# Alternative Energy Sources for Aviation- Literature Review

**Christina Hiers**

Middle Tennessee State University, Unites States

In the current market, growth is inevitable. Fuel and aircraft sales are increasing and the Federal Aviation Administration is creating a new market called Business Aviation. Business Aviation is opening doors for organizations that previously used roads or airlines for travel. Since 9/11 the aviation industry partnered with the government to create and implement security measures to prevent future terrorist threats. This improved the social aspect of aviation, as people are not as afraid of flying as they once were.

## Sustainability

Sustainability is the economic development that meets the needs of the present generation without compromising the future (Epstein, 2008). This includes corporate social responsibility, citizenship, and improved management of social and environment impacts (Epstein, 2008). By improving the sustainability of an organization, leaders are able to increase the benefits for stakeholders in the future by ensuring resources for continuance. The current state of sustainability shows signs of improvement in the future.

The aviation industry faces severe environmental opposition. Organizations criticize the aviation industry for CO emissions it emits. However, the aviation industry only contributes 2 percent to the global emissions. Below, Figure 1 shows the Contributors to Global Emissions. The largest contributors in order are the Energy Supply, Industry, Forestry, Agriculture, and then Transportation at 13 percent. Of the 13 percent the transportation sector, the aviation industry only makes of 2 percent of the global emissions, road travel makes up 10 percent (Owen, Lee, & Lim, 2010).

In the aviation industry, leaders are working to create drop-in fuels that are plant based in order to not become dependent on oil for fuel supplies. Drop-in fuel is a fuel alternative that is added to jet fuel, as much as 50 percent add-in, and is interchangeable in jet engines (Abeyratne, 2010). The problem with the current drop-in fuel is the alternative is two to five times more expensive than jet fuel (Abeyratne, 2010).

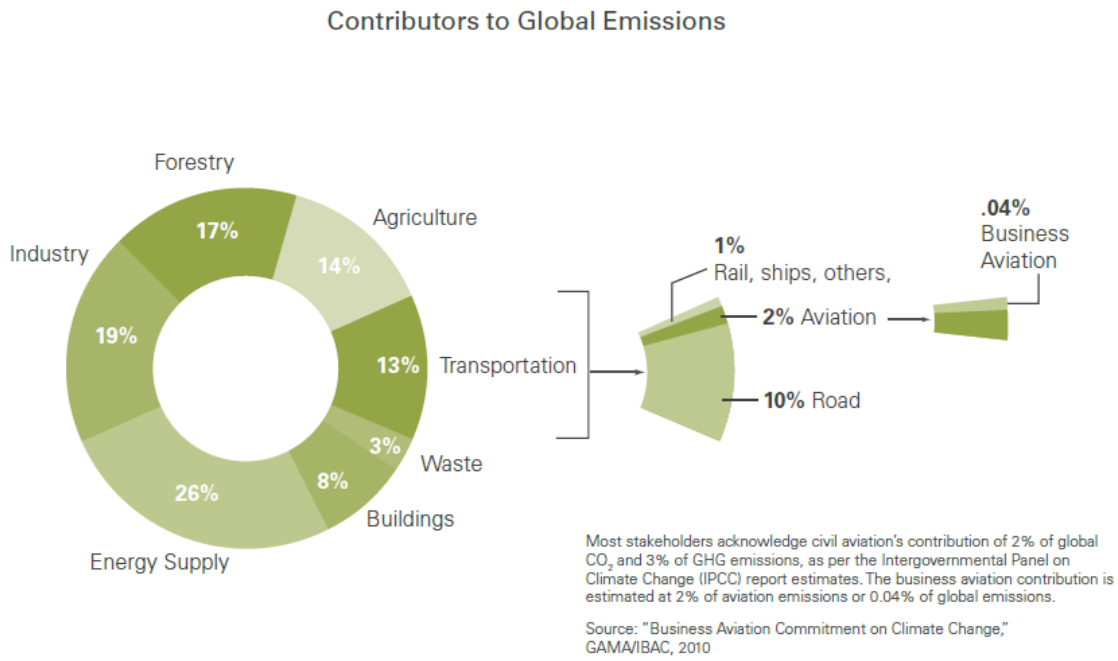


*Figure 1.* Contributors to Global Emissions "Business Aviation Commitment on Climate Change" GAMA/IBAC, 2010. (NBAA, 2010)

