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BIOFUELS FOR AVIATION:
A REPORT ON A SCIENTIFIC SUMMIT

Held September 1 and 2 at the Crystal City Doubletree Hotel

1. Introduction

The US Air Force will have all of its fleet of aircraft certified for 50 percent use of biofuels by the end of 2012. The commercial aviation industry is not far behind the Air Force in certification plans for its fleet of aircraft. In part, this is a function of the fact that the Air Force is conducting the certification process for its fleet in cooperation with the jet engine manufacturers. The same is true for the Army and the Navy in terms of their efforts to obtain 50 percent alternative fuel certification for their fleets of aircraft.

The Air Force is currently certifying Fischer Tropsch (FT) derived fuels for use in all aircraft and tactical systems. FT fuels can be produced from coal, natural gas, oilseeds and cellulosic biomass. Currently blends of percent FT fuels are blended with petroleum derived fuels to make a blended drop in fuel. The Air Force would like to expand the sources of fuels to include more biomass derived alternatives such as seed crops or cellulosic materials. To meet the needs of the Air Force, the biofuel Summit meeting was conceived to gain insight from the agricultural community on the best alternatives for feedstock for use in producing jet fuel for the military. The commercial airlines are also interested in the use of biomass derived fuels to help provide

alternative sources of supply and for reductions in life cycle greenhouse gas emissions. The commercial sector has recently published ASTM 7566, a new fuel specification for alternative fuels such as FT and biomass derived fuels. The Federal Aviation Administration (FAA) is leading certification efforts for the commercial fleet for both FT and biomass derived fuels.

With the certification of the Air Force fleet and related certifications coming along for the other armed services and the commercial airline sector, and the objective of obtaining these biofuels from agricultural production of biomass and biomass waste streams, a number of important questions have emerged. These include:

- Which feedstock to use,
- What are the issues related to feedstock logistics
- What processing or conversion mechanism to utilize,
- How to develop strategies for deployment, and
- How can the economics and policy questions on pricing, contracting and other regulatory issues that involve the current interventions in agriculture markets by the federal government be resolved?

The fuel demand for the domestic commercial airlines and the Air Force and other armed services, is equal to approximately 8 percent of the total transport fuel demand in the U.S. Thus, the demand for biofuel to be used as jet fuel is substantial in terms of total domestic transport fuel consumption.

Along with these more practical questions are two additional sets of questions or issues that are important to resolve. The first set of issues that must be explored and resolved with respect to aviation biofuel or any other production of biofuel are:

- Sustainability,
- Carbon and greenhouse gases, and
- Fuel/feed competition.

Not understanding or mishandling these issues could result in derailing the otherwise cogent plans for acquiring aviation biofuels from agricultural biomass and waste streams of biomass. The consequence of the Air Force selecting a biofuel feedstock that cannot be produced sustainably is unacceptable and must be avoided. Alternatively, what are the consequences of the Air Force selecting a feedstock that generates unacceptable levels of carbon emissions, greenhouse gases and other pollutants? Finally, what happens if the Air Force selects a feedstock that is highly competitive with food production? These are issues and questions that need careful thought and analysis before the Air Force selects a (or a combination of) feedstock(s) to be used to produce aviation biofuels.

A second set of questions relates to the rapid changes in production, storage, handling and processing technologies that are underway in the biofuels industry. New feedstock alternatives are being developed for biofuels, such as algae, oilseeds and cellulosic crops that are not now commercially grown and without well defined markets. In addition organic waste materials such as paper mill waste materials and Municipal Solid Waste (MSW), which are in plentiful supply in many areas of the nation, are being successfully investigated as sources for biomass. Conversion is undergoing a potentially drastic improvements as processes for the direct

conversion of cellulose into biofuels are being seriously investigated, and researched with promising results is emerging from scientific labs and on a pilot scale. It is important that during the process the Air Force uses to select a biofuel or biofuels that feedstock development, logistic implications, processing technologies, deployment strategies and economic and policy assumptions are consistent with ongoing and future developments of technology in the biofuels industry.

Given the dimensions, complexity and potential impact of these issues, the Air Force commissioned a *scientific* Summit to not only explore but also begin a process to bring resolution to these issues. The Summit was managed by the National Center for Food and Agricultural Policy (NCFAP) with logistics and organization support provided by Concurrent Technologies Corporation (CTC). The Summit was financed by the Air Force (Air Force Research Laboratory) and planned by a group of representatives from the Air Force, National Center for Food and Agricultural Policy (NCFAP), FAA, the Commercial Aviation Alternative Fuels Initiative (CAAFI), U S Department of Agriculture (USDA), Department of Energy (DOE) and the five Executive Directors (EDs) serving land grant university Experiment Stations. The EDs engaged the land grant universities to assure premier scientists were nominated for participation in the Summit.

The result was a scientific Summit that included as participants a cross section of scientists, economists and engineers from the agricultural and energy disciplines, and representatives of the Air Force, the airline industry, other branches of the armed services as well as USDA, DOE and US Environmental Protection Agency (USEPA). Many more worthy and talented professionals

were recommended as participants than could be accommodated. Due to the limitation on the number of participants, only those with exceptional expertise received an invitation. The Summit was by design scientific focusing on the difficult issues and questions related to the factors discussed above. The scientists were from the universities in the US (largely land grant universities) and government agencies (primarily USDA and DOE), with some representation of other federal agencies and the private sector. The Air Force, other military services, FAA, CAAFI and the commercial airline interests were well represented as well. In addition we selected a small group of farmers, political agents and Non-Government Organizations (NGO) representatives to fill out the 175 participants invited to the Summit.

The Summit was structured and designed to develop answers to the questions briefly outlined above. The exact structure of the Summit is provided in Appendix 1. Generally, the Summit was divided into three types of sessions:

1. Opening or plenary sessions and luncheon speakers providing background information from the Air Force, DOE, USDA and CAAFI,

2. Concurrent sessions on feedstock availability, feedstock logistics, conversion or processing, deployment and economics and policy. (These concurrent sessions were focused in three general issues, carbon and greenhouse gases, sustainability and food/fuel questions). In addition questions were prepared for each of the concurrent groups specially designed to focus the discussion on critical aspects of the of the concurrent session topics

3. Four regional concurrent sessions on the factors to be considered in making decisions on biofuel acquisition for aviation in the US (West, South, Northeast and North Central) were conducted. The US regions were specifically selected to align with the land grant university/USDA definition of regions in order to capitalize on the existing science and communication structures.

This report is designed to provide a summary of the Summit for use by the Air Force, other defense agencies, those in the airline industry, and the host of other individuals involved in feedstock production, logistics, processing, deployment and economics and policy for the biofuels, and the financial sector which will ultimately make the investments to assure the production of biofuels for the armed services and the airline industry. In addition to summarizing the Summit, the report will attempt to distill the recommendations that emerged from the dialogue at the Summit related to the science and the factors to be considered in moving the Air Force, other branches of the armed services and the airline industry to acquire recent vintage biofuels. Finally, the pressing research issues that emerged during the Summit will be identified and briefly discussed.

2. Objectives of the Summit

What are the developments in the petroleum industry that are behind the efforts of the Air Force, the commercial industry and other armed services of the US to develop biofuels for aviation? The effort is focused on a “drop in” bio based jet fuel that can be easily mixed with petroleum based jet fuel. These summary comments come from the materials in Appendix 2, the plenary and luncheon talks for the first day (Michael McGhee, Acting SAF/IEE US Air Force; Jacques

Beaudry Losique, Deputy Assistant Secretary for Renewable Energy DOE; John P. Heimlich, Vice President and Chief Economist, Air Transport Association (representing CAAFI) Patrick Dublin, Executive Director, Defense Energy Support Center; and Gale Buchanan, former USDA Chief Scientist and Under Secretary for Research, Education and Economics, REE/USDA and Dean and Director Emeritus, College of Agriculture and Environmental Sciences, University of Georgia)

The five developments, which were explained in the plenary sessions by Air Force, industry and government leaders are:

- Security,
- Variability of prices of petroleum jet fuel,
- The margins in the pricing of jet fuel,
- The trend toward alternative fuel production in the US in recent years, and
- Delivery mechanisms for petroleum based fuels to airports and military bases.

The first of these developing issues is security. In a nation that consumes 25 percent of the global petroleum produced, is responsible for only 5 percent global petroleum production, and in which the Air Force is a major consumer of petroleum based jet fuel, there are major concerns about security. Other nations tend to control the access to the energy necessary to meet their military objectives. The primary directive of the US Air Force is to dominate air, space and cyberspace for America (McGhee). Thus, the Air Force has and is addressing this fuel availability problem from aspects that include initiatives more inclusive than just their interest in renewable energy. The major themes of the Air Force approach for managing energy consumption are to:

- Reduce demand (conservation and efficiency)
- Increase supply (fossil and renewables)
- Change the culture concerning energy.

Reductions in energy demand have been impressive and have fallen from nearly 380 million MBTUs in 2003 to under 320 million MBTUs in 2008, even during a period of conflict on several international fronts. These reductions have related to a number of factors including more efficient flight routes and reducing the weight of Air Force aircraft. The increase in supply initiative includes alternative fuels and diversity of sources that is a benefit in terms of fuel availability. The culture change is a matter of a longer-term adjustment but the objective is to have all Air Force personnel thinking about energy routinely.

Energy costs for the Air Force were still $9 billion in 2008, 84 percent of which were for aviation fuel. This cost of energy has increased from just under $4 billion in 2003, or a more than 100 percent increase in five years. Clearly there is an incentive on the part of national security for the Air Force to secure alternative sources of fuel, as well as to secure fuel sources that are under domestic control.

