

Carbon Remediation for the Airline Industry via ATF Drop-in Substitution: Strategic and Operational Perspective

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ABSTRACT

The need to address environmental challenges by aviation industry is apparently obvious. As evidenced within the industry, it takes a three pronged strategy - more efficient aircraft, improving operational efficiencies and development of sustainable biofuels. In terms of actual growth of airline business, the two major drivers are domestic air service expansion within BRIC economies and rapid spread of Low Cost Carrier (LCC) models. Focusing not only on environmental challenges, even sustainable business development and growth of LCC depends critically on ATF substitution by alternative fuels. The inherent need for carbon subsidy and airline-airport partnership towards sustainable substitution with bio-alternatives is discussed in first part of the paper. A framework for such an airline airport win-win partnership is delineated. In the second half of the paper, focus shifts to complexity of operationalisation of blended ATF strategy for airlines as well as manufacturer from a sophisticated operational safety and liability perspective. The need for aircraft manufacturer and airline cum airport partnerships for globally acceptable and operational safety for partial drop-in substitution on the lines of biofuel certification standardisation and usability is examined. The authors highlight that carbon neutral strategy by aviation industry is not just critical in terms of environmental dimension but as would be evidenced in the coming decades critical in terms of capitalistic interests as well.

CITATION: Varadarajan, V., Pathak, M. and Gupta, A., "Carbon Remediation for the Airline Industry via ATF Drop-in Substitution: Strategic and Operational Perspective," *SAE Int. J. Aerosp.* 5(1):2012, doi:10.4271/2012-01-1509.

I. INTRODUCTION

Carbon footprint reduction and energy source substitution are very critical for a proactive approach to sustainable economic development. Despite its relatively small contribution to worldwide greenhouse gas emissions, the aviation sector acknowledges its responsibility to limit and reduce emissions in the entire well to wake emission value chain if it may be referred to as that. Looking at a future with lesser economic dependence on energy import at volatile prices, it makes sense to firstly reduce dependence on imports and secondly substitute current sources with bio derived energy sources as drop-in. The drop in option is particularly important given the projected growth of the military aviation industry in the coming decades and its limited currently viable options as compared with other transport sectors, to divert from the use of fossil fuels. A variety of emission

reduction approaches, including the deployment of alternative fuels, are being seriously considered and rigorously being researched in industry and academia. However there are key requirements in terms of synergetic partnership alliances between airport, airline and aircraft manufacturer that is brought out in this paper. Also the legislative angle to a carbon strategy implementation with trading permits in regional markets and its potential impact on the Competitiveness of the industry is investigated. The summary of this paper identifies common threads and messages emerging from the wide range of research and development in bio-fuels integration within the aviation ATF supply chain and shape them into framework for multidimensional stakeholder SWOT analysis for a carbon strategic partnership is presented.

II. NEED FOR SWITCH OVER: ENVIRONMENTAL IMPLICATIONS FOR THE AIRLINE INDUSTRY

Aviation currently accounts for a small proportion of total GHG emissions i.e. 2% of globally [13]. This however is likely to change. Projections show that global demand for aviation will grow at 5% annually for at least the next 15 years. Growth will occur in both mature markets and across developing markets - most notably China. The world consumes about 85 million barrels per day of petroleum products [5]. It costs \$6 billion per day considering the average price per barrel as \$70 from 2000-2010. All oil consumers are vulnerable to increased payments for oil when oil exporters reduce supplies to the world oil market. The More pertinent issue would be the economic impact of a large and extended disruption in global oil supplies as a result of conflict or natural disasters. Total consumption including civil aviation in India has varied from 25 million bpy in 2008 to 35 million bpy in 2010 as reported by the Ministry of Petroleum and Natural Gas [4]. The increase in crude oil import affects the country's economy and its development. The closer the world gets to binding commitments to carbon cuts the closer the airline industry also has to move towards reducing its carbon footprint. If left unchecked, by 2050 emissions from aviation are estimated, would contribute to 15-20% of global GHG emissions. The aviation industry is addressing environmental challenges as evidenced in the market outlook reports by manufacturers [11] as a three-pronged strategy of designing more efficient aircraft, improving operational procedures, and developing sustainable biofuels. Further, governments throughout the world are expected to align with the industry's strategies to reduce emissions and achieve carbon neutral growth. This approach is to ensure industry growth within the landscape of tough environmental legislations. However there are certain pertinent issues that have to be resolved and key stakeholder partnerships established for concrete action from all parties concerned to effect the carbon reduction objectives. The following sections trace the path through opportunities and Constraints landscape of actual implementation of the third element of the three pronged strategy, i.e. sustainable bio-fuels, for stakeholders. The authors conclude with a total quality management approach to transitioning to a low carbon, bio-derivative based global ATF usage scenario. As pointed out by IATA in the form of a thought piece in their vision documents, this transition is expected within the next 40 years.

