

THE FEASIBILITY AND POTENTIAL ENVIRONMENTAL BENEFITS OF ALTERNATIVE FUELS FOR COMMERCIAL AVIATION

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Abstract

High fuel prices and the environmental effects of aviation are motivating strong interest in alternative jet fuels. In the first months of 2008, prices for jet fuel were at record levels and concerns regarding the environmental effects of aviation on air quality and global climate change were strong. Since 2006, the Commercial Aviation Alternative Fuels Initiative (CAAFI) has brought together the government, industry, academia, and non-profits to investigate and promote alternative aviation fuels. To date, CAAFI has held two major conferences and has facilitated tests of possible alternative jet fuels. As a result of CAAFI's efforts, new specifications for jet fuels are being drafted that may enable the commercial introduction of alternative jet fuels. A forthcoming study investigates ten potential alternative jet fuels (alternatives in terms of both feedstock and fuel composition are considered). Within the next decade, the production potential of alternative jet fuels without policy incentives is on the order of ten percent of expected consumption. The emissions of particulate matter and precursors that affect air quality are significantly lower for many of the fuels considered in the study. The life-cycle

carbon dioxide emissions of the alternatives range from roughly zero to many multiples of conventional fuel. This range depends on the feedstock, the conversion technology, the availability of opportunities for geologic carbon capture and sequestration, and any indirect land use changes that result from the creation of the biomass feedstock. Lastly, ultra-low sulfur jet fuel can provide an immediate means for reducing emissions that degrade air quality while also paving the way for future alternative jet fuels.

1 Introduction

Since the energy crisis of the 1970s, almost all of the energy, aircraft, and engine companies, as well as government entities, have been investigating the practicality of using alternative fuels in aircraft, albeit at a relatively slow pace. Because of price and environmental pressures, interest in alternative jet fuels derived from non-petroleum sources is once again growing. Alternative fuels, if available in sufficient quantities, offer the potential to reduce price, mitigate the effects of supply disruptions, and reduce the environmental impacts of aviation.

In the U.S., in coordination with international collaborators, the FAA and industry launched the Commercial Aviation Alternative Fuels Initiative (CAAIFI)¹ in 2006 to chart a course toward developing and adopting, alternative jet fuels [1]. CAAIFI's stated goal is "to promote the development of alternative fuels that offer equivalent levels of safety and compare favorably with petroleum based jet fuel on cost and environmental bases, with the specific goal of enhancing security of energy supply."

More specifically, government, industry, academia, and non-profits are working through CAAIFI to pursue alternative jet fuels for the purpose of:

- Securing a stable fuel supply.
- Furthering research and analysis.
- Quantifying the ability to reduce environmental impacts.
- Improving aircraft operations.

CAAIFI adopted three high level goals:

- Develop the means to quantitatively differentiate alternative fuels on aircraft platforms.
- Develop methods to quantitatively differentiate alternative fuels at airports on both an environmental and economic basis.
- Establish a secure web based means of communication within the enterprise.

CAAIFI has held multiple conferences and facilitates ongoing communication among stakeholders to develop and share data with the various elements of the aviation supply chain. This process is guided by four teams focused on the specific areas of research and development; commercialization; environmental impacts and fuel certification. Early findings from these interactions include: 1) the aviation industry is interested in the possible savings and price stability offered by alternative fuels; 2) industry is willing to produce these fuels if there is a viable market for them; and, 3) industry and

regulators may be able to use alternative fuels to mitigate air quality issues, thus allowing engine designers to focus on other environmental concerns such as noise and climate change. However, a number of technical, environmental and policy questions need to be answered.

