption rate of 7.2 million barrels/day). Thus, 320 billion liters of biofuel produced from algae would meet more than 75% of global airline fuel requirements each year. So hypothetically speaking, with current technical expertise and by allocating an area equivalent of 16,500 square miles and harvesting algae to provide biofuel, the fuel requirements of entire airline fleet in the world could be sustainably supplied.

2.2 Political aspects of biofuels

The literature on biofuels indicates that promotion of biofuels maybe politically attractive for various reasons such as: taking practical action to slow down global warming, reducing dependence on fossil fuels thus gaining more economical stability, and promoting agricultural activities and providing ample employment opportunities (Charles, 2007). The latter point maybe more interesting for decision makers in developed nations because this may introduce a competitive advantage in their agriculture sector over developing countries, which have entered the competition by exporting agricultural products at cheaper prices due to lower labour costs.

2.3 Debate on CO_2 emissions from biofuels

According to Boeing, biofuels have the capacity to reduce the greenhouse gas emissions by up to 80%. Also, RFA argues that benefits of biofuels are recognized in two domains. The first benefit is to combat the effects of greenhouse gas (GHG) emissions on the global climate. The argument behind this claim is that the carbon dioxide released during a jet engine's propulsion is "recycled" by the plant as it grows. Therefore keeping the total added CO_2 to the nature at zero (Liska, 2009). The second benefit is that biofuels are renewable resource fuel. Thus biofuels are theoretically sustainable and no need to fear about their depletion (Marsh, 2008).

Some studies suggest first generation biofuels (e.g. bioethanol) substantially reduce the greenhouse gas emissions (Wong, 2008). The second generation biofuels (e.g. algae) perform even better than earlier biofuels types by producing lesser greenhouse gases than first generation biofuels (Deurwaarder, 2005). On the contrary, other researchers are less optimistic and they speculate over certain biofuels to have negative effects on climate. Gallagher (2008), who is the chairman of the UK's Renewable Fuels Agency, recommends that although there is high demand for alternative fuel but biofuels should be investigated with more precision. This is done to avoid producing fuels with more negative effects than fossil fuels.

2.4 Biofuels Trials

Virgin Atlantic was one of the frontrunners in testing biofuels on commercial aircrafts. A Boeing 747 fuelled with biofuels, flew without passengers on 24th February 2008, from London Heathrow to Schiphol airport in Amsterdam (Marsh, 2008). Air New Zealand and Boeing have created a research partnership to sustainably produce biofuel from Jathropa. Among the plants considered up until now, Jatropha is one of the best candidates for the biofuels production (Barta, 2007). A two-hour test flight between Auckland and Wellington (New Zealand) was performed by consuming biofuels and involved one of the airline's Boeing 747-400 aircraft (Simon Blakey, 2011). In such flights a combination of new biofuel with Jet A-1 were successfully tested on current jet engines.

3 Adoption of biofuel according to Feitelson and Salomon's framework

Feitelson and Salomon's framework (Feitelson, 2004), as seen in figure 2, is often used for assessing adoption possibilities of an innovative solutions mainly in transport related studies. In this framework, three main features namely technical, social and political aspects are examined for their feasibility for an innovation. In this section, the three aspects are discussed regarding adoption of biofuels by the airline industry.

3.1 Technical & Economical feasibility

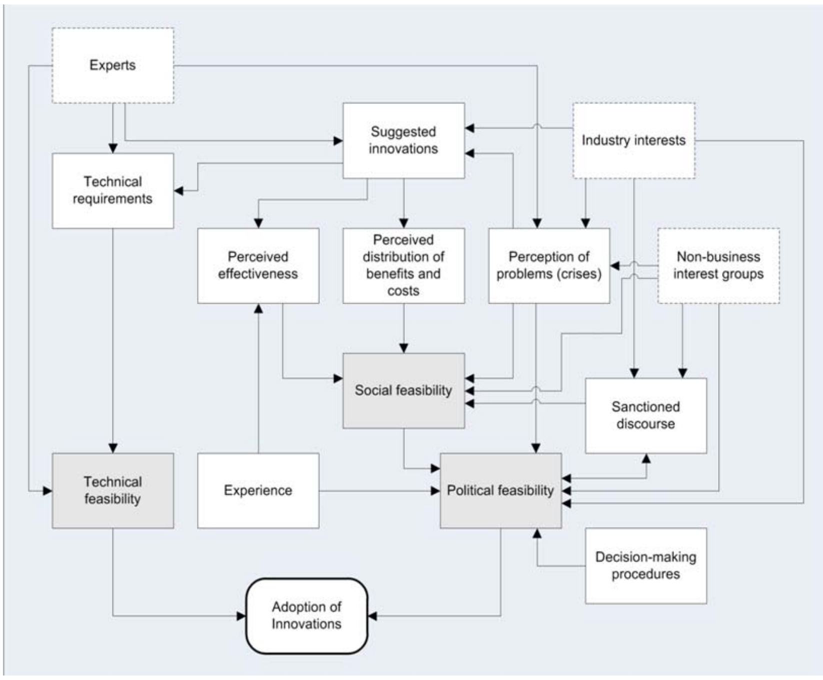

Figure 2: Feitelson and Salomon's framework for assessing innovation ((Source: Feitelson, 2004)