III. STRATEGIC IMPERATIVES FOR STAKEHOLDERS

In the past 40 years the volume of air travel has expanded tenfold and air freight has grown by a factor of fourteen. The world's economies have grown three to four times over the same period. There is immense opportunity in terms of airline

services in the emerging economies (BRIC) for the growing air travel needs of businesses and individuals who can now owing to the rapid economic growths that are happening, afford as well as prefer air travel to other slower and sometimes congested means of transport. In meeting this demand the industry has benefitted from airframe and engine technology improvements that have doubled fuel efficiency in the past 40 years [16]. Airline have also substantially raised asset utilization and delivered large productivity improvements for all their major inputs. The unit cost of air transport has more than halved over this period as a result. Utilization and productivity gains were driven by changing business models and substantially increased competition, as liberalized market access became widespread over this period and many new airlines entered the industry [16]. Consumers have benefitted immensely by this. However, along with this opportunity comes also additional responsibility in terms of reduction of the carbon footprint of the industry. Unbridled capitalism is not the option anymore and any growth story has to have a sustainability dimension to it. The threat from human induced climate change is real and present. The industry also realizes that there is need for switchover to greener and low carbon technologies, especially so in case of the fuel. The gains from technology improvement in terms of specific fuel consumption have no doubt halved but the demand for air travel in emerging economies as well as technological limitations in efficiency improvement beyond a point mean that there is no choice but to look at transitioning options from a pure synthetic ATF scenario to a bio derivative blended drop in substitution scenario and planning for this eventuality

IV. TECHNO ECONOMICS OF TRANSITION

FUEL COSTS AND TECHNO ECONOMIC INTERVENTIONS: SCOPE FOR INNOVATION

Over the past 40 years the real cost of providing air transport services has fallen by more than 60%. The inflation-adjusted price for consumers has fallen by a similar extent. The sharp decline in travel costs is driven by increasing efficiency of new aircraft, higher utilization of airplanes, and better operational performance of airlines [18]. Airline operational performance has improved markedly over the past four decades. Passenger load factors have improved by 20 percentage points, better utilizing available seats in the air. Aircraft utilization has also sharply improved, with lengthening sectors and faster turnaround times leading to an increase in daily hours in the air for the average aircraft [18]. Overall asset utilization by airlines has improved significantly. The productivity of other key inputs has also improved, in terms of the Average Seat or Tonne Kilometre produced by each unit of input. The three major costs for airlines are fuel, labor and aircraft. External costs include in

particular environmental costs from noise, local air pollution and greenhouse gases. These will not directly impact airline profitability but will have indirect effects through government regulation. Airlines, airframe and engine manufacturers have made substantial reductions in the economic cost of aircraft noise in recent decades. In spite of a many-fold rise in the number of aircraft movements there has been a reduction in the number of people exposed to noise levels that impose economic costs. This has allowed the expansion of services at some densely populated city hubs that otherwise would have been constrained. Greenhouse gas emissions have also been dramatically reduced over time for the average flight or passenger departure. However, the absolute level of CO₂ emissions is still rising and adding to the industry's climate impacts. In jurisdictions such as Europe this external cost is becoming a commercial cost for airlines in 2012, with the extension of the EU Emissions Trading Scheme to cover all air travel to and from EU airports. This will add a new commercial cost to air transport for about one-third of the industry [18].