The second developing issue, the variability of petroleum prices or prices used for jet fuel, was addressed by Heimlich. Again for the commercial fleet, the volume of fuel consumed was reduced by about 5 percent over the years 2000-2008. However in this time period, the cost of jet fuel consumed increased from $16 billion to $57 billion. But, as important as the price of fuel is to the overall budgets of the commercial airlines, the critical and difficult issue to manage is the variability in price. During this same time period, the volatility of jet fuel prices, which are

correlated with the change in petroleum prices, ranged from about $45 dollars per barrel to over $145 per barrel, with significant fluctuations within a period of five years. And, in 2009 jet fuel prices varied between 110 cents per gallon to about 190 cents per gallon. The point to be made is that the aviation industry is highly dependent on fuel costs/prices, and that the market is responding to very unpredictable factors. As a consequence of this and of course other factors, the S&P ratings for most commercial airlines were below BBB in corporate bond ratings—the lowest grade in the commercial bond ratings.

A third factor discussed by Heimlich was related to the margin in the price for jet fuel. This issue is a bit more complicated but relates to the fact that the cracking of raw petroleum yields only 4.1 gallons of jet fuel per barrel. If gasoline for autos and diesel fuel for other transportation and heating (which make up 30 gallons of the 42 gallon barrel) are in low demand, then the price of jet fuel rises due to the fact that the jet fuel is driving the demand for refining of crude oil. This has been a particular problem with the slowdown of the US economy during the past 2 years. Another factor that has affected this margin is the availability of biofuel for auto and truck transportation—which has reduced the demand pressure for refined petroleum fuels. Thus, the price margin issue is still another problem for jet fuel consumers in terms of price predictability.

The fourth factor is related to the emphasis on alternative fuel production in the US during recent years. The USDA and the DOE have been focused on ground transportation fuels for the past several years. Little of their budgets have addressed jet fuels. As Beaudry-Losique showed, the Department of Energy has invested significant amounts in building the fuel capacity for ground

transportation, and is making significant progress. The USDA has as well made significant investments to encourage the development of ethanol and bio diesel plants. In part, these efforts have been driven by regulations related to high octane additives for transportation fuels. But, it seems that now is the time to turn at least some attention to the Air Force, Army, Navy and airline industry and their special problems related to supply of jet fuel from petroleum.

The fifth factor is related to the delivery mechanisms for petroleum based fuels—mainly pipelines to military bases and airports. As shown by Heimlich, the routes for petroleum fuel pipelines in the US are largely South to North. There are some deviations for Alaskan crude in California and the Western states along the seashore and in New England for fuel imported from other countries. But the main delivery by pipelines is South to North. In general, this means that the pipelines are not particularly well set for delivery of biofuels, which are currently produced mainly in the Midwest and the Southeast.

One issue that was not mentioned is that at juncture points where the pipeline passes through particularly rich biofuel feedstock producing areas, biofuel, especially a “drop in” fuel, could be added to the pipeline flow at this junction point (mixing station), rather than produced near an airport or air bases. With careful management the combination bio/petroleum jet fuel would then be transferred to the airport directly through the existing pipelines. This observation significantly increases the delivery points for biofuel, and would work since the drop-in biofuel could travel as does the petroleum based jet fuel through the pipelines to the airports or air bases. This transport system could directly meet the needs of the airports for 50 percent biofuel by using the same system that now delivers petroleum-based jet fuel, and reduce the need for

alternative delivery systems. This observation as well expands the sourcing points for alternative biofuels supply.

The first plenary luncheon speaker was Patrick Dulin of the Defense Energy Support Center (DESC). His remarks addressed all of the DoD with the focus on energy—the Army Energy Strategy, the Air Force Energy Strategy and the Navy Energy Strategy, specific aspects of the DoD approach to the purchase of fuel and jet fuel inventories. The mission of the DESC is "to provide the Department of Defense and other governmental agencies with comprehensive energy solutions in the most efficient and economical manner possible". Energy purchases are becoming more efficient and better coordinated. And, various DoD agencies are beginning to acquire recent vintage biofuels for testing and trials. A remaining problem for the DoD is the limitations on the purchase agreements, which to oversimplify, have the DoD agents purchasing fuel in the spot market almost entirely. More contracting flexibility could lead to lower energy costs even if the purchases were restricted to petroleum based fuels. This could be listed as a fifth problem of the petroleum market developments but is not because it is, in fact, related to DoD energy purchasing policy.

Buchanan emphasized the critical importance of photosynthesis in the production of biofuels. The scientific expertise and research capacity of the land grants and the USDA, those entities that brought us the green revolution, must be engaged and funded to bring in a biofuels revolution. The call was for joint work with the land grants, USDA and the Air Force on feedstock production, handling, storage, conversion, and possible delivery points. He emphasized the future feedstock developments, cellulose conversion, and the possibility for the Air Force developing specifically targeted joint projects with the USDA labs and with the land

grant universities. There is much talent at the land grants in not only feedstock production and processing technologies but also in the economic and policy issues that are just beginning to be effectively focused on biofuels for aviation. To date, much of the focus had been on ground transportation fuels, where there have been available significant federal grant and contract funding, and private funding as well.

Several clear types of analysis that could assist the Air Force, commercial airlines and other DoD units are:

- Analysis of the coherence of petroleum and agricultural feedstock prices,
- The development of different contracting mechanisms based on the results of the analysis of coherency of prices,
- Different purchase policies that recognize the availability of forward and futures contracts, and
- Financial alternatives to holding inventories as a strategy for price stabilization.

If the quest for biofuels from agriculture is all or in part motivated by the possibility of stabilizing purchase prices for all fuel, there are real valuable results to be had from these investigations. Agricultural prices are not moved by the same factors as energy or fuel prices. Studies of the coherence of jet fuel from petroleum and prices of agricultural products that can be used as feedstocks for biofuel for aviation could provide purchase strategies that would yield a more stable "energy price" for the total bundle of energy from petroleum and renewable energy sources used by either DoD or the commercial airlines. This set of research problems could be directly addressed currently.

As well, contracts (short and long term) with agricultural producers of feedstock which are attractive for biofuel feedstock production and aviation could be developed by the Air Force, DoD and the commercial airlines. These contracts or purchasing mechanisms could benefit both agricultural producers, the Air Force, DoD and the commercial airlines. These contracts or purchase mechanisms could also address the large and costly inventories apparently now held by the Air Force. And, the contracts could as well deal in a more comprehensive way with the security issues that the Air Force and other military services face.

Finally, there are possibilities related pipelines that could positively impact delivery of biofuel to the Air Force bases and airports and fuel inventories. Pipelines traversing the nation provide an alternative to sourcing the biofuel near the Air Force bases and airports. Again, biofuels could be sourced anywhere near the major pipelines, and from multiple sources. This would take away from the congestion near the airports and military bases, and importantly give access to locational differences in the prices of agricultural commodities used as feedstocks for biofuel. That is, make it possible to source the biofuel feedstock far from established Air Force bases and commercial airline airports and at lower prices. This observation could have implications for MSW and the timber industry as well where the sourcing of biofuel feedstock could be location stranded due to transport costs and transport availability. The diversity of sources implied by this observation could have major implications for the size of inventories held by the military services.

These last issues will be among the major conclusions of this report concerning work to be completed in the immediate future to support Air Force interests in jet fuel from biofuel as an alternative to petroleum based fuel. . The relationships of alternative feedstock pricing processes and the nature of contracts have much to do with stability of the jet fuel price, inventory management and other issues that are at the heart of the Air Force concerns about the petroleum market and possibility of achieving more price stability from diversified sources of supply for jet fuel.

3. The Concurrent Sessions and Conclusions.

The first set of breakout or concurrent or breakout groups had three sessions each. Again, the three concurrent or breakout sessions were:

- Carbon and greenhouse gases,
- Sustainability and
- Food and fuel competition.

There was one moderator for each of the sets of breakout or concurrent sessions. Recall that the concurrent sessions were for:

- Feedstock availability,
- Feedstock logistics,
- Processing or conversion,
- Deployment, and
- Economics and policy.

Each of the concurrent sessions had a set of panelists to lead the discussion and to respond to pre-set questions that were designed to focus the dialogue on critical issues related to carbon and greenhouse gases, sustainability and food/fuel competition. The panelists were required to prepare a "2-pager" responding to the general theme of the concurrent session (carbon and greenhouse gases, sustainability or food/fuel) and to specific question(s) that were put to them by the Summit organizers. The 2-pagers prepared by the panelists and the summaries of the moderators are provided in Appendix 3. (The questions that the panelists were asked to respond to are listed in the Appendix 1.) The breakout or concurrent session panelists were almost entirely scientists from the land grant universities, but with selected individuals from the private and other public sectors. The 2-pagers are recommended for further reading on the subject areas of the Summit. And, they provided a rich background for the discussions during the breakout or concurrent sessions. At a general session following the breakout or concurrent sessions, the moderators for the breakout sessions summarized the conclusions from the five concurrent or breakout groups for the benefit of the full set of participants in the Summit.

Background documents on the subjects for the breakout or concurrent sessions were as well provided by the moderators for the participants to read in advance of the Summit and for panelist's reference in preparing their 2 pagers. There are approximately five papers or related reading materials provided by the moderators for each of the five breakout sessions. These are important to the results of the Summit and are provided in Appendix 4. Specifically, there are approximately twenty five of these documents, five per breakout session, organized by breakout or concurrent group and provided in Appendix 4.

In the following portion of this Summit report, the findings and recommendations of the participants in each of the breakout or concurrent groups are summarized. Because the participants at the Summit were selected for their expertise, the selection process assured an even distribution of participants (about 30 each) in each of the concurrent or breakout groups.

Feedstock availability (Moderator, Ken Cassman, University of Nebraska)

The participants in the feedstock availability concurrent session group had much to say about each of the three themes or issues around which the sessions were organized. Carbon and greenhouse gases were viewed as directly related to the different feedstock alternatives. Generally, feedstock alternatives that require large inputs of nitrogen and heavy tillage of the land have greater greenhouse gas emissions per unit biofuel than those that produce high biomass yields with minimal fertilizer and require minimal tillage. Thus, for example, corn and soybeans (highly variable depending on tillage methods and production management) tend to have greater greenhouse gas emissions compared to dedicated perennial crops such as switchgrass or poplar trees. Alternatively, MSW and paper products that use waste materials in biofuels production may, in fact, be net reducers of emissions of carbon and greenhouse gases.

