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Synthetic and Biomass Alternate Fueling in Aviation

R.C. Hendricks
Glenn Research Center, Cleveland, Ohio

D.M. Bushnell
Langley Research Center, Hampton, Virginia

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National Aeronautics and
Space Administration

Glenn Research Center
Cleveland, Ohio 44135

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National Aeronautics and Space Administration
Glenn Research Center
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D.M. Bushnell
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23681

Summary

Worldwide, aviation alone uses 85 to 95 billion gallons of nonrenewable fossil fuel per year (2006). General transportation fueling can accommodate several different fuels; however, aviation fuels have very specific requirements. Biofuels have been flight demonstrated, are considered renewable, have the capacity to become "drop-in" replacements for Jet-A fuel, and solve the CO_2 climate change problem. The major issue is cost; current biomass biofuels are not economically competitive. Biofuel feedstock sources being researched are halophytes, algae, cyanobacteria, weeds-to-crops, wastes with contingent restraints on use of crop land, freshwater, and climate change. There are five major renewable energy sources: solar thermal, solar photovoltaic, wind, drilled geothermal and biomass, each of which have an order of magnitude greater capacity to meet all energy needs. All five address aspects of climate change; biomass has massive potential as an energy fuel feedstock.

Introduction

While transportation fueling can accommodate a broad range of alternate fuels, aviation fueling needs are specific, such as the fuel not freezing at altitude or becoming too viscous to flow properly or being of low bulk energy density that shortens range. The fuel must also be compatible with legacy aircraft, some of which are more than 50 years old, while satisfying aviation environmental constraints.

Worldwide, the aviation industry, with 4 percent annual growth, in 2006 alone used some 85 to 95 billion gallons of hydrocarbon-based "fossil" fuel, which is about 9 percent of that used by the transportation industry. United States civil aviation alone consumes nearly 14 billion gallons. The enormity of the problem becomes overwhelming, and the aviation industry is taking alternate fueling issues very seriously. Our research is directed toward the alleviation of these issues.

Fundamental Problems

Biofuels—if sourced from halophytes, algae, cyanobacteria, "weeds-to-crops"[1] and wastes that use wastelands, wastewater, and seawater—have the capacity to be drop-in fuel replacement for petroleum fuels. As such, biojet fuel from such sources SOLVES the aviation CO_2 emissions issue without the downsides of "conventional" biofuels, such as competing with food and freshwater resources. Most of the existing fuels infrastructures are applicable. Processed alternate fuels, also termed "synthetic paraffinic kerosene" (SPK) or "hydrotreated renewable jet"(HRJ) depending on feedstock sources, have thus far proven to be equivalent in performance to jet fuel (Jet-A) in actual flight experiments, such as the Virgin Atlantic flight from London to Amsterdam, with no discernable problems. For this flight demonstration,

[1]Developing crops (which are planted and cultivated, with uniform maturity and productivity trends) from weeds, which grow wild, are sporadic in these trends, and are often invasive.

one of the four 747–400 engines was fueled on a biojet blend of 80 percent Jet-A and 20 percent processed coconut oils. At present, processed-biofuel operational feasibility is essentially proven, or soon will be.

Of the many current fundamental problems, the major biofuel problem is cost. There has not yet been significant investment in the halophyte, algae, cyanobacteria, and "weeds-to-crops" crop residue and wastes biofuel arenas. Algae is still a "boutique" crop. Halophyte costs are on the order of those for conventional agriculture, with much reduced land and water costs; therefore, the halophyte cost picture is currently more favorable than algae. Algae bioreactors are currently very costly, and previous studies indicate that open-ponding algae cultivation is preferred from a cost standpoint. However, even open ponding is not yet financially feasible. Research and development as well as creative engineering are required to reduce these biofuels costs for fuels production. The capacity and operability are there, but cost is the issue. Research is also ongoing in several areas of improvement including refining, processing, and biologics with greater disease resistance, greater bio-oil productivity, reduced water and/or nutrient requirements, and so forth.

Research and Development Approaches

Our current research is intended to aid both the industrial and aviation industries end-to-end in biology, growth, capacity, processing, and refining activities. NASA in collaboration with industry and other Government agencies are working the cost reduction issues from a systems standpoint, including looking into powerplant and wastewater treatment plant synergisms and scaffolds at sea or in open waters using continent-sized nutrient streams, such as the Gulf of Mexico below the Mississippi River outflow. We are considering different modeling approaches, growth media, and refining approaches; different biological feedstocks; methods of sequestering carbon in the process(es); fuel certification for aviation use; and overall, ensuring that biofuels are feasible from all aspects—operability, capacity, carbon cycle, and financial. We are providing common discussion grounds and opportunities for the various parties, disciplines, and concerned organizations involved to share both issues and potential ways for moving forward, and overall, we are trying to educate those concerned with the innate limitations of "conventional" biofuels (lack of freshwater and arable land, essentially a lack of capacity) and the solutions provided by nontraditional feedstocks such as halophytes, algae, cyanobacteria, and "weeds-to-crops" (e.g., jathropha, castor, and camelina) that use wastelands, wastewater, or saline water and have an immense capacity potential.