Together with the U.S. Department of Defense (DoD) and other CAAIFI stakeholders, the U.S. Federal Aviation Administration (FAA) is pursuing a number of studies to address the following points to address questions and concerns regarding alternative jet fuels:

- Identify the motivating factors (i.e., drivers)
- Clarify technical feasibility
- Quantify environmental benefits
- Identify the needed infrastructure to support transition
- Qualify and certify fuels
- Determine what, if anything, should be done to promote alternative jet fuels

The sections below outline progress on these efforts. This paper discusses some of the motivating factors that are pushing aviation toward alternative jet fuels. It then presents results of recent studies weighing the technical feasibility and environmental benefits and costs of alternative jet fuels. It also includes an update on certification activities.

2 Motivations for Alternative Jet Fuel Use

At the moment, the largest single driver for development and adoption of alternative fuels is the high cost of petroleum combined with aviation's total dependence on petroleum-based fuel. In addition to concerns about rising fuel costs, the possibility of disruptions in petroleum supplies, such as those experienced in the wake of Hurricane Katrina, and the environmental impacts of aviation on climate and air quality are also powerful drivers.

2.1 Price considerations

The recent dramatic rise and volatility in fuel prices has caused intense concern in the aviation

¹ The authors of the present paper are actively engaged in CAAIFI activities.

industry and is driving significant fleet restructuring. The current price of jet fuel is approximately four times what it was just four years ago. (see Figure 1).

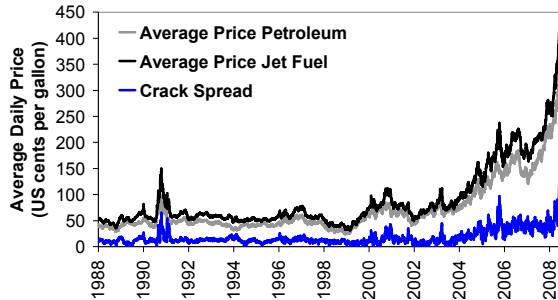


Figure 1: Price for jet fuel and crude oil as well as the “crack spread” between them [2].

This unprecedented escalation has created a fundamental shift in the economics of air travel in which gains in other areas of the airline industry are being negated by increases in fuel costs. As long as jet fuel that is derived from conventional petroleum remains the dominant fuel, the price of petroleum will define the market price for jet fuel. However, alternative fuels offer the potential for a shift away from a petroleum dominated market.

2.2 Air quality considerations

The air quality impacts stemming from the contributions of aviation emissions are a continuing issue [3]. Emissions of oxides of nitrogen (NO_x), carbon monoxide (CO), unburned hydrocarbons (UHC), some of which are classified as hazardous air pollutants (HAPs), and particulate matter (PM) are of concern in the vicinity of airports. NO_x , CO, and UHC emissions from aircraft and other ground-based sources lead to local and regional production of ozone in photochemical smog reactions while secondary PM precursor gases (NO_x , SO_x , and UHC) can also react in the atmosphere to form PM. Airborne PM in turn can cause respiratory illnesses and aggravate cardiovascular disease; in addition the sulfur also causes acid rain that damages infrastructure.

Ozone and PM National Ambient Air Quality Standards (NAAQS) in the U.S. were

recently tightened. Within the ground transportation sector significant emissions reductions are being achieved through requirements for cleaner fuels and more stringent emission standards for cars and light trucks, heavy-duty trucks and buses, and off-road vehicles and engines. Though small by comparison [4, 5], aviation’s contribution to emissions that impact local and regional air quality is projected to increase and become more prominent as a result of industry growth [6]. Furthermore, many state and local authorities are looking to airports, many of which are in nonattainment areas [7], to contribute to the regional emission reductions that are needed to meet the NAAQS.

Alternative fuels offer the potential for reduced emissions that affect air quality. The specification for jet fuel allows for up to 3000 parts per million of sulfur, but estimates from the U.S. military [8] indicate the average is more likely 700 ppm. As will be discussed, the use of either low sulfur content conventional fuels or low sulfur content synthetic fuels, which are also low in aromatic compounds, could yield benefits of reduced emissions that contribute to airborne PM.