These conclusions on greenhouse gases were somewhat guarded because of the fact that much research needs to be done before conclusive and quantative answers are available. Research is needed on measurement, modeling and validation of greenhouse gas emissions for different biofuel feedstock options, especially new crops such as switchgrass, poplar, and other dedicated perennials.

On the issue of sustainability, again, the most direct dependence among the five breakout groups was in the feedstock availability group. And, there are many different definitions of sustainability. In this report, we choose the more practical of the definition;

- Does the agricultural product grow with sufficient yield to merit consideration as a feedstock (called "densification" later in the report)?
- Can the feedstock be produced profitably?
- What are the environmental impacts on water, air soil etc.?

This definition may be a bit narrow but it involves a framework that can be directly applied for decision. For the first issue, is the production in sufficient volume that the agricultural product can be a candidate for a feedstock? Sufficient volume can be measured in yield per acre and used as a metric for dealing with questions of collection, storage and transport to a processing or conversion facility. This is often called the "density" criterion for feedstock and is useful in deciding the distance that must be traveled for processing or conversion. For some crops, the grains and oil seeds that are already marketed for livestock feed and food use, this criterion is not a major consideration since formal markets already exist for these commodities.

However for bulky or low yield crops that may require specialized transport processes, sufficient yield played into the results of the feedstock and logistics breakout or concurrent session groups. For some possible feedstock alternatives the mechanisms for collection and transport are already in place—as in the case of wood products, MSW and sugar cane. For others, this is a consideration that will require additional research that may eliminate certain feedstock alternatives from commercial consideration. There is as well the question of storage and delivery of constant quality feedstock material. It is safe to say that for many of the cellulosic

feedstock alternatives the storage and consistent quality issues are considerations that will require additional research before a satisfactory answer is available.

The question of profitable production is as well another one that has answers for grains and oilseeds that are already marketed for other purposes, but research needs to be completed for feedstock alternatives that are new or different like switchgrass and MSW. In each case, the parameters are different and specialized studies are needed to determine profitability. And, these may be different types of studies. For example, the feedstock from MSW may have tipping fees to involve in the profitability calculations. As well, there are different problems in determining markets for byproducts, for example, from new oilseeds that may be considered for feedstock production.

The last question relates to environmental impact and will likely be the source of continuing studies and research. Currently indirect land use is a hot issue for biofuel feedstock production. But, there may be other concerns or issues that emerge in the future. The recommendation is for more complete studies and research of feedstock alternatives. We know some of the important issues; water, fertilizer, tillage, carbon and greenhouse gases, soil conditions, and others. The recommendation is not to be blinded by the concern of the day in connection with biofuel feedstock sources. We need to make sure that the environmental impacts related to factors that we know are important are clearly understood, and be alert to the emergence of others. This is the approach that will get the biofuel community farther along than chasing after the latest concern from Washington or other centers of discussion on biofuel production impacts.

The actual feedstock availability group (and the other four groups) sessions were developed for two time frames, 2012 and 2017. The objective for this and other panels with the same mandate was to get short term and medium term projections from the scientists assembled. The feedstock availability concurrent session group developed two tables that will be helpful in distilling the dialogue during the sessions, and that were presented in the summary for the group by Cassman, the moderator for the feedstock availability set of concurrent sessions.

The tables were developed using the following set of guiding assumptions:

- The biofuel feedstock does not directly compete with the food supply—nonfood crop, non food component crop, MSW and marginal land or existing degraded crop land,

- It has a neutral or positive environmental impact i.e. less greenhouse gas emissions relative to petroleum based jet fuel and –maintains soil and water quality and protects wildlife and biodiversity,

- It is cost reasonable and competitive i.e. incorporates security value of domestic feedstock and addresses the increasing cost of importing oil, and

- It meets the 50 percent Air Force jet fuel needs i.e. approximately 1.2 billion gallons per year and 13 billion gallons for the domestic airline industry and the other military services.

With these assumptions as guidelines the two tables were constructed by the feedstock availability concurrent breakout session group. The dialogue leading to the construction of these two tables had panelists reporting on the themes and questions used to focus the discussion. Thus, for added detail the 2-pagers provided by the panelists in the feedstock availability concurrent sessions should be consulted. With these qualifications the tables presented by the feedstock availability are reproduced here.

Table 1 provides the concluding decisions of the feedstock availability breakout or concurrent session group for feedstock by major region of the country; South, Midwest, Northwest, West and Alaska and Hawaii for 2012. The consensus choices of biofuel feedstock(s) presented by area along with indicators of the quantity that could be made available, are schematically provided in column one. For the South-- the most advantageous feedstock alternatives are forestry and switch grass, for the North Central-- the choices are soybean and corn stover, for the Northeast—the best feedstock alternatives are MSW and woody crops, for the West—the choices are dead timber (which there is much of currently due to damages of the pine beetle) rice straw and MSW, and for Alaska and Hawaii the feedstock is dead timber and as brought out in the discussion of the moderator's report sugar cane in Hawaii. Each of these crops currently has little direct impact on food/fuel issues, there are concerns about greenhouse gases, water quality and quantity are of minor importance, and soil carbon is important for corn stover, soybean and wheat straw. The uncertainty about the impacts is indicated by the question marks.

Table 1.
Feedstock supply and performance characteristics by 2012

Region	Feedstock	Biomass Quantity	Food v Fuel	GHG	Water, quantity	Water, quality	Soil-C
South	forestry	+++	0	+++	0	?	?
	switchgrass	++	--	?++	0	?++	?+
	rapeseed*	+	?	?	0	?	?
Midwest	waste cooking oil-animal fat	+	0	++	0	0	0
	switchgrass	+	--	?	0	?++	?+
	corn stover	+++	0	---	0	--	---
	soybean	++	--	---	0	---	---
Northeast	MSW	++	0	0	0	0	0
	woody crops	++	0	++	0	0	?0
West	dead timber	+++	0	++	0	0	0
	wheat straw	++	0	--	0	0	----
	rice straw--CA	+	0	0	0	0	0
	MSW	++	0	++	0	0	0
	Camelina	+	--	?	0	0	?--
Alaska, Hawaii	dead timber-AK	++	0	++	0	0	0

*Insert into existing cropping systems without loss of yield in those systems (rotations with wheat, substitution for cotton, others?)

The surprise to the audience came from the importance emphasized for MSW, which is an environmental concern especially in the highly populated coastal areas. Another feedstock that was not mentioned was the waste from paper and other timber processing enterprises. As will be mentioned in the report from the concurrent or breakout sessions on feedstock logistics, there are other advantages to looking to industries that have developed the capacity to handle large amounts of bulky non-dense materials.

Table 2, for 2017 five years after the Air Force will have all of its fleet certified for 50 percent biofuel use, is provided to show what the feedstock availability concurrent session group deduced would be the changes between 2012 and 2017. Major changes between Table 1 and 2 involve the elevation in importance of switch grass, sweet sorghum, algae and high yielding grasses. These changes suggest that the feedstock availability concurrent session group was convinced that cellulose conversion would become commercially viable during the five year

period. These agricultural products appear to be less competitive relative to environmental concerns, but there are serious question marks as well. It is time for the agricultural scientists to put into place research to clarify these environmental impacts. Again, the paper mills were not specifically mentioned except to highlight the forestry products in the Southern area.

Table 2.
Feedstock supply and performance characteristics by 2017.

Region	Feedstock	Quantity	Food v fuel	GHG	Water, quantity	Water, quality	Soil-C
South	forestry	+++	0	+++	0	?	?
	switchgrass	++++	--	?++	0	?+	?++
	rapeseed*	+	?	?	0	?	?
	sweet sorghum	+++	?	?	0	?	?
Midwest	waste cooking oil-animal fat	+	0	++	0	0	0
	switchgrass	++	--	?	0	?++	?+
	corn stover	+++	0	---	0	--	---
	soybean	++	---	?—	0	?	?
	sweet sorghum	++	--	--	0	--	?
Northeast	MSW	++	0	0	0	0	0
	woody crops	++	0	++	0	0	?0
West	dead timber	+++	0	++	0	0	0
	wheat straw	++	0	--	0	0	----
	rice straw	+	0	0	0	0	0
	MSW	++	0	++	0	0	0
	Camelina	+	--	?	0	0	?—
	Algae	+	0	?+	++	--	?+
Alaska, Hawaii	Dead timber-AK	++	0	++	0	0	0
	High yield grass	+	0	++	0	+	++

*Insert into existing cropping systems without loss of yield in those systems (rotations with wheat, substitution for cotton, other substitutions?)

Research issues relative to feedstock availability are many and relate to the impacts on the environment of the various feedstock recommendations. In addition, there are a number of new feedstock sources for the 2017 projection that need to be further and more carefully evaluated. There is as well suggested uncertainty about greenhouse and carbon implications for the new feedstock candidates. Finally, there is the question about the emergence cellulose processing that is implicitly involved in the differences between the 2012 and 2017 recommendations.

Feedstock logistics (Moderator, Robert Fireovid, USDA/ARS)

Feedstock logistics was the second set of concurrent sessions and became more important than perhaps was initially thought on the basis of the recommendations of the feedstock availability concurrent or breakout session group. Many of the recommendations of this first group were for feedstock alternatives that do not now have well developed systems for accumulation, storage and quality assurance. These products were the province of the feedstock logistics concurrent session group. An overall conclusion of this group related to the importance of minimizing waste in the logistics plan or system. Sources of waste were suggested by such factors as maximizing loads for transport, densification/liquid fractioning in energy operations, utilization of satellite storage and staging sites, selecting least cost ways of transportation and minimizing losses within the feedstock delivery supply chain. The point was made that many of the newer feed stock alternatives are relatively low value and perhaps have high costs of assembly for processing. The idea of feedstock intensification—getting more yields per acre, came alive in this set of concurrent session recommendations.