As mentioned in section 2.4, biofuels have been tested successfully on number of flights. Though technical tests are still continuing, most of them report satisfactory results in using biofuels to power conventional jet engines. However, technical feasibility, as pointed out by Feitelson et. al. (2004), is closely tied with economical feasibility. Economical feasibility is initiated by "industry interests" to invest on a proven and/or promising technology. Biofuels are yet to attract large scale investments. Industry has performed pilot projects (e.g. Shell' biofuel plant in Malaysia) to produce sustainable biofuels. However, these developments have some distance from full scale industrial and economically viable production (Emma Nygren, 2009). Moreover, overproduction and availability of crude oil at low prices is the other reason for lack of interest on biofuel production.

On contrary, the future seems to be bright for the biofuels. There have been predictions that crude oil production may be reaching to its peak without any suitable replacement being found for it. Besides, the technological developments are pushing the production cost down i.e. signs of economics of scale can be seen in making of biofuel. Putting these issues together and considering current prices of oil above US$100 per barrel, production of biofuels may become an interesting issue for entrepreneurs and investors. The CEO of Aurora Biofuels, Robert Walsh, who is incidentally a former Royal Dutch Shell executive, has declared that his company was able to commercially produce biofuels from algae biomass at competitive price with crude oil, given the price of oil stays above US$50 per barrel (LaMonica, 2009). Therefore, current high oil prices can positively contribute to the economical feasibility of biofuels.

Next to economical feasibility, one can mention the important position of airline industry for economical growth and stability. Reliance of airline industry on, purely, fossil fuels puts this sector in vulnerable situation which in turn threatens economic stability. Thus the economical stability of markets are tied to development and reliable production of alternative fuels in foreseeable future (Emma Nygren, 2009). However, airline industry is not the only potential consumer of biofuels. There will be high demand from other industry sectors such as auto industries and power (electricity) generation sector (Kar, Bonnefoy, & Hansman, 2010). This concern raises the issue that who should get the bigger portion of biofuels when there is not enough to go around. Thus, the outlook for economical aspects seems to be favourable towards mass production and investment on biofuels. According to Feitelson and Salomon, should result into more intense research to be done to resolve any remaining technical issues for safely and regularly usage of biofuels. Thus the technical feasibility of mass use of biofuels is soon to realised.

3.2 Social feasibility

Given the ever increasing demand for air travels, sustainable solution for growing airline industry would be supported by the public. However this public support is not unconditional. To achieve a minimum social feasibility one can think of at least three pre-conditions. First of all the new solution should be safe i.e. the biofuels should perform just like the conventional jet fuel without causing any significant incidents. Secondly the new jet fuel should not affect the ticket prices, i.e. the cost of air travel should not be increased dramatically, when airlines start to pump their aircrafts with biofuel. The third condition is that the production of biofuel should not compromise food production by converting the land reserved for food production to biofuel production. These three conditions seem to be essential for biofuels to become socially feasible.

The industry seems to be aware of these issues, for instance Air New Zealand has declared that consumption of biofuel is in line with their social responsibility (Miller-Reeves, 2008) to reduced environmental footprint but in the same time not compete with food consumption. These objectives set by Air New Zealand implicitly shows that airline industry is also aware of the potential success factors of biofuels. Therefore if the mentioned conditions are met by the producers of the biofuels, then these type of fuels can be socially feasible.

3.3Political feasibility

From the Feitelson et.al. (2004) framework we understand that social acceptability is one of the important factors that determines political feasibility (Feitelson, 2004). Politician, on the other hand, always try to address highly publicized issues which would bring them popularity and political credit. Politicians, in general, raise the issue of the security of supply of crude oil, self-dependence on providing energy sources and promoting agricultural activities. Therefore, these highly sensitive issues can be suitable political motives for politicians to focus more on biofuels and endorse the research producing safe and low cost biofuels. This can, in turn, act favourably for economical feasibility which will thus create a positively re-enforcing feedback loop. These policy goals are also demonstrated in EU guidelines for justifications of biofuel production (Faaij, 2006). Therefore the political grounds are in favour of further development of biofuels.

Finally, for the issue of biofuels adoption by the airline industry, one can conclude form Feitelson's framework that out of the three factors, one of them (i.e. political factor) seem to be positively feasible but technical and the social factors are "conditionally" feasible. Therefore, according to this framework, biofuels may gain a green light from the industry to be adopted as an innovation.