2.3 Global climate considerations

While energy efficiency and local environmental issues (noise and air quality) have traditionally been and remain primary drivers, the impacts of aviation emissions on the global climate are a serious long-term environmental issue facing the aviation industry [3, 5, 9].

Certain alternative jet fuels offer the potential to significantly reduce the life-cycle carbon dioxide (CO_2) emissions from aviation. This is not because their use results in a change in combustion emissions of CO_2 . The reduction is possible because biomass is created by photosynthesis of atmospheric CO_2 with water. Biomass is thus created by extracting CO_2 from the atmosphere. This can be contrasted with fossil fuels, which are effectively atmospheric CO_2 that has been sequestered in the ground for many millions of years. When biomass is consumed in combustion, the CO_2 is released to

the atmosphere from which it recently came; when fossil fuels are combusted, the CO₂ that had previously been sequestered is released to the atmosphere. The biomass creation thus offsets the biofuel combustion. To adequately capture this important difference, the full life-cycle CO₂ emissions of a fuel need to be assessed.

As shown schematically in Figure 2, a full life-cycle assessment includes all of the emissions associated from the fuel's origin, "the well," to its ultimate destination, "the wake" that follows the aircraft. This includes feedstock production, transportation of the feedstock, feedstock processing to create the transportation fuel, delivery of the finished fuel to the airport, and combustion of the fuel. The production processes include the mining, drilling or harvesting operations, as well as the refining, gasification or liquefaction processes. If biomass is involved, then life-cycle analysis should also take into account potential land-use changes that would result from feedstock growth [10 and 11].

Finally, it is also important to understand the environmental impacts of fuel composition on aircraft operational capability (e.g., allowable cruise altitude) and aircraft fuel consumption, both of which have an effect on environmental performance.

2.4 Technical and market considerations

The significant public and political pressures faced by aviation to reduce its impact on the environment are a strong driver behind the active pursuit of alternative jet fuels. As an example, global climate change has been cited as a reason for rejecting multiple airport

expansion projects in airports near London, UK. However, most if not all alternative fuels, regardless of feedstock, could be used by ground transportation in either pure form or as a blending stock with conventional petroleum-based fuels. Similarly, the same biomass feedstock could be used to generate electricity, heat, fuels for ground transportation, or fuels for aviation.

Ground transport fuel consumption is considerably larger than aviation fuel consumption and the ground transport sector has considerable experience in alternative fuel use (e.g., ethanol, biodiesel, and liquefied natural gas). Because aircraft must carry their fuel aloft, the requirements for aviation fuels are more stringent than those for fuels used for surface transportation. In certain circumstances and because of fuel properties such as octane and cetane number, ground-based vehicles may serve as a more appropriate application of alternative fuels and feedstock resources.

Because of the large global aviation fleet designed to operate on a petroleum-based kerosene-type fuel and the existing supporting infrastructure, much attention has been focused on the development of a "drop in" fuel (one that is functionally equivalent to current jet fuel). It is unwise to underestimate the technical difficulties that may be encountered even with "drop in" fuels. Slight differences in fuel composition can have a cumulative effect on operations over time, and there is a constant need to ensure the safety of operations.

Production cost and production potential of the alternative fuel are also key considerations. Current high petroleum prices are motivating interest in alternative jet fuels, but the potential for a price drop combined with the expected dominant position of conventional jet fuel