The three themes or issues for each of the concurrent sessions are discussed first. The conclusions for carbon and greenhouse gases and indirect land use were exactly related to minimizing waste. If waste is reduced the impacts, especially for carbon and greenhouse gases, are in turn reduced. The idea was to learn from high volume low cost industries ways to develop low cost accumulation and delivery approaches. Examples given were cotton, container shipping, mining for metals extraction, and forest products. In all of these cases, mechanisms have been developed to address the high volume low value traits of the products or commodities.

Second, there is the issue of sustainability for feedstock logistic systems. Here there was a particular concern about the acceptability of the logistics methods as they impacted communities. Scenarios for switchgrass such as having a large number of trucks on the roads day and night were discussed. It is clear that issues of community acceptability have not been sufficiently worked out and understood. More to the point of sustainability, there are issues of timing of harvest, crop rotations, cover crops and intercropping that need to be better understood before decisions are made about acquiring a feedstock of a particular type. Alternatively, the point was made that in the Western US, fragile ecosystems are not wastelands and must be treated carefully, if they are brought into the production of feedstock. In short, the logistics issues were judged not have great implications for sustainability unless there is major waste in the system that is developed. However, it was observed that, if cost is a consideration, the waste issue should be self regulating

Finally there was the food/fuel issue. Here again there is not much to say about the implications of logistics as they relate to food and fuel tradeoffs. One point made in the feedstock logistics group and in other concurrent session groups is that the food and fuel concerns should as well take into consideration feed. There was a great expression of uncertainty about circumstances leading to food versus fuel during the summer of 2008. The issue was put to rest by the time that analyses were available to make the concern more than a shouting match. But even these studies did not fully take into consideration the fact that much of the corn and soybean consumption is by animals. In all three themes, carbon and greenhouse gases, sustainability and food and fuel, there is not much of a contribution related to feedstock logistics.

Research questions coming from the feedstock logistics concurrent sessions were, however, substantial. A major conclusion as already mentioned, was to study the logistics of systems that have evolved for high volume low density feedstock. Some of these systems have been operating for significant time periods, and appear to be efficient. Still an other recommended research area was to work on systems that are efficient and eliminate waste. In the end, waste will make the difference in selecting between logistics systems and feedstock alternatives that are to be used in biofuel for aviation. Lastly, the acceptability to communities issue could have major implications for logistics and feedstock selection.

Processing or conversion (Moderator, Robert Brown, Iowa State)

The processing and conversion concurrent session group made a number of clear and decisive recommendations. Perhaps the most emphatic was a statement that came in the oral discussion of the moderator's report. The discussion emphasized that the issues related to the right choice of feedstock will be made not by the processors or conversion specialists, but by conditions as they relate to availability and logistics of feedstock. The idea is to design the processing or conversion system to the specifics of the feedstock and its availability. Quotable statements by Bull and Holmgren added to the content of the report of the moderator and will be repeated here.

Coming to the three themes of the concurrent sessions, alarm was expressed about the focus on indirect land use and the inclusion of language about this issue in the 2007 EISA legislation. There is a feeling that the information is so difficult to understand that it should not be written into law at this point. The issue was that the feedstock production and direct land use topic could dominate legislative decisions and swamp the debate related to procession and conversion.

More specifically, the discussion of processing and conversion by the concurrent session group identified four attributes of processing technologies that reduce greenhouse gas effects. They are:

- Do not use fossil fuels in the processing of biofuels,
- Avoid distillation and drying of products, it is energy intensive,
- Utilize carbon dioxide or other carbon rich by products as bio-products or carbon sequestration agents (biochar is an example), and
- Employ non-biomass sources of hydrogen (solar and wind) to enhance yields of biofuels and reduce CO2.

The recommendation was for federally supported research to target these issues and to keep the results in the public domain as a way of contributing to more rapid development of processing and conversion technologies that are more greenhouse gas and carbon sequestration benign. As well, the concurrent group argued for technical publicly accessible techno-economic analysis and life cycle analysis of technologies to precede federal investments in demonstration projects.

On the sustainability issue, the report started out with a suggestion made during the session by Bull on what does sustainability encompass. For the processing and conversion group, these were as well the aspects of processes that determine sustainability:

- Greenhouse gas emissions,
- Economic prosperity,
- Land use,
- Biodiversity,

- Air quality, and
- Water use.

This list is a bit more comprehensive than those laid out above (in connection with the discussion of breakout group on feedstock availability) but reflect the same type of reasoning. The important thing is to establish metrics for sustainable systems and then design the systems to meet them. There were as well some reported new results that made this statement ring true. A soon to be released NREL study comparing ethanol production from biochemical and thermo-chemical processes shows that all cellulose processes will require capital investments in the range of $200-$600 million for 2000 ton per day plants and produce fuels at a cost exceeding $2 per gallon of gasoline equivalent. Fuels from micro-algae and bio-oil have some theoretical advantages, but these advantages may diminish as more is learned about these relatively immature technologies. In connection with the discussion on sustainability, the notion that the feedstocks will drive the selection of processing technology was again strongly asserted. For example, large scale processing will be possible only if biomass is densified before transport (Dale)—a feature emphasized in the feedstock and logistics discussions.

For the food and fuel issue, a vision was provided that guided the comments of the moderator (Holmgren). It was:

- To produce fuels that are truly "drop-in" instead of simply producing additives,
- Leverage existing refining/transport infrastructure to lower capital costs, minimize value chain disruptions and reduce investment risk, and

- Focus on a path toward second generation feedstock alternatives, which can get up to 40 percent petroleum replacement.

With this general set of principles in place the moderator indicated that the concurrent or breakout group felt that there was a great misunderstanding about the relationship between food and fuel. Huge opportunities exist for integrating bioenergy and food consumption. Intensification of land use could provide food and fuel from fewer acres. But dismissing the concerns of the skeptical "with a few facts" will not convert them to the side of the biofuel supporters. We must recognize that leaving the petroleum age behind means we will have to learn to harness energy flows in the biosphere for food and fuel as well as a host of other products and services. The biofuel industry needs to come together with other stakeholders to define the metrics of performance and link the industry to them.

Research issues from this concurrent session were many. The metric question was clearly identified. The need for linking these metrics to standards of performance for the biofuels industry was noted. Needs for increased life cycle analysis and technical analysis were mentioned. The determination of processing and conversion technology based on feedstock characteristics was stated and emphasized in several of the comments of the panelists in the concurrent session group, and by the moderator. And, there were a number of short and concise statements for guidance related to sustainability and the biofuels industry.

Deployment (Moderator, John Ferrell, EERE/DOE)

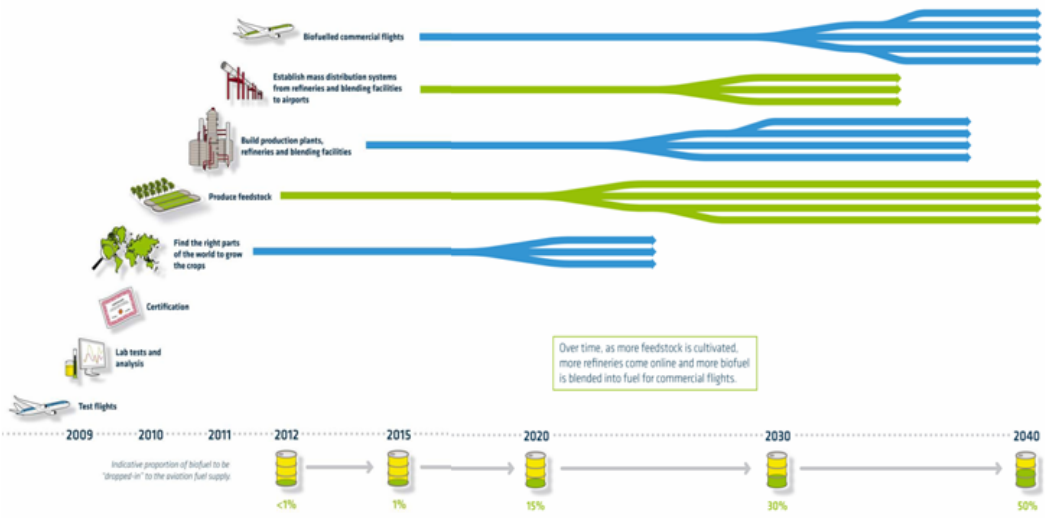
The deployment concurrent sessions group reviewed ATAG's "flight plan " for biofuels for the Air Force and the commercial airline industry and the other military services stretching to 2040

to reach the 50 percent biofuel goal. This chart is reproduced as Figure 1 below and lays out what could be a conservative schedule--but this reflects the agreement within the deployment group.

The figure shows quite a long period until there is significant production of biofuel for aviation, 15 percent by 2020. A critical part of this flight plan is the finding of the appropriate feedstock (consistent with the information developed in the first three concurrent or breakout sessions). Arrangements to produce the feedstock and manufacture it into biofuel follow, and will begin the large scale build up to the Air force target of 50 percent.

Figure 1.

Flight Plan to Commercialization of Aviation Biofuels



Beginner's Guide to Aviation Biofuels, May 2009, Air Transport Action Group (ATAG)

Major deployment issues other then the carbon and greenhouse gases, sustainability and food and fuel issues, on which the deployment concurrent session group commented, were:

- Safety and certification

- Performance

    - High energy density and low sulfur

    - Reduced carbon footprint (life cycle), and

- Compatibility

    -"Drop-in" fuel

    - Use current delivery system.

The carbon greenhouse gases conclusions from the concurrent session group called for studies of carbon life cycle for aviation fuels, improved nitrogen use efficiency for feedstocks and development of uses of co-products high in nitrogen. Like the other breakout groups, the deployment group suggested citing feedstock production close to conversion and blending facilities, and focusing on the high density feedstock as ways to provide a more favorable greenhouse gas profile for aviation biofuels. The group also introduced the idea of small scale systems as an option for distributed fuel production and enhanced energy security.

