What influence does the choice of processing technology have on land use change?

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Aviation power is unique in that there is little debate on alternative technologies beyond liquid fuels. Few technologies offer the potential of liquid fuels high specific energy density needed to power aircraft with minimal weight. Aviation fuels, consisting of straight chain and cyclic hydrocarbons typically in an 8 to 16 carbon range, are currently produced from petroleum distillates which are upgraded in a refinery and blended with additives. This creates a fuel with the required properties including the ability to operate at high temperatures, have low freeze or gel points, and above all be reliable due to the consequences of an engine failure.

Aviation travel contributes significantly to both the consumption of petroleum resources and greenhouse gas emissions. This has created considerable interest in having a biobased fuel alternative. Ethanol, the most prolific first generation biofuels, is not suitable for aviation due to the lower energy density and freeze point characteristics. Additionally, due to the large expense of replacing aviation fleets, most technologies being considered are advanced fungible biofuels that can be treated as or blended with standard aviation fuels. Therefore, the first generation processing technologies that have been focused on are primarily upgrading of hydrocarbons derived from seed oil plants.

These technologies start with oils rich in triglycerides, which are extracted typically from seed oil plant feedstocks including jatropha, camelina, and palm. The triglycerides are chemically converted into free fatty acids, which can be catalytically deoxygenated and reformed via traditional petroleum methods to the fuel specifications required. This conversion technology is progressing and has already produced high quality fuels at a modest scale that appear quite capable of powering our aviation fleets.

A debatable concern for many of these seed oil plant technologies is land use, which stems from the relatively low amount of fuel being produced from the land and the subsequent removal of the land to produce food. Seed oil yields range from ~60 gal/acre for camelina to ~600 gal/acre for palm, on monoculture fields or plantations. Considerable land would need to be changed from its current use to accommodate the need for aviation or other biofuels. Although it can be argued that there are nations with underutilized land resources, there will continue to be issues with food scarcity and pressures on the best use of land. As land is a limited resource, countries may end up trading the benefits of biofuels with the creation of problems in food supplies or environmental services such as natural habitat, soil degradation, or water cleanliness.

This potential issue of land use is not singular to biofuels but can extended to the livestock production for meat or dairy. However, as all industries should seek to promote efficient land use for food, fuel, and materials, one can look to solve these issues through either a) obtaining increased biomass production from our land through improved agricultural practices globally or b) develop processing technologies that utilize a greater portion of the biomass produced for food, fuel, or materials.

Focusing on processing technologies, there is an advanced biofuels technologies that is capable of utilizing land to create substantially more biomass for fuels. Algae oil research appears promising with much higher oil yield per acre and the ability to use land not suitable for agriculture or even utilize oceans. Oil processing is done in a similar method to seed oil extracts, but considerable research is required in the aquaculture, harvesting, and oil extraction methods.

Another promising advanced processing technology is the thermochemical or biological reforming of lignocellulose biomass. From a land use perspective these biofuels technologies have the potential to reduce pressure on food crops as they can utilize agricultural wastes such as corn stover, wheat straw, or logging slash. The ability to utilize lignocellulose biomass as the non-edible portion of the plant may allow these feedstocks to supply fuels without impacting the global food supply. Additionally, as this material can be harvested from all plants, energy feedstocks can be created from native plants to maintain ecological services.

The advanced processing technology of the lignocellulose material is actually a category of processing technologies where the material is broken down into smaller components and then catalytically reformed into hydrocarbons utilize different pathways. Hydrolysis, gasification, and liquification are common routes of breaking the recalcitrant lignocellulose into either basic sugars, bio-oils, or syn-gas. These materials are then converted into hydrocarbons through catalytic or enzymatic reactions and catalytically upgraded to form the appropriate fuels. These pathways typically create a multitude of products and require recycling streams similar to petroleum refinery. Hence, the production of fuels in this manner is typical envisioned as a large scale “biorefinery”.

Aviation fuels should consider waiting for advanced biofuels and their expected improved yield of fuel per acre of land. The initial technologies utilizing seed oils will impact how we utilize land and do not represent the most efficient use of this limited resource. Focused research in advanced biofuels technologies of either algae oil or lignocellulose reforming should continue as these technologies represent a sustainable solution that allows societies to meet the needs of fuels and food in a balanced manner. Focusing on advanced biofuels will take longer but are required to insure sustainability of the solution.