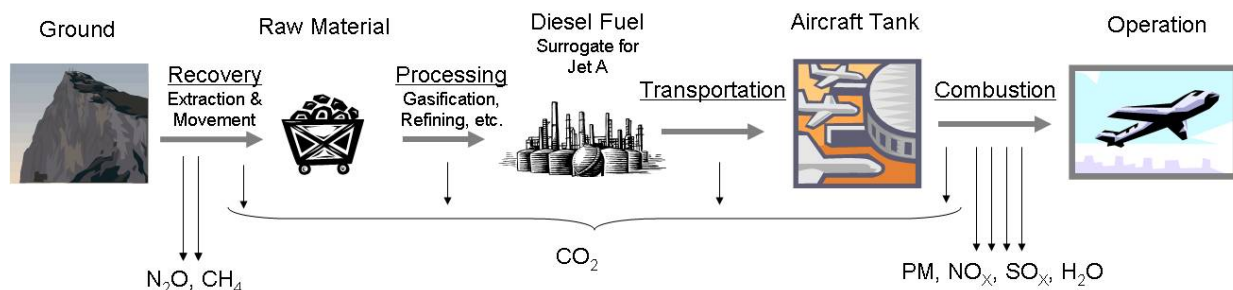


Figure 2: Schematic representation of a well-to-wake life-cycle analyses methodology.

complicate the development of alternative jet fuels.

3 Establishing feasibility

A forthcoming study [12] represents an initial investigation into the feasibility of alternative jet fuels. The effort addresses the following fundamental question: are there alternative fuels for commercial aviation that could:

- 1) Reduce price and price volatility of jet fuel?
- 2) Reduce the environmental impact of aviation?

The study considered ten potential alternative jet fuel pathways. A fuel pathway considers the feedstock and the finished fuel as well as the process used to create the finished fuel from the feedstock. The analysis was limited to those fuels that could be available within the next decade using resources primarily from North America. These choices were made to limit the scope of the study to a tractable range of options that may be able to use the current infrastructure of pipelines, airports, and aircraft. The study did not consider long-term future fuel options such as hydrogen, which would require entirely new aircraft and fuelling infrastructures. The focus was essentially on “drop in” alternative fuels, which is in line with FAA and industry interests for alternative fuel options that might be employed in current fleets as soon as possible. This focus also corresponds to the near and mid term solutions that are being considered by the Next Generation Air Transportation System (NextGen) [6].

The fuel pathways evaluated included: ultra low sulfur (ULS) Jet A from conventional petroleum using conventional refining techniques; current-specification Jet A from oil sands or very heavy oil (VHO) using both in-situ and surface mining extraction techniques; current-specification Jet A from shale oil using an in-situ extraction technique; synthetic paraffinic kerosene (SPK) fuels derived via the Fischer-Tropsch (F-T) process using either coal (with and without carbon capture and sequestration, CCS), natural gas, or biomass as a feedstock; fatty acid methyl ester (FAME) bio-diesel (in a 5% blend with Jet A); SPK fuels derived from hydrotreated plant/animal oil (referred to as biojet); ethanol; and, butanol. The biofuel feedstocks that were examined in the

study were generally first generation in that their large scale use could result in competition with food production.

Each fuel was tested and ranked based on the following set of criteria:

- 1) Usability in current systems, including transportation and delivery infrastructure as well as aircraft fuel systems
- 2) Fuel Readiness Level (FRL), a qualitative measure of the maturity of the fuel production technology
- 3) Production potential, the amount of aircraft-appropriate fuel that may be available in North American markets in the next decade
- 4) Production cost of the fuel (not including taxes or marketing fees, nor taking into account potential learning curve efficiency gains)
- 5) Life cycle “Well-to-Wake” and “Tank-to-Wake” CO₂ emissions
- 6) Air quality, relative to reductions in primary PM and secondary PM precursor gases (nitrogen oxides and sulfur oxides)
- 7) Merit of aviation use relative to use in ground transportation.

The study concludes that multiple pathways exist to create potential alternative jet fuels in the near term:

- Production of unconventional petroleum resources (e.g., oil sands and oil shale)
- F-T synthesis of natural gas, coal (with carbon capture and sequestration), and biomass feedstocks
- Refining renewable bio-derived oil products to a synthetic paraffinic kerosene fuel

The production potential in the next decade of aviation-suitable fuel derived from these resources in North America is limited to approximately 10% of forecast U.S. jet fuel demand.