Volatility in fuel costs, culminating in recent price spikes, impelled airlines to adopt two important short-term tactics: one to increase revenues by applying fuel surcharges, the other an attempt to iron out volatility by adopting increasingly complex hedging mechanisms. However, in the long term with stricter environmental regulations, this would not suffice. Analysis suggests current surcharges can generate up to 50% of the nominal cost of fuel. Fuel hedging attempts to manage fuel price risk [18]. Most European airlines have adopted hedging mechanisms to a greater or lesser degree in recent years. Given the currently weak fundamentals of the European financial institutions, adding more complexity and resulting unpredictability to the objective of fuel cost control. Hedging and surcharges are reactionary measures. Other short-term to medium-term responses by airlines focus on increasing fuel efficiency through improved operational profiles, while enhancement of aerodynamic performance can reduce fuel burn. However, results here are limited to relatively small, one-off improvements. Medium-term and longer-term strategy should focus on increasing the fuel-efficiency of operations and developing renewable sources of fuel, while regulatory initiatives increase the pressure on airlines by placing them within the European Emissions Trading Scheme (ETS).

BIO ATF DROP IN SUBSTITUTION

The single most important spearhead in the carbon reduction strategy is the fuel source namely aviation turbine fuel. While it is impractical to look at 100% substitution with synthetic alternatives, partial blending with bio derivatives (BTL, CTL, XTL) appears promising, till hydrogen fuel technology becomes commercially and operationally viable. It has been pointed out [2] that alternative fuels derived from coal or natural gas and GTL are certainly suitable for aviation and potentially provide energy benefits. However there is a

trade-off between carbon emissions and fuel economics. Further it has been suggested that current commercial bio-fuels though low on carbon emissions are not yet as practical as "drop in" owing to cost and compatibility issues. Clearly, the available variants of Bio fuels categorized as Bio diesel cannot be used as drop ins even with additives to improve the cold flow properties. The only viable option for ATF is conversion of sustainable bio-derived oils (triglycerides and free fatty acids) to Synthetic Paraffinic Kerosene (Bio-SPK). Bio-SPK has close resemblance to conventional petroleum jet fuels in terms of similar chemical structure, fuel hydrocarbon, non hydrocarbon composition, jet fuel characteristic properties and engine operability tests [20]. Despite noteworthy opportunities generated by alternative fuels, there are significant risks both for producers and users. Above all is the large capital cost of any new project. Investment decisions on large capital projects are said to be especially difficult to make under uncertain economic conditions and with volatile energy markets. For bio-fuel there was uncertainty regarding the feedstock availability and the cost. At present there is no credit given for alternative fuels in market-base measures. Any selection of feedstock would need to carefully consider existing land use, and use of biomass during conversion as well as impacts on water use. In addition, the feedstock production for any bio-fuels must not cause deforestation or biodiversity loss. For such reasons, all sustainability parameters must be clearly articulated as "criteria" in a global roadmap. Two viable methods to bio derivatives based fuel production include the FT method and usage of hydro renewable oils. Fischer-Tropsch method can be applied to a variety of carbonaceous feedstock including natural gas, coal and biomass. FT Method begins with conversion of feedstock materials to a gas containing CO and H₂. This gaseous mixture referred to as synthetic gas, is next sent to a chemical reactor where it is converted to a mixture of liquid hydrocarbons via a process known as FT synthesis. These liquid hydrocarbons are further processed into fuels. Relative techno economic merits and deployment constraints are well documented in [6, 12]. The focus is shifted to bio-derived oils. Renewable oil including those from algae sources, plants and animal fats (some sources) in their own states. These oils and fats contain oxygen and have a chemical structure that makes them unsuitable for direct use as fuel. But technical approaches are available that can convert renewable oils from their raw states to fuels appropriate for military applications. All evidence suggests that blends of hydro treated renewable Jet fuel and petroleum-derived (JP-8 or JP-5) can be formulated that meet the requirements of all military applications now served by pure petroleum-derived JP-8 (or JP-5) supporting the findings are successful results reported from flight tests involving three commercial Boeing jet aircraft [9]. Also, relevant are fuel analysis conducted by the Air force Research Lab and others that show strong similarities in the chemical composition of FT and hydro treated renewable oils [10]. The