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Assessment of Biofuels in Aviation Industry for Environmental Sustainability

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The world has come to increasingly accept that conventional sources of fuel and energy are being depleted since the process of forming fossil fuels takes millions of years longer than the rate that it is rapidly consumed. Aircraft engines cause noise pollution and emit gases and particulates that reduce air quality and contribute to global warming and global dimming, where dust and ash from natural and industrial sources block the sun to create a cooling effect. This paper looks into the working of biofuel as to how it can be the solution towards solving fuel price and energy crisis in the aviation industry. It reviews the usage of biofuel in the aviation industry by airlines in the world focusing on strategies conducted by Virgin Atlantic Airways and some other selected airlines. The understanding of low carbon fuels has developed rapidly over the last decade and Virgin Atlantic are closer than ever before to bringing a sustainable product to the market for commercial use. The paper also considers the biofuel impact on sustainability of the environment and how such usage of biofuel can be adopted into Malaysian aviation industry using available biofuel resources in Malaysia. With many technologies designed for aviation industry, biofuel has come to be utilised in many countries, including the Malaysian Aviation industry. Biofuel ensures the lower emissions of Greenhouse Gas (GHG) as well as sustainability against depleting fossil fuels. It has been estimated that if greenhouse gas emissions continue at the present rate, Earth's surface temperature could exceed historical values as early as 2047, with potentially harmful effects on ecosystems, biodiversity and the livelihoods of people worldwide. Recent estimates suggest that on the current emissions trajectory the Earth could pass a threshold of 2 °C global warming, which the United Nations' IPCC designated as the upper limit for "dangerous" global warming, by 2036. By prioritising research and deployment of advanced technologies that can convert sustainable waste into biofuel, future aviation industry can witness new development.

1. Background of the Study

1.1 Need of biofuels as an energy source in aviation industry

Speaking from cotemporary context, in the aviation industry, biofuel is known for being the most promising fuel in the aviation fuel alternatives, and although biofuels perform unfavourably to global warming to some extent, many companies are using this fuel since it is comparatively better than fossil fuels (Bomani et al., 2009). Biofuel is an environmentally friendly product, and it forms an important renewable resource and alternative fuel. Biofuel comes from "animal fats (tallow, lard, white or yellow grease, poultry fats, or fish oils); recycled greases (used cooking and frying oils); and most commonly, plant oils (from soybeans, corn, rapeseed, sunflowers, and cottonseeds, etc.). To use this biofuel in diesel engine its require no engine modification as well (Shahabuddin et al., 2012). Biofuel represents all liquid and gaseous transportation fuels, and among biomass, biofuel and biodiesel remains as the two most promising fuels in transportation sector.
In modern world, there is a worldwide interest in biofuels as renewable as well as long-term fuel sustainability, since there are high chances of fossil fuels being depleted (Bomani et al., 2009). Unlike fossil fuels, what is required in biofuel is simply a fully renewable resource that can be manufactured within a short period of time, and which produces less or virtually no greenhouse effect. What is required now in fuel sector is a safe,

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reliable, and efficient method for generating alternative sustainable fuel, which the biofuel can fill the gap. This biofuel is renewable and sustainable because it is derived from plant and it also uses the biodegradable waste material to use as fuel or industrial production. The Hubbert's Peak predicts that the world will be shortly threatened with energy starvation, and the usage of biofuel is an answer to such challenges (Bomani et al., 2009). As compared to road transport biofuel, the aviation biofuel has higher energy density and chemical stability, lower freezing point, and conventional biofuels are usually not suitable. Thus, the biofuels for aviation system differs from the road transport biofuel. The advancement through biofuels has been efficiently going together with aviation technological advancement, where the aircraft has been developing four times more efficient than those built 40 years ago (Bomani et al., 2009). Through the usage of biofuels and other sustainable fuels, fuel efficiency in aviation improved by 70 % from 1960 to 2000, and by 20 % from 1990 to 2000. It is again expected to increase by 40-50 % by 2050, bringing in immense development as compared to other transport mode of industries (Saynor et. al., 2009).