Alcohol fuels (ethanol and butanol) were determined to be inappropriate for aviation use due to their reduced energy density compared with jet fuel as well as other technical issues. Using these fuels in jet aircraft results in a reduction in the greenhouse gas benefits (assuming a benefit results from their use) relative to their being used in ground

transportation. As such, these fuels are better suited for ground transportation.

Fuels derived from renewable feedstocks (e.g., biojet and biomass-to liquids via F-T process) could reduce the impact of aviation on climate change while also reducing the impact of aviation on air quality. Presently, however, the production potential of these fuels is limited. In the near term, ULS jet fuel derived from conventional petroleum offers some immediate benefits. First, its use could improve air quality. Second, given the similar chemical structure of ULS jet fuel to leading candidates for alternative jet fuels, successful introduction of ULS jet fuel would likely ease alternative fuel introduction by providing practical experience of engine performance and maintenance. Removing sulfur from jet fuel could provide the most immediate improvement to the environment, as it would significantly reduce health impacts of aircraft emissions.

Within the next decade, in the absence of policy incentives no fuel analyzed within the study has the production potential and properties sufficient to appreciably reduce price and price volatility while also reducing the environmental impacts of aviation on climate change and air quality. For example, Jet A from Canadian oil sands and F-T fuels from coal are two alternative fuels that show promise in terms of production potential, but they have life-cycle CO₂ emissions greater than those of fuels derived from conventional petroleum.

4 Quantifying Environmental Benefits

The verification and quantification of environmental benefits is a key activity in the assessment of alternative fuels. To this end, CAAFI is leading activities to quantify the environmental emissions characteristics of both synthetic and renewable alternative jet fuels via testing and emissions measurements as well as in-depth life-cycle analysis.

4.1 Emissions affecting Air Quality

Recent work by Sequeira [13] in support of the Energy Policy Act of 2005 estimates the health

impacts associated with aviation emissions that degrade surface air quality. Roughly half (46% to 69%) of health impacts due to aviation emissions were estimated to be due to secondary PM associated with SO_x emissions, roughly a fifth (18% to 20%) were estimated to be due to secondary PM associated with NO_x emissions, and the remainder (11% to 38%) were due to primary PM emissions. Using a modified version of a methodology that relates mobile ground-based emissions sources to health impacts, Rojo [14] found similar trends. Both the Rojo and Sequeira studies point out the significant role played by PM precursor gases, SO_x and NO_x, relative to direct emissions of primary PM.

As discussed above, many alternative fuels being considered for aviation use have the potential to reduce PM because of reduced sulfur content and/or because their chemical composition results in reduced emissions of primary PM.

Recent tests indeed show that significant reductions in primary PM are possible using alternative fuels. Corporan et al. [15, 16] measured primary PM within the exhaust of older technology, low bypass ratio gas turbine engines (TF33 engine which is used in the B-52 aircraft) and turboshaft gas turbine engines (T63 engine which is used in some helicopters) when burning mixtures of conventional and synthetic fuels. The results indicate that reductions in primary PM mass are proportional to the percentage of F-T fuel that was being consumed, and this was true for both engine types (see Figure 3).

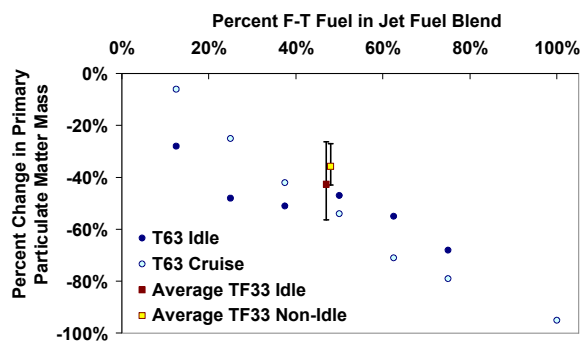


Figure 3: Measured reductions in primary PM in military gas turbine engines burning various alternative fuel blends [15, 16].