Recommendations for sustainability were consistent with the three breakout groups previously reviewed. Recommendations included: improved efficiency in feedstock collection, fractionating fuels to meet ground and air transportation needs, and collaborating with Cooperative Extension Service and land grant universities on feedstock availability and logistics issues. To minimize stress on natural systems, the deployment group recommended feedstocks be selected based on their ability to adapt regionally, tolerate drought conditions, use nitrogen efficiently and produce high yields. Development of sustainability criterion and broadly acceptable indicators should be supported according to the deployment group. As noted in previous sessions, sustainability criterion have a greater role in feedstock production and logistics than processing.

For the food versus fuel issue, the deployment group recommended efforts to increase crop yields so as to reduce pressure on land, thus leaving more agricultural land available for food crop production. The food versus fuel issue has been exaggerated in the US, and oil prices not corn or ethanol had a major impact on the 2008 food price increases. In the near term, the primary feedstock alternatives will likely be oilseeds and MSW and in the longer term there was support for algae based fuels. An advantage of using energy crops for biofuel production relative to food crops is that energy crops have less of a relationship to the food system. The resulting disadvantage is that energy crops are more vulnerable to disruptions in the fuel market because they have limited alternative uses and therefore limited markets.

Other conclusions and recommendations were related to mitigating the nitrogen impact, and focusing on drop-in fuels with few if any infrastructure constraints (drop-in fuels can be transported in existing pipelines and require no engine modifications for use). According to the deployment working group, efforts should be made to develop business models that can potentially satisfy all parties. For instance, long term purchase agreements between farmers and bio-refiners may be necessary to ensure predictable quantities of feedstocks. Meeting grower needs is critical to developing sufficient feedstock to meet the requirements for the Air Force and commercial airline industry. There was concern that the implied timeframe for development of aviation biofuels is highly aggressive. The deployment group highlighted the need for the military and commercial aviation industry to consider a more realistic timetable.

This concurrent session group had a number of research suggestions that paralleled those of the foregoing concurrent or breakout session groups. One of the suggestions related to improving feedstock density. The deployment concurrent session group argued for prioritization of feedstock that could be grow in dense settings. They also concentrated on nitrogen more than the other groups, and called for nitrogen to be an additional research focus for the feedstock production systems. The group mentioned it would be highly beneficial to include Cooperative Extension and farm organizations in large scale deployment efforts. And again, as for the earlier concurrent session groups, they called for a set of metrics that could be applied in the deployment process.

Economics and Policy (Moderator, Harry Baumes, USDA Office of Energy Policy and New Uses)

The last of the concurrent session groups focused on economics and policy. Their report, provided by moderator Baumes, was somewhat different than the others, emphasizing the policy angles related to biofuel feedstock production for aviation. For example, in the discussion of carbon and greenhouse gases there was a call for separating the first generation feedstock from the second generation feedstock. The first generation used technology that was widely available and directly substitutable for food in production. As well, it was supported by policy on fuel additives (EPACT 2005 and EISA 2007).

Second generation, largely cellulosic, technologies will rely on processes that have not been tested commercially, but expand the set of feedstock alternatives considerably. They as well provide additional alternatives for addressing carbon and greenhouse gases. In the discussion of carbon and greenhouse gases, this group cited the fact that the current criterion are too

"narrow"—there are at least seven greenhouse gases and any one of them could be a problem for the nation. As well, the group argued for life cycle analysis for indirect land use as well as for carbon and greenhouse gases; there are is a real demand for developing metrics that are agreed on for moving forward. The group as well highlighted the issue of livestock production and its important role in the demand for by-products of biofuel production and conversion. Finally there was concern for the development of efficient market systems for the second generation biofuel feedstocks.

Sustainability was treated in terms of market development. That is, the market can develop appropriate prices for sustainable aspects of production, if they are appropriately measured and markets for the characteristics emerge. The theme was that there is presently too much government control in the treatment of the sustainability questions. The market cannot go all the way in addressing sustainability, but can be used more efficiently than it appears to be presently. What is the correct role for government in these environmental goods areas? They as well discussed other issues related to the broadness of the definition of sustainability;

- What is it we want to sustain?
- How long do we want to sustain it?
- What level of certainty do we want to impose to sustain it?

These questions are important to consider in developing sustainability definitions of a more practical dimension, and should be a part of the discussions on the development of pragmatic definitions of sustainability. The necessity of an integrated, across the various components of biofuel production, approach to sustainability was emphasized as well.

The concurrent or breakout session group had different things to say about food versus fuel as well. First, there was the observation that if you can make biofuel out of a feedstock, you can make food out of it. Thus, the food and fuel issue is a matter of degree. Those feedstock alternatives that are far from the food chain are likely better choices for dealing with the food/fuel debate than ones that are directly competitive. But the real issue is that food and fuel are in fact, competitors for biofuel feedstock alternatives.

The group identified food/fuel as a "hot topic" that has passed from the public arena of concern. There are other hot topics now and there will be even other hot topics in the future. Indirect land use is one of the hot topics now. Water and soil conditions may be hot topics in future. The problem is that the hot topics to date have emerged when there is little available scientific basis for to saying much about them. Careful research could make these discussions more reasonable and productive. What we require is a solid set of metrics that can be applied to biofuel/feedstock production and research to make sure that we know the impacts of increased production on these agreed on metrics. For the second generation biofuels, there is time to make these investments in research. What we need is more of a consensus about what research is to be done and who will do it. The question is which scientific disciplines and which federal agencies and universities should do develop the research to support the metrics.

Research suggestions from this group as mentioned, differed somewhat from the reports of the other breakout groups. For example, there was the call to focus on second generation biofuels, and to get the policy right at the same time as the technology develops. More research on life cycle analysis as the technologies for the second generation feedstock alternatives emerge as

well as the development of integrated research on the impacts of production, logistics, processing and deployment systems. For sustainability, the call for a set of metrics was again heard. In this case of sustainability, we heard an additional set of criterion that should impact the application of the pragmatic definition of sustainability. For food and fuel there was less attention to the direct issue and more to the potential list of hot topics that may emerge in future, if we are not careful about looking into all of the implications of increases in biofuel production.

The breakout group closed with a list of suggestions for the Air Force and the other proponents of biofuel production increases. Outreach and education are of importance in a time of rapid technology change—not enough attention has been given this aspect of the transition process. The Air Force might consider funding one or several of the biofuel feedstock alternatives suggested—likely MSW or byproducts of paper production, and develop a business model with the government and the private sector participating, looking into all of the issues related to carbon and greenhouse gases, sustainability, and food versus fuel. The idea would be to provide a business model template for properly introducing the commercial production of the second generation biofuels which are sure to be coming along.

Summary of the Concurrent/Breakout Session

This section attempts to summarize the main points that emerged from the concurrent or breakout session as we look across these sessions for common themes. This is a difficult task but there are some selected conclusions that were common to the breakout sessions and moderators reports. We will list them with brief comment about how they were reflected in each of the

breakout sessions where appropriate. The common points among the concurrent groups and moderator's reports were:

1. Most of the concerns about carbon and greenhouse gases, sustainability and food verses fuel were focused on the feedstock availability concurrent or breakout group. In short, feedstock choice is where the action is relative to these major concerns. Other breakout sessions reflected on how to make their part of the biofuels production process more efficient with respect to these three factors, but either in the reports of the moderators or actually within the breakout groups in one way or another endorsed this conclusion.

2. There is as well a conclusion that the focus of the biofuel for aviation effort should concentrate on second generation feedstock alternatives. The preoccupation with fuel additives that initiated the first generation biofuels production should be left behind. This came out clearly in the dialogue of most of the breakout groups.

3. The feedstock recommendations from the feedstock availability breakout session held up rather well in terms of feedstock alternatives that should be concentrated on in different regions of the nation. These recommendations by top agricultural scientists were among the most important recommendations from the Summit.

4. The systems for production of biofuel for aviation should be looked at in an integrated manner. That is, the production, logistics, processing, deployment and delivery of the fuel should be seen as a system and evaluated as such. There is currently too much research on specific portions of the supply system or value chain.

5. Sustainability is difficult to define. In fact, in the summary of the breakout sessions we gave three definitions of sustainability. Our recommendation is that we select the first and more pragmatic of the definition put forward—production (and density of production), profitability and environmental impacts (stated clearly). Policy concerns related to for example government interventions in agricultural commodity markets should be recognized (directly and indirectly) as well. The idea is to understand that this definition is an "approximation" that may as we develop more scientific results, need to be changed. But the emphasis is to have a pragmatic definition that is generally accepted and used.

6. Food and fuel and indirect land use are, or have been, hot topics for biofuels. There will be other hot topics in future such as a "low carbon economy". What is needed is a systematic approach to the development scientific information for the food/fuel and other hot issues that can provide information for the debates when they emerge. With this approach, the research and actual production and use of biofuels can progress more evenly.

7. This came out clearly in the deployment section, but there was a feeling among the participants in that breakout group that the implicit time schedule for implementation of the 50 percent biofuel goal seemed a little optimistic. This is not necessarily bad, but we need to recognize it add to it as a concern for the scientists working on the biofuels development process.

8. The MSW and paper mill byproduct as feedstock alternatives appear to be possibilities for early investigation of feedstocks for use in the production of biofuels for aviation. These feedstock alternatives are already accumulated and there are apparent environmental benefits from using them in biofuels production.

9. Get the feedstock decision correct and build the rest of the production, processing and distribution systems around the choice of feedstock. This was a major conclusion of the processing and conversion session that resonated throughout the breakout sessions.

10. For input into logistics research, closely investigate systems that already have developed methods for dealing with high volume low value input materials. As well, be concerned about density of output for production systems in terms of per acre yield.