1.2 Overview of use of biofuel in Malaysian aviation industry

The growth of Malaysia's commercial aviation industry is significant in the region, since it has undergone rapid development over the years, starting from a nascent stage to building important domestic and international services. Rapid progress of the industry has garnered interests to study the aviation industry, in terms of fuel and technology in this country. In particular, the commercial aviation in Malaysia has been booming and it is being monopolised by two airlines – Malaysia Airlines and Air Asia. Till 2015, there are 112 Malaysian aircrafts and 72 Air Asia aircrafts operating in the country. The aviation industry in this country is expected to grow even further owing to its growing tourism sector in the country (Tan and Yap, 2015). South Asia in general shows healthy aviation industry growth rate, and Malaysia with 25 % seat capacity growth (2012-2013) contributes to such success.

The International Air Transport Association (IATA) noted the Malaysian aviation industry growth rate as 5.3 % per annum since 2012 to date (Tan and Yap, 2015). In Malaysia, biofuel is widely used, and the main source of biofuel is palm oil, which is produced domestically in order to reduce the dependency of oil being imported from other country. In 2009-2010 alone, the country produces around 40% of world palm oil (Shahabuddin et al., 2012). The country is able to produce high quality biodiesel consistently at optimised cost, even meeting international standards.

2. Aim and Objectives

The aim of this research is to analyse the usage of biofuel as alternative energy in the aviation industry. The objectives of this research are:

i) To determine the usage of biofuel in the aviation industry by airlines in the world focusing on strategies conducted by airlines who have adopted biofuels.

ii) To determine the biofuel impact on sustainability of the environment and how such usage of biofuel can be adopted into Malaysian aviation industry using available biofuel resources in Malaysia.

iii) To understand the advantages and challenges are there for the aviation industry of Malaysia in utilising biofuel

3. Literature Review

3.1 Introduction to type of fuels used in the industry

Aviation fuel comes in two main types: one is the aviation gasoline and the other is the jet fuel. Aviation gasoline is found in use in light aircraft and older civil aircraft, and has lower boiling range of 38-170 °C, when compared to conventional gasoline (1-200 °C). The lower boiling range ensures better distribution of the vaporised fuel, and since aircraft operates at high altitudes, the vapour pressure of the aviation gasoline must be limited (Speight, 2005). Aviation gasoline consists primarily of straight alkanes, branched alkanes, cycloalkanes, and aromatic hydrocarbons, with more or less the same distribution that allows the aircraft technology to function and work. Jet fuel is regarded as the aviation turbine fuel. It is a light petroleum distillate, which is available in several forms suitable for use in various types of jet engines, and produces maximum efficiency in aircraft. Many types of jet fuels such as JP-4, JP-5, JP-6, JP-7, and JP-8 exists that proves to have been employed broadly (Speight, 2005). Volatility is considered as an important property of gasoline, and its performance requires low-boiling hydrocarbons that vaporise easily in cold weather. Petroleum solvent is another type of fuel, which has high dissolving power that makes jet engines to run very effectively. Stoddard solvent, a petroleum distillate also acts as dry-cleaning solvent, making it to become a general cleaner and degreaser of aircraft fuel (Speight, 2005). Stoddard solvent mainly consist of mineral spirits, white spirits, and naphtha (Speight, 2005).