Tests have recently investigated the emissions characteristics of modern, high bypass ratio turbofan engines operating on synthetic fuels. In November/December 2007, the mobile laboratories operated by Missouri University of Science and Technology (Missouri S&T), Aerodyne Research, Inc. (ARI) and the Air Force Research Lab (AFRL) at Wright Patterson Air Force Base, (WPAFB) joined forces to characterize the emissions characteristics of a commercial aircraft engine operating on alternative fuels at the GE Engine Test Facility in Peebles, OH. The primary objective of this effort was to examine and, where possible, quantify changes in primary PM and hazardous air pollutants (HAPS) emissions from a CFM56-7B engine burning a 50% blend of F-T and conventional jet fuel. Data from this study are still being analyzed but preliminary results, shown in Figure 4, illustrate the reduction in primary PM number-based emission index, EI_n , as a function of engine power.

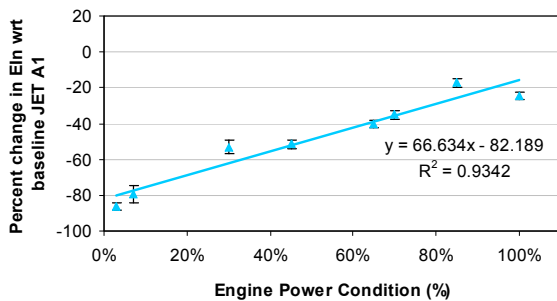


Figure 4: Preliminary results showing observed reductions in primary PM in a CFM56-7B engine burning a mixture of 50% F-T fuel and 50% Jet A-1.

The data from Figures 3 and 4 demonstrate the primary PM reductions that may be achieved with the use of low sulfur, low aromatic alternative fuels such as those created from F-T synthesis. These reductions also appear to be robust to the vintage and type of gas turbine technology being used. Efforts to characterize the emissions of other fuels in in-service engines are continuing under the auspices of CAAFI.

4.2 Emissions affecting Global Climate Change

As discussed in Section 2.3, some alternative fuels offer potential benefits in reducing the greenhouse gas emissions of commercial aviation; however, other alternative fuel options may increase emissions of CO_2 compared to conventional fuel.

A well-to-wake (WTW) fuel life-cycle analysis (as discussed in Section 2.3) was recently conducted [12]. The study used standard production pathways as discussed in the literature [e.g. 17]; it used the Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) framework with data from the literature [18]. The results were assessed in terms of the life-cycle CO_2 emissions per unit of fuel energy delivered to the aircraft tank as well as per payload-distance flown. The latter metric accounts for changes in fuel use that accompany a change in fuel energy content. To ease analysis, diesel was used as a surrogate for Jet A. This should provide a conservative estimate given that the distillation range of Jet A is within that of diesel fuel and the refining process for Jet A requires less energy than diesel [19]. Ongoing analysis suggests the difference between the life-cycle CO_2 emissions of diesel fuel and jet fuel may be on the order of a few percent. Additional details of the life-cycle CO_2 analysis can be found in [12].

Illustrative results of this analysis are shown in Figure 5. The CO_2 emissions are broken into the various steps that were schematically shown in Figure 2. Conventional jet fuel is represented by the crude to diesel fuel bar. The biojet bar represents an average value from industry for the process of creating an alternative diesel fuel from hydrotreatment of renewable oil sources such as vegetable oil [20, 21, 22]. The combustion CO_2 emissions vary little with fuel type as these are all hydrocarbon fuels with similar properties. For the reasons discussed in Section 2.2, the combustion CO_2 emissions for the biomass-based fuels are zero. Additionally, the emissions associated with transportation are negligible. However, the

emissions from recovery and processing vary considerably among fuel types.