Fossil energy resources could meet this requirement through burning coal. This means $CO_2$ emissions in the atmosphere would need to accommodate twice their pre-anthropogenic values by 2050 using present technology (Brinker, & Ginger, 2011). This would suggest not only a negative impact on the climate, but also significant world competition for these limited resources. Energy price increases would make energy intensive commodities like fertilizer or manufacture of steel and metals expensive to produce and sell. This would be a geopolitical problem and maintain social consequences, making energy an issue of national security in the future (Brinker, & Ginger, 2011).

Scientists are working to develop energy production methods that produce fewer carbon emissions than previous methods. These methods involve more efficient production methods, recycling or reusing materials, biofuels, alternative sources of energy, and energy storage methods (Tonn, 2008; Tillman, 2009). These methods might give organizations a more sustainable future than current methods.

Scientists predicted global energy consumptions to increase 40 % of the present value in the next 20 years, and double by 2050 (Brinker, & Ginger, 2011). In 2006, President George Bush declared that biofuels were the answer to the worldwide dependence on oil (California Agriculture, 2009). Corn-made ethanol seemed to be the key to the biofuel question. Shortly there after, grain prices increased. Again, scientists must look for a sustainable biofuel. Scientists projected the human population to increase from 7 billion people in 2008 to 9 billion people by 2050; additionally it is difficult to see how the transportation industry could handle an increase in energy consumption and costs (California Agriculture, 2009).

Since the 1980s, organizations have been looking towards the future in terms of sustainability. Leaders recognized the need to provide stakeholders with useful options for the future. In 2005, Hurricane Katrina hit the New Orleans area causing an energy shortage in the United States through the effects of the oil production sites in the area (California Agriculture, 2009). In the United States, leaders are in a regular political debate over the dependence on other countries for oil production and consumption (U.S. Department of Energy, 2010). Government organizations and private sector organizations look for biomass possibilities for sustainable fuel alternatives.

Corporate sustainability is a business approach to establish long-term shareholder value by implementation of opportunities and managing risks from economic, environmental, and social issues (Makipere, & Yip, 2008). Leaders must force organizational wide sustainability efforts in order to achieve progress. The four challenges facing this pressure are the nature of the industry's product, the level of energy consumption, the human capital needed for success, and the size of the company within the industry (Makipere, & Yip, 2008). Makipere and Yip (2008) suggested leaders turn these challenges around into incentives. If products are not environmentally friendly, soon customers will discontinue purchasing those products, instead, companies need to search for environmentally friendly products (Makipere, & Yip, 2008). Many companies such as steel production have high-energy consumption, thus all the more reason to search for an alternative source of energy. Many organizations struggle to find and retain top-level knowledgeable employees, by making the organization more sustainable and environmentally friendly, employee moral will be higher, and employees will enjoy their jobs (Makipere, & Yip, 2008). In the study by Makipere and Yip (2008), the only two industries that showed a correlation between company size and its success in environmental and social sustainability were pharmaceuticals and automobile industries. This research suggested that corporate sustainability should be achievable in most industries in companies of all sizes (Makipere, & Yip, 2008).

## Current Theories

In order for organizations to promote sustainability in the future, they must examine energy alternatives. Currently scientists are working in the fields of biofuels, recycling, technology for energy storage, and alternative sources of energy. Currently, all of these fields require more research and engineering before they will become worthy alternative forms of energy.

## Biofuels

Biofuel production could reduce the United States' dependence on foreign oil. Biofuels are alternate energy sources derived from plant materials and of other types of biomass (Tillman, 2009). Biofuels came into prominent existence as a homegrown alternative to petroleum. Biofuels have seen criticisms and praises. Scientists are investigating the use of energy created from municipal and industrial wastes for biofuel production (Tillman, 2009).

## Recycling

Recycling is a form of reusing products that are more efficient than producing more products. Recycling or reusing products, such as newspapers, aluminum cans, and plastic containers, can reduce products going into the waste streams, thus reducing emissions (Tonn, 2008). Scientists found ways of converting urban and industrial wastes to produce liquid fuels for other energy applications (Tillman, 2009).