Within Biofuel, Ethanol is one type of biofuel that acts as alcohol-based alternative fuel, which is produced by fermenting and distilling starch crops that have been converted into simple sugars. Ethanol has been used since 1908 in United States, and the primary feedstock for this fuel includes corn, barley, wheat, and other vegetable (Liska, 2009). Ethanol is by far the best and most popular biofuel used in United States, and for being high-octane, clean-burning and renewable resources. Ethanol is produced in mature technology, and has become one of the most useful alternative resources. Over the years, ethanol has enjoyed success as renewable biofuel, and its success down the line could dramatically become the most successful biofuel used in transportation. Cellulosic ethanol is another type of biofuel which is abundantly available through naturally available plant cell walls (Liska, 2009). Biodiesel as an alternative biofuel is also produced from domestic, renewable resources and it is made through the process of trans esterification are also available across many countries (Liska, 2009). Biodiesel from Palm Oil is another type of biofuel which is found in abundance in countries like Malaysia, and since demand in palm oil is rising, the biofuel from this product will continue to rise. Biofuel from algae, halophytes (seed plant), etc. are coming up as important biofuel (Bomani et al., 2009). Inside the usage of biofuel itself, the temperature, viscosity, and opacity (clean/clear) required for the aviation-grade fuel has been the most difficult challenge. Aviation-grade ethanol (AGE – 85) has however been very successfully used, and it is one of the improved form of biofuel as an alternative solution (Bomani et al., 2009).

3.2 Overview of Biofuel Demand on Global level

The United Nations is engaged in coming up with Sustainable Development Goals (SDG), and among such goals, biofuel constitute as the main factor. Since sustainable fuel has become an international agenda, governments, intergovernmental organisations, corporations, non-governmental organisations (NGOs) and even individuals are looking towards bringing about sustainable fuel and alternative energy sources (UNCTAD 2014). Since 2006, many developed and developing countries has been coming up with regulatory setups to enhance biofuels production, distribution, and usage. These steps include coming up with blending targets, sustainability norms, as well as research and deployment strategies in advancing biofuel technologies (Wahab and Dong, 2016).Such efforts have made many biofuel industries to become more self-reliant at present, thereby stabilising the demands of biofuels. International trade is also dealing with biofuels which shows advancement in biofuel demand and usage (Wahab and Dong, 2016)

3.3 Case examples of Airlines using Biofuels

Sustainable alternative fuels play increasing role in bringing down the challenges of shortages of fuel. In countries like the United States, the aviation industry has been supporting sustainable biofuel development, which in turn helps in the entire global economic growth (Singh, 2013). In all countries, government policies support advanced biofuels in order to make the aviation industry to develop successfully and compete against foreign nationals is essential. This effort also means that the industry is being motivated to go for clean energy alternative or sustainable biofuels that will allow airlines to fly cleaner and foster job growth for the people. Many airline companies are involved in research efforts to bring better biofuels since they aim for efficiency and development within their business network (Roy et al., 2015).

Since 2009, Virgin Atlantics has been emphasising that improvements of fuel, along with air traffic management efficiency will allow the company to become more efficient, and also give overall efficiency (Roy et al., 2015). Accordingly, Virgin Atlantic in their firm flies has been flying the Boeing 747-400 with one engine on biofuel (20 %), and the remaining part with babassu oil and coconut oil since February 2008 (Johansson et al., 2012). Cathay Pacific is now working with the Sustainable Aviation Fuel Users Group (SAFUG) in order to accelerate commercialisation for the sustainable aviation jet fuel. Other airlines like, The United Airlines is also working with Commercial Aviation Alternative Fuels Initiative (CAAFI), in order to make sustainable fuel to be available in short as well as long term. Japan's All Nippon Airways' (ANA) have even gone to the extent of announcing the launching of world's first transpacific flight in an aircraft that will purely operate on biofuel (Roy et al., 2015). Airbus aviation firm has been flying its Air bus-A380 with the combination of Gas-To-Liquid (GTL) fuel and conventional jet fuel since February, 2008 (Johansson et al., 2012). Air New Zealand has also been flying their Boeing 747-400 since December, 2008 on jatropha-derived hydro-treated renewable jet (HRJ) on one engine (50 %), and kerosene on the rest (50 %) (Johansson et al., 2012). Continental Airlines has also been flying their 787-800 on jet fuel (50 %) and algae and jatropha (50 %) since 2009. JAL has also been flying their 747-300 on HR biofuel which is derived from camelina, jatropha, and algae (50 %), and jatropha mix (50 %) since January, 2009.