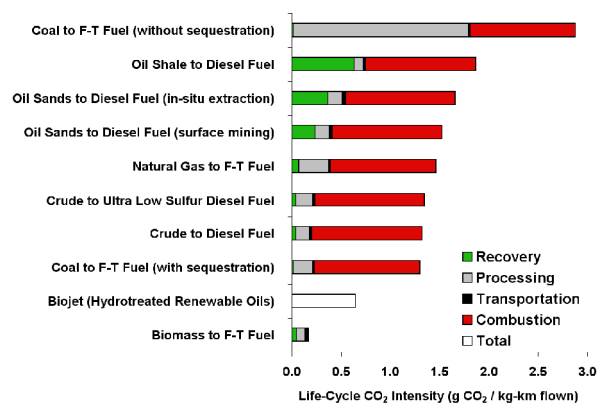


Figure 5: Preliminary assessment of alternative jet fuel life-cycle CO₂ emissions. Data are broken out by emissions that are accrued in each step from “well-to-wake.”

In addition to breaking out the results into the key steps in creating the various fuels, the uncertainties in feedstock property and processing are being examined. Figure 6 illustrates these results in the form of uncertainty bands for three pathways that result in F-T fuels. The low, baseline and high cases are derived by varying the assumptions made on the F-T processing efficiency, type of feedstock used and carbon capture efficiencies (for the coal to F-T fuel pathway with carbon capture) (details can be found in [12]).

Figure 6 also presents a scenario analysis of land use changes that may accompany the large-scale production of a biomass based fuel such as biojet. The four land use change scenarios are not meant to be exact; instead, they provide bounds on the emissions that could accompany the large-scale production of a biofuel that competes with the agricultural industry. The scenarios are:

- Scenario 1: no changes in land use; the CO₂ emissions correspond to the production, refining, and transportation of the fuel. This scenario was also used for the biomass to F-T Fuel pathway under the assumption that the fuel was created from waste products or on products from marginal land.

- Scenario 2: conversion of Cerrado grassland in Brazil to cropland for the growth of soybeans [10].
- Scenario 3: conversion of different types of non-crop lands (e.g. forests and grasslands) worldwide to cropland to replace U.S. food crops diverted for biofuel production [11].
- Scenario 4: conversion of peatland forests in Indonesia / Malaysia to palm plantations for the production of palm and palm kernel oils [10].

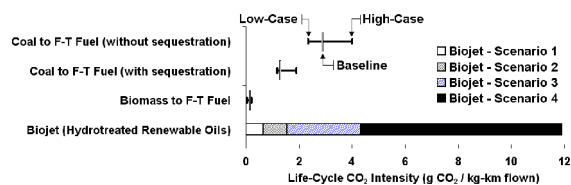


Figure 6: Preliminary assessment of uncertainty in alternative jet fuel life-cycle CO₂ emissions.

The results show that coal-to-liquid fuels (via F-T process with CCS) have comparable life-cycle CO₂ emissions to conventional fuel (assuming the use of bituminous coal with efficient processes) and their use could improve air quality. Without CCS, however, life-cycle CO₂ will double (or possibly triple with low efficiency and the use of lignite coal) because of the large emissions that result from fuel processing. The emissions from fuels derived from oil shale and oil sands are higher than conventional fuel due to the increased emissions associated with their recovery from the ground.

Because of increased processing requirements, there is roughly a 2 percent increase in life-cycle CO₂ emissions over conventional jet fuel (this estimate is based on ULS highway diesel experience and is being further assessed in ongoing work by the authors); however a ULS jet fuel offers air quality benefits as discussed above.

The results show that alternative fuels exist that could both reduce life-cycle CO₂ and improve air quality (e.g., biojet and biomass-to-liquids via F-T process). Although at present the production potential of these fuels is limited, these options could offer the possibility of low carbon or even carbon-neutral jet fuel. It is also

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apparent from the results presented in Figure 6 that appropriate consideration be given to indirect land use changes. Substantial research efforts are underway through CAAFI as well as the U.S. DoD to try to advance understanding and production of these bio-based fuels [1, 23, 24].