Currently, organizations look towards more efficient production methods to use fewer resources, and produce fewer wastes (E.E., 2012). Many organizations are finding ways to recycle or reuse materials such as recycling cardboard shipping containers and wooden pallets. A group of researchers developed a method of using mixed recycled aggregate from nonselected construction and demolition waste (CDW) in rural road construction (Agrela, Ayuso, Galvin, Jimenez, & Lopez, 2012). They found that using the CDW versus limestone had similar structure. They subjected both roads to various tests, and the road made of CDW had the same results as the road with limestone aggregate (Agrela et al., 2012).

## Energy Storage

A research team from Drexel University in the College of Engineering developed a new way of quickly and efficiently storing large amounts of electrical energy (E.E., 2012). Energy companies can produce energy during times of reduced usage such as during the night time when families and industries are not working. The electrical energy can be stored and put into use when offices, schools, and businesses open and increase the demand for electricity (E.E., 2012). The researchers created a plan to incorporate an electrochemical storage system that combines principles of the flow of batteries and super capacitors to store electrical power. These researchers could implement this strategy into the grid of mainstream communities (E.E., 2012).

## Alternative Energy Sources

Scientists are working on creating new technology that would allow extensive production of biofuels with fewer negative impacts than previous technologies (Tillman, 2009). Evans, Strezov, and Evans (2009) examined the different alternative energy sources including coal, nuclear power, hydropower, geothermal, wind, and photovoltaics. Evans, Strezov, and Evans (2009) evaluated sources of energy using the factors: technology cost of generated electricity, greenhouse gas emission, availability of renewable sources, and efficiency of energy conversion, land requirements, water consumption, and social impacts. These authors concluded that solar power was the best present available source of sustainable energy (Evans, Strezov, & Evans, 2009).

Currently there are benefits and drawbacks to every method. Wind required the smallest land use, and little social impact but did not provide much energy compared to other methods (Evans, Strezov, & Evans, 2009). Solar Power was the first in terms of power created, land usage, and resources used for energy supplied (Evans, Strezov, & Evans, 2009). In addition, solar energy has little social impact (Evans, Strezov, & Evans, 2009). Corn-based biofuels required large amounts of resources and land use (Evans, Strezov, & Evans, 2009). Biofuels in their present situation are expensive and require massive amounts of land and resources for

production (Evans, Strezov, & Evans, 2009). In 2012, drought conditions in the midwest of the United States (US) limited the creation of corn, one of the major biofuels (California Agriculture, 2009). For a fuel or oil alternative, biofuels still need further research and development (California Agriculture, 2009). Scientists found that organizations could easily obtain, store, and utilize solar energy or photovoltaics to a grid system. Organizations are testing solar cells in the housing and office building markets. Solar cells require optimized space to transform solar light into electrical energy (Tonn, 2008). Leaders are considering land buffers, such as near airports for possible sites for solar arrays.

## Impacts

Industries that require large amounts of fuel such as the transportation industry would see the greatest reduction in emissions and efficiency. Automobiles are being made more energy efficient with the use of alternatives fuels such as electrical or hybrid power (Tonn, 2008). Vehicles are improving aerodynamics to decrease energy consumption on the highways.

Many organizations, homeowners, and businesses already use solar technology to reduce emissions and energy costs. Organizations could study and implement energy storage using methods such as solar power to increase sustainability. A storage system combined with solar technology could create self-sustaining energy (Tonn, 2008).

All of the energy sources have benefits and drawbacks. Biofuels have high land and resource utilization. Solar energy has high costs of implementation. Energy storage has high costs of implementation. The overall problem with sustainable energy alternatives is costs (Orecchini, Santiangeli, Valitutti, 2011). In seven to ten years, solar power could cost the same to customers in markets like California and Italy as electricity generated by fossil fuels (Lorenz, Pinner, & Seitz, 2008).