Recommendations for Research and Inquiry

Research recommendations were addressed specifically in relation to moderator reports and the dialogue during each of the breakout sessions. Thus, we will be brief in the summary. But there were common recommendations that ran through the moderator's reports and the actual discussions of the breakout groups. These are summarized here. Specifically, the research questions related to:

1. The necessity of developing metrics for evaluation of the sustainability of biofuels production systems. Researchers are currently going about this process of evaluation in an unsystematic way. This hurts the biofuels effort and leaves much to be exploited in terms of hot topics. Some kind of a "consensus committee or group" should be formed and supported by one or a number of government agencies to come up with a working

definition of sustainability. And, the evaluations of different feedstock alternatives and full production processes should use this "approximate definition" of sustainability and assure that it is developed for complete systems of production or supply and delivery.

2. The focus should be on second generation technology for biofuels. Government should support this research for purposes of keeping the resulting findings in the public sector—not proprietary research that is unavailable to other researchers.

3. Focus on the feedstock recommendations of the feedstock availability breakout group. These can be seen as recommendations of a rather distinguished group of scientists and should guide near term research.

4. Consider policies broadly in the processes for the development of feedstock alternatives. It is important to have the government, local, state and national, on board relative to the biofuel feedstock and production systems being considered. One of the places to investigate for implications is the government interventions already employed in agriculture and their direct and indirect impacts on biofuel production development. Another is to investigate the possibilities for the drop in jet fuel to be transported by existing petroleum pipelines. As noted, this pipeline use could significantly increase the delivery points for biofuel and reduce investments in infrastructure.

5. Integrated, dynamic, systems approaches should be developed to investigate feedstock availability, feedstock logistics, processing or conversion, deployment and economics and policy for intended sites (locations) for biofuel for aviation production.

Currently, too much of the research is only on a part of the integrated systems process and of limited scope.

6. The Air Force and the industry as well as the rest of the military should consider organizing a group of top scientists and technical specialist to assist in their efforts to develop biofuel for aviation.

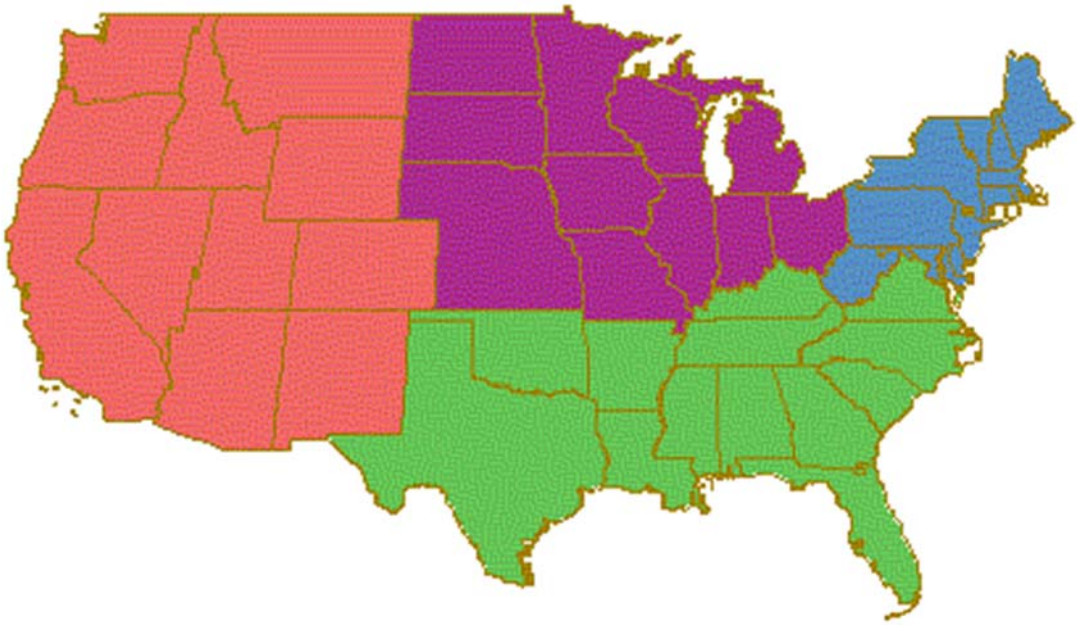
4. Factors to be Considered by the Air Force, Other Armed Services and the Industry in the Development of Biofuels to Meet their Goals

The last set of breakout or concurrent groups of the Summit addressed the topics of the first breakout discussions from a different perspective. The first breakout session areas were again, feedstock availability, feedstock logistics, processing/conversion, deployment and economics and policy. However, for the second set of sessions there was a regional focus: Eastern, North Central, South and West. The regions were specified to align with the USDA and land universities' regional delineations. This regional format capitalized on the established scientific and communications system of the land grants and assured rapid, competent and trusted connections to the land grant universities especially their colleges of agriculture (including their Experiment Stations and the Extension Services). Figure 2 provides a visual delineation of these regions.

Since feedstock alternatives are critical to the issues reviewed (carbon and greenhouse gases, sustainability, and food/fuel) and feedstock alternatives are inherently connected to agricultural and forestry production, the USDA and land grant regional system, which was developed largely

from a production viewpoint is the logical and functional way to address the biofuel for aviation issues.

Figure 2. USDA Region Map



Participants for this second set of breakout sessions were selected by the region of the country in which they resided and not by their technical or scientific expertise. About thirty individuals participated in each of the four regional groups. This reflected the fact that the participants to the Summit were selected to reflect the nation and not a particular region of the country

The scientific and technical questions presented to each of these four regional groups were derived from the first set of breakout or concurrent groups, and from specific issues provided by the airline industry representatives and the Air Force. The scientific issues were those considered by the first breakout or concurrent groups--mentioned in the paragraph above. The Air Force and airline issues were related to concerns about fuel procurement, consistency of

supply and delivery. Initially, the dialogue for the scientific issues for the four breakout tracks will be discussed. Each regional group was asked the questions listed in the tables below and in turn asked to rank issues of concern related to these questions by voting. Tables 3 through 7 below, we provide a listing of the areas of concern voted by the participants in the regional groups to be the most important.

The ideas, issues and concerns that emerged in this second set of breakout sessions begin to tell the story of the issues that are important when we begin to think explicitly of the magnitude of production for jet fuel required by the 50 percent certification of the Air Force, the commercial airlines and the other branches of the military. The feedstock alternatives and other aspects of the value chain involved in addressing this demand may be very different in different parts of the nation. Thus, the concerns identified should be read with two ideas in mind—the magnitude of the requirement for feedstock and the possibility of different feedstock alternatives in different areas of the nation.

The second set of questions in the regional breakout groups refer to the issues that are important to the Air Force and the commercial airlines in actually moving from petroleum based jet fuel to a 50 percent drop in biofuel. The goal of these questions was to develop a set of "factors" that can guide the Air Force and the commercial airlines to ask the right questions about the availability of biofuels and how to provide farmers /growers incentives to produce them in the amounts needed meet the biofuel for aviation objectives. These are practical questions but still important and relevant to the scientific issues and concerns discussed in connection with Tables

3 through 7. These questions are, in fact, more similar in nature to the scientific issues then might at first be recognized.

The linkage between these sets of questions is revealed in the value chain analysis. Value chains take the output price as given and work backward to determent the price available to producers or growers of feedstock. In this case, the fuel market price that we are working with is known—the price of petroleum based jet fuel. These calculations may be altered by co-products available from biofuel and jet fuel production. But, the critical relationship is between the petroleum based jet fuel price and the price that is available to feedstock growers and producers from a biofuel drop in alternative. It will be important to continue to think of these relationships in a value chain framework, because this is the framework that connects all of the disparate dots in the questions about biofuel.

Moderators for these four sessions were the EDs from the Experiment Station Sections of the land grant universities and individuals from the private sector. Specifically for four regions the moderators were:

- West: Dr. Michael Harrington, Western ED and Dr. Bruno Miller, Regional Manager for Fuel, Delta Airlines
- South: Dr. Eric Young Southern ED, Dr. Carolyn Brooks, ED for the 1890 Institutions, and Joel Murdock, Managing Director, FedEx Air Operations
- North Central: Dr. Arlen Leholm, North Central ED and Richard Altman, Executive Director, Commercial Aviation Alternative Fuels Initiative
- Northeast: Dr. Dan Rossi, Northeast ED and Don Schenk, President, ACA Associates, Inc.

Questions of a more scientific nature

The first set of critical issues/concerns was directly related to regional differences in feedstock availability. The feedstock availability group recommendations (Cassman) were relevant and seemed to hold up in this discussion. In fact, many of the issues and concerns raised were directly correlated to the recommendations identified by the breakout group moderated by Cassman. However, there are several special concerns that emerged in this second set of concurrent sessions. These are highlighted in Table 3 where the top three issues/concerns are reported—albeit with some modification by the authors of this report to make them conformable to the Table 3 format. One of the significant concerns of the West group was water, which is in increasingly in short supply and is necessary for biofuels production from agricultural land.

The South tended to focus on absent markets and the need for contracts to replace the current markets at least in the short run. The North Central had as its top concern the densification and handling of biomass, and the Northeast concentrated on MSW. Other issues related to the lack of infrastructure, the animal waste opportunities, environmental issues, the need for systems optimization and multiple feedstock alternatives. The lists offered by these concurrent session groups were actually longer then the three top concerns listed, and many times had the same issues ordered differently. These are summarized from the full reports of the groups that are provided in Appendix 4.

The take home message for the Air Force and the commercial airlines from this set of questions for the second concurrent groups are listed below. The key issues are:

- Water requirements for the locations selected for biofuel production for aviation,

- Recognize that feedstock alternatives do not have clear cut markets available for setting appropriate prices,
- Densification and handling of feedstock alternatives is important, and
- MSW as a feedstock already has many of the handling issues settled.