4.3 Future work

An illustrative analysis [12 and 25] of the benefits and costs of ULS fuels showed significant reductions in health impacts via reductions in both primary and secondary PM emissions. The FAA, in collaboration with CAAFI stakeholders, is sponsoring the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) Center of Excellence to conduct a more in-depth study in coordination with the Coordinating Research Council to assess the benefits and costs of ULS jet fuels. Ultimately, reducing PM is especially important for airports in crowded urban areas that already have poor air quality and alternative jet fuels may provide an attractive solution to mitigate aviation PM impacts.

Efforts by PARTNER cosponsored by the FAA and the U.S. Air Force will continue to examine environmental costs and benefits of alternative jet fuels through measurements and modeling. Future plans include refining the life-cycle assessment. Refinements include the development of new baseline estimates for petroleum Jet A (prior analysis used diesel fuel as a proxy for Jet A), addressing uncertainties in feedstock inputs, and the inclusion of the impacts of direct and indirect land use changes, as appropriate.

5 Enabling Alternative Fuel Use: Fuel Certification

Once feasible fuels have been identified, successful deployment of alternative fuels depends on approval and acceptance by the technical community, engine and airplane manufacturers, and aviation regulatory authorities. The approval process for potential alternative jet fuels presents a significant hurdle.

Under the umbrella of CAAFI, the aviation community is addressing the approval process in three areas. First, CAAFI is working with the DOD, engine and airplane manufacturers, and fuel producers to develop fuel evaluation methods and procedures and to expedite the evaluation of candidate alternative fuels. Next, CAAFI is playing a key role in the effort by the American Society for Testing and Materials (ASTM) International and other specification-issuing organizations to develop new specifications for alternative jet fuels. ASTM International has recently established a subcommittee to specifically focus on emerging fuels. Finally, CAAFI is coordinating the development of certification procedures for alternative jet fuels with the FAA and other aviation regulatory authorities. The CAAFI goals for the certification of alternative aviation fuel are shown in Table 1.

Alternative Fuels – CAAFI Targeted* Certification Timing		
YEAR	FUEL TYPE	STATUS
• 2008	- 50% Syngas blends including biomass	- ASTM and FAA approval expected by yearend 08'
• 2010	- 100% Syngas blends including biomass - 50% Biojet blends	- Supporting low sulfur cost/benefit starting 4/08 - Working with ASTM, FAA and engine/aircraft OEMS
• 2013	- Pure Hydrogenated Oils - 2 nd Gen – Algae	- DARPA program complete. Fuels available for FFP tests - DARPA program source announcement pending

* Targets based upon technical outcomes to date and fuel availability for needed tests

Table 1: CAAFI alternative fuels certification goals.

6.0 Summary

Alternative jet fuels for aviation are an area of great interest and ongoing research because of their potential to ease jet fuel price pressures and their potential to reduce aviation’s impact on both air quality and global climate change. Since 2006, the FAA, DoD and the aviation and fuels industries (along with other stakeholders) have aligned their efforts to explore the potential of alternative jet fuels through the Commercial Aviation Alternative Fuels

Initiative (CAAFI). Considerable momentum and coordinated work have resulted.

This paper presents the results of a forthcoming study of the feasibility of alternative jet fuels for commercial aviation. It also details the ongoing work of the CAAFI to identify and quantify the potential air quality and greenhouse gas environmental benefits of alternative jet fuels. Finally, it provides an update on CAAFI's progress to date in enabling the safe adoption and broad acceptance of emerging alternative jet fuels. As long as the price of petroleum remains high and concerns about the environment persist, interest in alternative jet fuels derived from non-petroleum sources will grow. While technical hurdles remain and further measurement and study of the costs and benefits is necessary, alternative jet fuels appear to be both technically and economically feasible and environmentally promising.

7.0 Acknowledgements

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