Qatar Airlines is popularly known for launching their first revenue flight on alternative fuel (2009), making the A340-600 to fly from London to Doha on its four engines on blend of GTL with the conventional jet fuel (48.5

%). Finally, KLM has been flying their Boeing 747-400 since 2009 on four of its engines on blend of GTL with the conventional jet fuel (Johansson et al., 2012).
The breakthrough towards developing commercially viable low carbon fuel is the result of a partnership between Virgin Atlantic and LanzaTech. Since 2011 they have been committed to producing the world's first jet fuel derived from waste industrial gases from steel mills via a fermentation process. The Lanzanol was produced in China at the RSB (Roundtable of Sustainable Biomaterials) certified Shougang demonstration facility. The innovative alcohol-to-jet (AtJ) process was developed in collaboration with Pacific Northwest National Lab (PNNL) with support from the US Department of Energy (DOE) and with the help of funding from HSBC. LanzaTech and Virgin Atlantic are now set to continue to work with Boeing and a host of industry colleagues to complete the additional testing aircraft and engine manufacturers require before approving the fuel for first use in a commercial aircraft. Assuming all initial approvals are achieved, the innovative LanzaTech jet fuel could be used in a first of its kind proving flight in 2017 (Virgin Atlantic, 2016). For the first time ever, 1,500 US gallons of jet fuel has been produced from 'Lanzanol'– LanzaTech's low carbon ethanol. Producing the world's first jet fuel derived from waste industrial gases from steel mills, via fermentation process. The alcohol-to-jet (AtJ) fuel has passed all its initial performance tests with flying colours Initial analyses suggest the new fuel will result in carbon savings of 65 % compared to conventional jet fuel (Virgin Atlantic, 2016).

3.4 Comparative analysis of Biofuel utilisation in Malaysian Aviation Industry and challenges faced

Biofuels are no doubt more abundant, and are known for being low-cost cellulosic feed stocks, but it has got its own challenges. In the Malaysian Aviation Industry, there are many challenges involved in utilising biofuel, which include supply cost, supply volume, technological development, infrastructure, popularity, and policy, among others (Shahabuddin et al., 2012). But like any other country and fuel consuming industry, scarcity and depletion are the most challenging issue in Malaysian aviation industry. While it takes millions of years in natural cycle to form fossil fuels from biomass, industrial plants and companies dramatically accelerate the geological clock by converting the biomass into synthetic fuels, and consuming it at rapid rate (Chuck, 2016).
Aviation industry is again responsible for more than 2 % man-made Co_2 emissions, but human efforts in reducing aviation fuel consumption and its related CO_2 emissions have made the industry to come up with several innovative products and technologies (Singh, 2013). The aviation industry is committed in reducing the global GHG emissions, and promotes global sectorial efforts in reducing carbon dioxide emissions.
While using biofuel, the Malaysian Aviation Industry again faces the issue of polluting the environment and atmosphere with GHG. There are multiple routes to convert biomass into fuels, but only three process routes are certified by ASTM International, which include Biomass-based Fischer-Tropsch (F-T) synthesis (certified in 2009); Hydrogenated Esters and fatty Acids (HEFA) (certified in 2011); and Direct-Sugar-to Hydrocarbon (certified in 2014) (Bomani et al., 2009). All these processes of conversions are known for emanating environmentally polluting gas such as carbon dioxide (CO_2) and other gases that comes under Green House gases (GHG). The CO2 presence in the environment has been intensified owing to many of such fuel conversion process.
Another main challenges involved in using biofuel is also the supply cost, since biofuel is several times higher than diesel and gasoline. Geographical situation and feedstock also determine the price of the biofuel, in addition to the fact that there are many refining trans esterification production costs, thereby discouraging people to use biofuel. The process like the biomass-based F-T process is known for capital-intensive challenges, and these challenges range from obtaining high-quality feed stocks that are required in large quantities, and from getting sophisticated technologies of high prices (Saynor et al., 2009). Financing such activities when the plant size is rather large like the aviation industry makes the challenges more common and obvious. In Malaysia, the issue of supply volume is not an important challenge, since the country is one of the main producer of world biofuel production, but the cost price has made the supply to people a core challenge in the country (Malaysia Airlines, 2012). Replacing existing fossil fuel means that there will be competitive fuel involved, making technological advancement to become a part of the fuel making process. Implementation of advanced technology is required in biofuel production in terms of plantation, processing, and the final use of the product.
Along with technology, deep research and development (R&D), are required in biotechnology, plant agronomy and precision agriculture techniques that build up towards biofuel. These R&D and technology breakthroughs still have a long way in biofuel making industry that many countries including Malaysia needs to cope up with. Along with technological advancement, there is the issue of infrastructure, where successful implementation of biofuels requires the establishment of hard and soft infrastructure. Hard infrastructure calls for setting up of biofuels blending and refuelling station facilities, or on the bigger level, the need to have complete transportation of biofuels supply network. Soft infrastructure requires all changes required as per modern demand in keeping up with innovation, which poses challenges for many countries who does not have the capital nor the capacity to demonstrate such responsibilities. For long social and economic development,