There are feedstock alternatives that can be pursued currently, and feedstock alternatives that will take additional planning, technologies and systems for full development. For both the former and latter, the value chain approach may be an effective approach for analysis, since it will lead to the inclusion of all of the critical elements in the planned system and as well give the price that is implied for the feedstock producers or growers.

Table 3. What are the Most Critical Issues/Concerns within the Region for Feedstock Availability?

Region	First Issue/Concern	Second Issue/Concern	Third Issue/Concern
West	Water for almost all sources of biomass	Multiple feedstock alternatives, blend of annuals and perennials, Technology hurdles	Transportation
South	Forest products and switch grass, lack of markets; contracts needed	Multiple feedstock; blend of annuals and perennials	Environmental impacts
North Central	Managing/consideration of residues	Upgrade/assure the infrastructure that exists, assess and build out where needed Competing Uses for feedstocks	System optimization/modeling Accelerate yields of a range of feedstocks
Northeast	Municipal solid waste, transportation infrastructure in place	Cultivated woody crops, need to develop markets	Animal or livestock waste, need to develop markets

Feedstock logistics concerns are provide in Table 4, which almost all relate to transport and handling. There was real concern among the participants about the amounts of feedstock that will require movement and handling for most of the bulkier feedstock alternatives. That is, for most of the feedstock alternatives used now, there are already markets set up for handling the grains and oilseeds involved. But for most of the other alternatives, there will have to be transport and handling systems set up to move the required amounts of feedstock. There are some alternative feedstocks possibilities that have these systems already set up for use in other ways. Again, MSW and the timber industry are examples.

The take home message for the Air Force and commercial industry from the feedstock logistics discussion is that in almost all cases there will have to be serious consideration of the logistics involved in getting the feedstock to the processing facilities. There was not much discussion of the movement of the drop in fuel from the processing facilities to the delivery points at the bases or airports. But this is a consideration as well. The observation made in Section 2 about the possibility of putting the drop in fuel into a pipeline or mixing stations remote from the airport or base should not be forgotten.

Table 4. What are the Most Critical Issues/Concerns within the Region for Feedstock Logistics?

Region	First Issue/Concern	Second Issue/Concern	Third Issue/Concern
West	Transportation/ distance /tonnage	Distributed processing centers	Existing infrastructure/ carefully investigated and assessed
South	Handling truck traffic—infrastructure; environmental impact	Energy densification for bio oil	Reducing costs in the system
North Central	Densification, processing, stabilization and storage of the biomass, satellite depots	System optimization/modeling	Upgrade/assure the infrastructure that exists (rail, transportation), assess and build out were needed. (there is some substantial exists, upgrades may be needed to handle volume)
Northeast	Utilize existing infrastructure for wood products	Utilize existing infrastructure for MSW	Approaches that reduce impacts on existing roads

The top three concerns of the groups relating to processing and conversion are listed in Table 5. These concerns mostly relate to the second generation biofuels. The issues involve existing capacities, technology hurdles, co-products and uses, and again, to the handling of feedstock. The concerns are in general, focused on feeedstock availability and processing that fits the feedstock and is efficient. The call is for systems that include the processing as a part of their development. Processing that is special to the feedstock and how it is delivered, and must be considered in an integrated system.

Table 5. What are the Most Critical Issues/Concerns in the Region for Processing or Conversion?

Region	First Issue/Concern	Second Issue/Concern	Third Issue/Concern
West	Technology hurdles	Lack of existing refining capacity	Distributed procession
South	Handling multiple feedstocks	Costs; capital investment and profitability	Environmental impacts
North Central	Quality issues (e.g., including contaminants and uniformity)	Conversion efficiency, waste streams, Management of co-products	Opportunities to co-products, co-production of feed and fuel products
Northeast	Forrest products industry has already invested in gasification	Need to make biofuel more profitable to producer than existing uses	Total profit and costs must be competitive

The take home messages for the Air Force and the commercial airlines from the processing group are three fold: look at second generation processing alternatives, design systems and business models that include processing in the basic calculations, and make sure that the participants along the way all have incentives to be a part of the integrated system.

The deployment concerns were handled differently for each of the four concurrent groups. Thus, to make their concerns logical in this presentation adjustments were made in the deployment reports to achieve similarity to the way the other scientific results were reported. The results of the concurrent groups are provided in Table 6. Reviewing the results from the concurrent groups, again within the top three concerns presented, a number of common areas of focus are apparent. First, there is a call for federal, state and local support for the first set of the deployment projects. The selection for a first biofuels for aviation production location is a development that can be of major importance to the local economies and should be supported by

government and private sector. Without such support, the development of deployment around airports and bases might be delayed until the next generation of biofuels technology is more accessible or available.

Risk management was another issue and relates to the government support of initial biofuels for aviation deployment possibilities. The government support could reduce or share the risk of first set of deployment developments. There was as well concern about the incentives for farmers or growers of the feedstock. Assurance of profitability will have to be in place for the farmers or growers to produce the feedstock alternatives in the amounts necessary to assure production levels of biofuels that are required to meet the Air Force and commercial airlines demands for fuel.

The take home messages from the deployment concurrent group discussions again are related to an integrated systems analysis of the deployment plans using a value chain framework. The issues or concerns involve risk sharing and some kind of government participation in the first deployment activities. There are as well concerns about the diversity of suppliers and the densification of production. These questions as well involve processing that is flexible and that may occur in stages that are adjusted more locally to the availability of the feedstock. Again, the call is for an integrated systems analysis using a value chain framework.

Table 6. What are the Most Critical Issues/Concerns in the Region for Deployment?

Region	First Issue/Concern	Second Issue/Concern	Third Issue/Concern
West	Competitive pricing relative to other markets	Diversity of suppliers and feedstock	Existing jet fuel infrastructure
South	High yield potential for crop in region	Low feedstock production and transportation costs for harvest/distribution	Risk management and proximity and compatibility with existing petroleum facilities
North Central	Additional federal programs, supportive state programs, local incentives for growers/producers—support of educational programs	High yield of crop in region (positive environmental impacts)	Airline buyer stability (consortium, collaboration to reduce risk
Northeast	Supportive state and local programs for growers/producers	High yield potential for crop in region	Does airport demand justify facilities cost

The final set of reported concerns on economics and policy is presented in Table 7. As with deployment, there are concerns about the level of risk and the attractiveness for private investment. The consensus is that private investment will not occur at the levels necessary to make biofuel available at the 50 percent objective without some kind of government intervention to minimize risk for producers, processors and distributors. One concern that deserves special comment is the need for an aviation "suite" of policies and regulations that is special and designed to get the investment necessary for meeting the biofuels target. This concern is well stated by the Northeast group, but reflected in many of the other regional concurrent group reports. There simply needs to be a suite of regulations and policies that addresses the risks at all of the steps in the process from growing the feedstock to delivery of the biofuel to the bases and airports.

The take home message from this set of recommendations is perhaps to have some trial deployments in different areas of the nation, and to learn from these activities what is necessary as a business model or models to make the deployment work at national and local levels. The discussions emphasized that the policy mix and the regulations necessary for getting to the Air Force and commercial airline goal is quite complicated and needs to be the focus of a concentrated effort by government at all levels, the Air Force and commercial airlines and the private sector to assure the investments at levels necessary to meet the biofuel goal of 50 percent.

Table 7. What are the Most Critical Issues/Concerns in the Region for Economics and Policy?

Region	First Issue/Concern	Second Issue/Concern	Third Issue/Concern
West	Risk throughout the supply chain	Regulation/permitting the known and unknown	Federal investment for research
South	Government assistance and financing in establishing commercial facilities	Climate policy; cap and trade	Policy stability
North Central	Contracting, long-term contracting, including aggregating third parties (very important for feedstock logistics)	Policy based on science and research based information (economic and life cycle analysis etc.)	Influences of oil prices and policies, oil markets (variable incentives associated with price of oil)
Northeast	Aviation needs the same *suite* of policies as autos to make bio jet financially viable	Look at bio mass scenario model developed by the DOE	Streamline permitting process

Questions from Air Force and commercial airlines

These questions were advanced to assist the scientists in understanding the concerns of the Air Force and commercial airlines about the prospects of biofuel for aviation. They are somewhat

more pragmatic than the questions of a scientific nature, but add to the set of concerns that will have to be worked out, if the Air Force and commercial airlines are to consume the amounts of jet fuel that are identified by the certification results. These questions are listed below with a few comments. The issues and concerns from these questions add to the discussion of the "factors" that must be fully understood for biofuels to become a major source of jet fuel for aviation.

What airports are most attractive for supply of biofuels and what attracts the agricultural community to these airports?

The airports and bases have different access to the petroleum based jet fuels due to factors related to their locations and pipeline connections, for example. Although we learned some of these factors at the Summit, they were not fully discussed. Additional understanding of this set of issues about differences in airport and base access to petroleum jet fuel is needed and will be useful in selecting the locations for the first deployments. The main reason from the production of biofuels viewpoint is the higher prices that may be available in these localities. Farmers are attracted by differences in incentives or output prices, and the length of the term of the guarantee of the incentives. These factors or issues for airports and bases that have special needs deserve to be investigated and specific contracts or partnership alternatives determined. And, these partnership alternatives will almost certainly involve government, the Air Force, the commercial airlines and the private sector investors in the system of supply.

What are the requirements for Jet A (and bio diesel) and how do they vary?

These requirements are defined in the certification process. There are as well another set of "requirements" that relate to the availability of biofuels from different feedstocks. Different feedstock alternatives have the capacity to produce different quantities of jet fuels, diesel and

other outputs as well as co products. These differences in yield of jet fuel and potentially valuable byproducts need to be clearly understood and the local markets for byproducts developed to make the conversion process efficient.

How important are pipeline connections to the supply of Jet A fuels?

Here we have made an addition to the potential value of pipelines. The observation is that the mixing stations for the pipelines are alternatives for the delivery of drop-in fuels. This adds to the possibilities for deployment sites and makes the problem of delivery to the bases and airports more manageable. In short, if the existing pipelines that can be used and the mixing stations are available, the current infrastructure is sufficient to deliver both the petroleum and agricultural feedstock based biofuels.