5 Conclusions

In this article we investigate, whether biofuels do have the characteristics of a successful predecessor for conventional jet fuels currently used by the airline industry. First we presented an overview on issues surrounding biofuels. Then we used this information and applied them in Fietelson's framework to assess the possibility of adoption of this innovation by the industry in short term future. We saw politicians have several strong motives to support developments of biofuels but they also need social backing from their people. The social aspects are rather uncertain. The society is observing the performance of biofuels in the airline industry regarding its safety and effects on ticket prices. The society may also be concerned about use of arable land to produce biofuels instead of food. The technical aspects regarding the safety of biofuels have proved to be successful but more in-depth research is required. Moreover, researchers must produce cheaper and less polluting biofuels which do not consume agricultural resources required for food supply. For the latter item the focus should primarily be on second generation of biofuels which do not necessarily require arable land. To conclude, one can say that biofuels in the political field qualify to be a successful predecessor of conventional fuels, but in the social and technical fields, it is not certain and under certain condition they can also succeed to replace conventional jet fuels.

As for the future research on this field, one can assess ways to develop a dominant political and legal regime for global recognition and utilization of the biofuels. Perhaps one can also study the influence of internationally renowned and trusted institute such as IATA and ICAO on gaining public support and confidence in use of biofuels by the airline industry. This would reduce the social uncertainty factor and increase the confidence of the industry to consider biofuels more seriously.

References

IATA. (2008, July 8). Retrieved April 12, 2011, from asia one news: http://news.asiaone.com/News/Latest+News/Business/Story/A1Story20080708-75407.html

Airbus industries. (2007). *Global Market Forecast 2007–2026.* Airbus.

Airbus Industries. (2009). *Global Market Forcast 2008–2028.* Airbus.

Barta, P. (2007, August 25). *Jatropha Plant Gains Steam In Global Race for Biofuels*. Retrieved June 1, 2011, from The Wall Street Journal: http://online.wsj.com/article/SB118788662080906716.html?mod=googlenews_wsj

Blakey s, L. R. (2011). Aviation gas turbine alternative fuels: A review. *Proceedings of the Combustion Institute*, 2863–2885.

Boeing. (2007). *Current Market Outlook 2007.* Seattle: Boeing.

Charles, M. a. (2007). Public policy and biofuels: The way forward? *Energy Policy*, 5737-5746.

Deurwaarder, E. (2005). Overview and analysis of national reports on the EU biofuel Directive: Prospects and barriers for 2005. ECN 5/1/2005.

Emma Nygren, K. A. (2009). Aviation fuel and future oil production scenarios. *Published in Energy Policy*, Pages 4003-4010.

Faaij, A. (2006). Bio-energy in Europe: changing technology choices. *Energy Policy*, 322-342.

Feitelson, E. a. (2004). 2 The Political Economy of Transport Innovations. *Transport Developments and Innovations in an Evolving World*.

Gallagher, K. a. (2008). Analysis of Policies to Reduce Oil Consumption and Greenhouse-Gas Emissions from the US Transportation Sector. *Belfer Center for Science and International Affairs Discussion Paper*.

Kar, R., Bonnefoy, P., & Hansman, R. J. (2010, 7 13). Dynamics of Implementation of Mitigating Measures to Reduce CO2 Emissions from Commercial Aviation. *International Center for Air Transportation*.

Kingdon, J. (1984/1995). *Agendas, alternatives and public policy.* Bostin: Little, Brown and company.

L. Rye, S. B. (2010). Sustainability of supply or the planet: a review of potential drop-in alternative aviation fuels. *Energy Environ. Science*, issue 3, 17-27.

LaMonica, M. (2009, 3 4). *Aurora's algae payoff: $50 a barrel, plus a price on carbon*. Retrieved 4 12, 2011, from Cnet News: http://news.cnet.com/8301-11128_3-10188491-54.html

Lee. (2009). Aviation and global climate change in the 21st century. *Atmospheric Environment*, 3520–3537.

Liska, A. a. (2009). Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol. *Journal of Industrial Ecology*, V.13 No.1 Pages 58-74.

Marsh, G. (2008). Biofuels: aviation alternative? *Renewable Energy Focus*, Volume 9 , Number 4, pages 48-51.

Miller-Reeves, S. (2008). *Air New Zealand Announces World First Flight using biofuel to Take off on December 3rd 2008.*

Simon Blakey, L. R. (2011). Aviation gas turbine alternative fuels: A review. *Proceedings of the Combustion Institute*, 2863–2885.

Van der Laak, W. a. (2007). Strategic niche management for biofuels: Analysing past experiments for developing new biofuel policies. *Energy Policy*, 3213--3225.

Wong, H. M. (2008). Life-cycle assessment of Greenhouse Gas emissions from alternative jet fuels. *Massachusetts Institute of Technology*. U.S.A.