Global Energy Perspective

There are five major renewable energy approaches, each of which has an order of magnitude greater capacity than that required to replace all of the "fossil" fuels. These are wind, drilled geothermal, solar photovoltaic, solar thermal, and biomass sourced from halophytes, algae, cyanobacteria, or "weeds" on wastelands using wastewater or saltwater. All of these are either now or soon to be at a lower cost than coal with byproduct sequestration to make it as environmentally friendly. Biomass biofuels are unique in providing transportation fuels. Electric vehicles, even if widely deployed, would nominally apply to only about 28 percent of the petroleum consumed.[2] Remaining will be aviation, heavy rigs, and petrochemical feedstock, for example, that will still require these fuels. Biomass, once the oils are extracted, can provide both food stocks (feed) and 24/7/365 base electrical load via burnt biomass. Biofuels are nearly "carbon neutral." In the carbon cycle, plants take up the atmospheric CO_2 during photosynthesis and sequester

[2]The 2006 transportation sector used 14 million barrels (Mbbl) of petroleum per day (out of 20.6 Mbbl/day), which was 67.9 percent of total petroleum usage, with 15.5 percent for buildings, 7.5 percent for industry, and 1.8 percent for utilities (Ref. 1). Personal vehicles used 42.5 percent of the highway transportation fuel (Ref. 2, Table 4.5). Electric vehicles at the present time would only supplant about (40 percent) × (70 percent) of the petroleum; we would still need massive amounts of petroleum replacement(s).

some of the carbon in their roots; the rest of the CO_2 is recycled back into the atmosphere when the fuel is burned. It should be noted that current proposals to feed algae CO_2 extracted from fossil fuel plant stacks would increase the net energy produced by a given amount of fossil CO_2, but the generated fossil CO_2 is still largely released into the atmosphere. It is important to ensure that biofuels utilize, recycle, and sequester existing and exhausted atmospheric CO_2, if they are to be truly "green" and useful in combating climate change to the extent possible. The other energy aspect of biofuels is a combination of financial and capacity. Most projections for peak oil are in the near future accompanied by large demand increases, leading to greatly increased prices and potential shortages. In addition to the climate aspects, this makes biofuels a win-win approach, proffering as they do—at least the ones we are studying—massive capacity, climate neutral-to-some sequestration, and ultimately, reasonable costs.

Concluding Remarks

Aviation fuels have unique requirements not imposed on other transportation fuels. The industry, which consumes 85 to 95 billion gallons of "fossil" fuel (2006), growing 4 percent per year worldwide, is actively seeking alternate fuel replacements.

1. Biofuels—if sourced from halophytes, algae, cyanobacteria, and "weeds" (e.g., jathropha, castor, and camelina) that use wastelands, wastewater, and seawater—have the capacity to be drop-in fuel replacement for petroleum fuels.
2. Biojet fuel from such sources SOLVES the aviation CO_2 emissions issue without the downsides of "conventional" biofuels, such as competing with food and freshwater resources.
3. Most of the existing fuels infrastructures are applicable.
4. Biojet fuel blends with Jet-A have been flight tested with no discernable problems.
5. Traditional biofuels rely on freshwater and arable land and essentially lack the capacity and solutions provided by nontraditional feedstocks such as halophytes, algae, cyanobacteria, and "weeds" that use wastelands, wastewater, or saline water and have an immense capacity potential.
6. The major issue is COST.
7. Biomass fuels must utilize, recycle, and sequester existing and exhausted atmospheric CO_2, if they are to be truly "green" and useful in combating climate change to the extent possible.
8. Renewable energy approaches that can replace all of the "fossil" fuels are drilled geothermal, solar photovoltaic, solar thermal, and biomass sourced from halophytes, algae, cyanobacteria, or "weeds" on wastelands using wastewater or saltwater.
9. Biofuels represent a win-win approach, proffering as they do—at least the ones we are studying—massive capacity, climate neutral-to-some sequestration, and ultimately, reasonable costs.

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2. National Transportation Statistics. Bureau of Transportation Statistics, U.S. Bureau of Transportation. http://www.bts.gov/publications/national_transportation_statistics/2007/pdf/entire.pdf Accessed July 23, 2009.

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Worldwide, aviation alone uses 85 to 95 billion gallons of nonrenewable fossil fuel per year (2008). General transportation fueling can accommodate several different fuels; however, aviation fuels have very specific requirements. Biofuels have been flight demonstrated, are considered renewable, have the capacity to become “drop-in” replacements for Jet-A fuel, and solve the CO_2 climate change problem. The major issue is cost; current biomass biofuels are not economically competitive. Biofuel feedstock sources being researched are halophytes, algae, cyanobacteria, weeds-to-crops, wastes with contingent restraints on use of crop land, freshwater, and climate change. There are five major renewable energy sources: solar thermal, solar photovoltaic, wind, drilled geothermal and biomass, each of which have an order of magnitude greater capacity to meet all energy needs. All five address aspects of climate change; biomass has massive potential as an energy fuel feedstock.

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