Burning of coal and fossil fuels is presently widely used because of reasonable costs and quantities of resources (Orecchini, Santiangeli, Valitutti, 2011). However, this common practice creates high amounts of emissions and greenhouse gasses. Global consumption is rising, while organizations and nations look for a more sustainable solution (Brinker, & Ginger, 2011). If organizations do not make the change to a cleaner form of energy, customers will purchase from more environmentally friendly organizations like those in the United Kingdom or other countries (Gibbs, 2009).

## Future Directions

Two thirds of the U.S. oil supply comes from other countries; the transportation industry uses 60% of this supply (U.S. Department of Energy, 2010). With the rise in the energy demand, competition for the world's petroleum rises. The U.S. Department of Energy is developing advanced alga biofuels from use in the aviation and transportation industry. The benefits of algal biofuels include high field efficiency, minimized competition with traditional agriculture, uses a small amount of water from a wide range of water sources, and it recycles stationary emissions of carbon dioxide (U.S. Department of Energy, 2010).

Solar power is a growing industry. By 2020, global capacity of solar power could be 20 to 40 times its level today (Lorenz, Pinner, & Seitz, 2008). With the projected growth in solar energy, this would represent only 3 to 6% of installed electricity (Lorenz, Pinner, & Seitz, 2008). Solar power could help to reduce emissions, create sustainability, and satisfy the need for more electricity (Lorenz, Pinner, & Seitz, 2008). The technology still requires more research for further development and implementation.

Biofuel production typically requires large areas of land and large quantities of water. The United States government and the Department of Energy are working on creating biofuels from alga (U.S. Department of Energy, 2010). Converting alga to biofuels requires harvesting the alga or removing the water to make a higher concentration of the alga. Conversion, extraction, and processing the alga have different products. These different products have different applications. Extracting the lipids or fatty acids from the alga is the most difficult part of the production (U.S. Department of Energy, 2010). Scientists are working to develop a secure method for removal or an alternative method of harvesting the alga. Using alga versus other crops for biofuel performance is promising due to the high yields of gallons of oil produced by the mass (U.S. Department of Energy, 2010). Alga harvests also do not require as much land or water use as other crops. An alga-based biofuel could have an impact in the transportation industry and produce fewer emissions.

## Potential Impacts

One industry that uses the largest amount of fuel is the aviation and travel industry (U.S. Department of Energy, 2010). The leaders of the Federal Aviation Administration (FAA) and the leaders of the Department of Energy (DOE) move towards technology development and standardization to reduce operation costs and increase the general aviation market (U.S. Department of Energy, 2010). In 2010, the government began an eight-year funding plan concentrating aviation fuel (U.S. Department of Energy, 2010). The aviation industry matched the eight-year funding for development (U.S. Department of Energy, 2010).

The U.S. Department of Energy currently has many applications for construction of biofuels and bioproducts from biomass (2010). The most promising alternative energy methods are advanced-biofuels including high energy density fuels for ground and aviation transportation. The alga biomass offers significant advantages for these fuel applications (U.S. Department of Energy, 2010). Developers need partnerships with experts in the aviation and transportation fields across the value chain to ensure the proper specifications of these biofuel productions, and address technical and nontechnical needs (U.S. Department of Energy, 2010).

Several organizations demonstrated that it is possible and worthwhile to pursue the goal of becoming a completely sustainable organization (Mirchandani, & Ikerd, 2008). In today's current environment, organizations look for sustainable alternatives. The best alternatives on the market today are recycling, or reusing materials, reducing costs through energy consumption, and researching new and future technologies for alternate energy sources (Meadows, 2009). Corn based biofuels in their current state are not effective for industries like the transportation industry; however, scientists are working to develop better methods of producing biofuels (Meadows, 2009).

## Conclusion

The future of aviation is in sustainability. To reduce energy costs and emissions, organizations could invest in solar technology or photovoltaics. Alga biofuels offer a sustainable alternative in the future of transportation and aviation. Recycling is another way for aviation companies to reduce consumption and plan for a sustainable future.

**About the Author**

Dr. Christina Hiers teaches in the Aerospace Department at Middle Tennessee University. She has 8 years of experience in various Aviation Management positions. Her research interest include Alternative Energy Sources for Aviation, Leadership and Innovation in Aviation, and Small Aviation Business Management. Dr. Hiers received her Doctor of Business Administration with a focus in Leadership from Walden University in 2016.

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