policy that is well established from the government is pivotal. The government is the critical stakeholder in implementing the need and usage of biofuel, and in staging suitable platform for the biofuel transaction system. Other non-governmental organisations and private institutions can also help in such policy implementation for developing biofuels blends (Malaysia Airlines, 2012). Government policies are useful in subsidisation scheme, tax relief, financial assistance, information dissemination, investment environment, authorisation and standards of biofuels blends, etc., and when such policies are being disregarded or are not followed, then issues in fully utilising biofuel arises. Finally, challenges regarding the need for public acceptance of biofuel are well-known, since mass public is the main user of the biofuel. When it is not accepted, then such alternative usage of fuel can easily destroy the business network of the biofuel. Malaysia requires such public acceptance, failing which the country will also witness catastrophic failure like the case of natural gas in Canada and New Zealand (Malaysia Airlines, 2012).

4. Conclusion

This section looks into working of biofuel as to how it can be the solution towards solving fuel price and energy crisis in the aviation industry. With many technologies designed for aviation industry, biofuel has come to be utilised in many countries, including the Malaysian Aviation industry. Biofuel ensures the lower emissions of GHG as well as sustainability against depleting fossil fuels. By prioritising research and deployment of advanced technologies that can convert sustainable waste into biofuel, future aviation industry can witness new development. Owing to much advancement in fuel, aircraft in modern day Malaysia are more using more efficient fuel than those that were manufactured some decades ago. Growth rate of aviation sector also means that emission of GHG becomes stronger, and given the aviation industry's success in Malaysia, emission is strong in the country. An estimate of five international airports in Malaysia produces 114g/km CO_2 emission, and long domestic flights even accounts for 259g/km of carbon dioxide in the country (Tan and Yap, 2015). But despite such challenges, the Malaysian Aviation industry is making great strides in reducing environmental impacts associated with the fuel producing the harmful gas emissions (Malaysia Airlines, 2012).

In Malaysia, although biofuel as renewable and sustainable fuel has been producing for more than a decade, the country's product development is still being hindered by lack of investment. Yet, the Malaysian aviation industry is committed in improving the aviation industry by environmentally being conscious of the usage of biofuel. The industry aims to establish policies and strategies that helps in improving sustainable fuel and helps environmental performance at the same time. Adherence and compliance of environmental legislation and sustainable policies are also followed in this country. However, depending on biofuels alone cannot solve the issue, and alternative fuels need to come up. For instance, liquid hydrogen can strongly improve aviation industry, reduce carbon dioxide intensity of aircraft, and also reverse the growing trend of CO_2. Transitioning towards hydrogen infrastructure will however be highly capital-intensive, and technologies like hybrid or electric propulsion systems will even require technological breakthroughs, but it will help the country to improve this industry. However, in the meantime second-generation biofuels from waste and renewable feed stocks can help in bridging the gap of such capital and technological shortages in the country.

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