How can the Air Force and the commercial airlines work to stimulate production of biofuels in amounts needed?

Value chain analysis can give the answers to this question. The answer likely will involve some type of longer term contract and cooperation with government, the Air Force and commercial airlines and the private sector. Many of the feedstock alternatives do not have well defined current markets. These markets will have to be developed for the feedstock alternatives—which will take significant cooperation. The fact that the markets are not developed is as well a plus, since the factors that will move the price in these developing markets will not be the same as those moving the prices in the petroleum market,. This will add to the value of diversification alternatives for biofuel

Factors that should guide the selection of bases and airports which are the first to implement the biofuel standard?

From the military base, airport and commercial airline perspective, those bases and airports with the most limitations for jet fuel delivery should be selected, or at least considered in the decision about first deployment. But this ignores the feedstock availability considerations. The recommendation would be to look at the feedstock alternatives developed in the feedstock availability concurrent session (Tables 1 and 2), and select the areas that have these feedstocks available at the lowest cost. This will require a value chain analysis but seriously restricts the number of value chains and their differences for first deployment consideration. For example, the MSW value chain analysis has many common parts regardless of the area in the country for which it is to be applied. Thus, by restricting the feedstock alternatives to the ones recommended, analysis for different airports could be more easily developed.

Starting from the petroleum based jet fuel and moving to 50 percent biofuel, what are the margins that are needed to sustain each of the actors in the production chain?

This issue is again a value chain investigation and should be made at selected sites, improving on the framework for decision as experience is gained. Margins can be associated with the risk that the participants are asked to assume—the more the risk the higher the margins. Margins of 20-30 percent seem reasonable, if the unusual risk is taken out of the equation. For the private sector this would involve a pay back on the investment of 3-5 years.

At the producer end of the value chain, what are the returns per acre necessary to call forth the supplies needed?

The way to look at this problem is to assess the land prices in the location. This value is essentially equal to the payback above direct costs, capitalized to estimate the price of land. Along with an assumed interest rate, the price of land, an assumption about yield, and transportation cost (wherever the responsibility for cost of transport would rest), a price of the feedstock can be estimated that would induce the growers to produce at levels consistent with the demand for aviation biofuel. This is, in fact, a rather straight forward analysis and could be completed first to determine the order of magnitude that the feedstock price would have to command to induce farmers and growers to produce it.

What changes in farmer-oriented policies are necessary to generate these (sufficient to maintain the production levels necessary) returns?

Farmers are not all the same, thus the feedstock price discussed above would have to be somewhat higher than the price yielding the capitalized number that would give the price of land. This would make it possible for those farmers with higher yields to generate some benefits for their management expertise. This could be determined by an analysis of the competition that the feedstock production would generate for the commodities now produced (generating a higher price for the traditional commodities) and making the feedstock price a bit higher. Farmers as well like stability, thus the argument for long term contracts is relevant as well.

The brackets involve two sides of the biofuel issue—petroleum jet fuel price and the return per acre for producers?

This may require that the petroleum price be used as an argument in the price of biofuels for growers/farmers. The price equation will be rather complicated until the market for many of the

feedstock alternatives is consolidated. And, if the feedstock is bulky the market may be local. But, the final results in terms of price and contract length can be estimated using standard economic analysis

What could change this relationship—environmental regulation, limitations on foreign fuel, improvements in biofuel technology?

The big unknown is the evolution of second generation technology for processing, the celulosic processes. Environmental regulations may change but the system of feedstock suppliers could be ready for these changes and, in fact, help to formulate them, if the proper set sustainability calculations have been made using agreed upon metrics. The farmers or growers will be allies of the Air Force and commercial airlines in these debates and need to be equipped for the challenges. Foreign fuel supplies will be more limited and at higher prices after the recovery from the current recession. These projections should as well be included in the calculations.

What is the value to the Air Force and the commercial airlines of a diverse fuel supply?

There is great value in diversifying supply because the prices for the feedstocks are driven by different sets of factors than the price of jet fuel from petroleum—the price series for the two fuel sources are not coherent. This presents the Air Force and the commercial airlines with a real set of possibilities for price stabilization. How much value there is in the diverse supplies is a question that has an answer, through analysis of alternative price series—which could be done currently, and is recommended. However, even this is analysis is complicated by several factors including the role of current government interventions in agriculture, the fact that some biofuel feedstock alternatives do not have already functioning markets, and the conversion technologies that are presently in a process of continual change. The introduction of alternative biofuels for

aviation will certainly contribute to making combined petroleum and biofuel jet fuel price lower than it is currently?

How do the answers to these questions on factors change between 2012 and 2017?

These answers change for a number of reasons. The first is the evolving processing or conversion technology and the prospective implications of more efficient processing of cellulose. The tipping point will occur when material sciences, information technologies and genomics come together. When this happens, the second generation of biofuels production will come into commercial operation. Other possibilities relate to the diversity of supply and the benefits from this diversity in terms of improved stability of fuel prices. As well, developments in logistics and storage will likely improve the efficiency of this aspect of the production process. But these are not insurmountable aspects to the process of generating biofuels for aviation. They simply take careful and well grounded analysis, analytical work and decision processes.

5. Conclusions and Recommendations

This report has summarized the results of the Biofuels for Aviation Summit held September 1 and 2, 2009. We want to thank those who participated in the Summit and especially those who contributed to the program as speakers, moderators, panelists and discussion leaders. The full listing of the participants in provided in Appendix 6. In each of the sections there have been recommendations for needed research and analysis. These have been either explicitly started or suggested as take home recommendations.

These recommendations are far reaching and perhaps one of the most complete sets of recommendations on biofuels production and consumption put together at this point in time.

However, because of the complexity of the recommendations and, in fact, the enormity of problem at hand, it is suggested that moving forward will require senior level guidance from a strategic team with the capacity to oversee the implementation of the recommendations from the breakout groups. The overarching general conclusions and recommendations below are a subset of the more detailed remarks in the previous sections, and will require in-depth knowledge of agricultural production systems, careful oversight of the implementation process including agricultural policy and regulatory issues and coordination of all sectors of the production and processing industries for optimum success. These conclusions and recommendations are:

1. The carbon and greenhouse gas, sustainability and food/fuel issues for the Summit fall mostly to the feedstock availability breakout track. The others breakout session groups suggested implications for the three issues, but they were rather small compared to the feedstock availability implications.

Recommendation: Feedstock production is regional and cannot be separated from carbon and greenhouse gases, sustainability and food versus fuel issues. A logical approach is to conduct life cycle analysis of a set of agricultural products likely to come into production as feedstocks. How to get this done? It could be done on a consortia basis with the federal government, state and local governments, the Air Force, commercial airlines and the private sector participating. Alternatively, the Air Force and the commercial airlines could request that a study addressing these aspects of feedstock production be completed before consideration of a feedstock from a particular area for production of biofuel for aviation. The later would almost certainly bring into the discussion the state and local governments impacted. Perhaps something

in between these two extremes is the answer, but a competent life cycle analysis must be completed.

2. The feedstock availability breakout group summary of possible feedstock alternatives for use in different parts of the country held up throughout the Summit rather well—not much was said that would lead to change in this summary (Tables 1 and 2).

Recommendation: Focus on these 2012 feedstock alternatives first, and do a complete analysis of the life cycle for each. For 2017, keep the door open and have an Air Force and commercial airline annual review and update of the feedstock alternatives suggested--in preparation for conducting a life cycle analysis for the new candidates for feedstock

3. Logistics is a matter of efficiency in use of resources, and there is much to learn about logistics processes from other industries that have similar issues for feedstock.

Recommendation: Since feedstock logistics is directly connected to feedstock sources and composition, it is recommended that in depth studies be conducted on delivery systems to conversion facilities for both high density feedstock and low density feedstock alternatives. These studies should be conducted in an integrated manner, reflecting all of the aspects of the supply chain in which the feedstock is to be utilized. There are in present operation alternatives for low density feedstock handling in timber, forage, cotton and other crops that should be looked to for ideas and concepts

4. Processing and conversion should be considered in an integrated systems approach to evaluation, and designed not to use fossil fuels in their application. First define the feedstock

and then move to identify the most effective and low cost processing alternative. And, make sure that the demands for fossil fuel in the conversion process are clearly understood.

Recommendation: Research and demonstration projects need to be initiated that address minimizing fossil fuel use in processing biofuels, avoiding distillation and drying processes, converting carbon rich byproducts into marketable commodities, and employing sources of hydrogen to enhance yields and reduce CO_2. These are feedstock specific and the feedstocks first addressed should be those recommended in Tables 1 and 2. The results of this research should be seen as a part of an integrated process, and input for establishing metrics for conversion of different feedstocks.

5. Deployment is likely to involve partnerships among government, the Air Force and commercial airlines and the private sector investors. The scientific concurrent or breakout group discussing deployment thought that the implied timeline for developing biofuels for aviation was overly aggressive.

Recommendation: Organize a team of experts that can establish a reliable timeframe for achieving the Air Force and commercial industry objectives for diversity of jet fuel sources based on the use of biofuel. Use this team on a continuous basis.

6. Economics and policy considerations relate to methods to reduce and spread the risk. This is not unusual for a new agricultural industry and will involve all parties to obtain a satisfactory solution. There is much uncertainty in policy and economics (and regulation) involving the actual deployment of this new industry. As well, there are technological uncertainties that are critical to successful deployment. Some of the latter involve cellulose

technologies, life cycle analysis for different feedstock alternatives, and different logistics systems that are efficient and do not cause problems in the rural communities.

Recommendation: Establish a guidance committee that can address and communicate these issues from a rational perspective based on science rather than reaction to public opinion. This will be critical, if the biofuel for aviation initiative is to attract the necessary capital from the private sector to succeed. And, in anticipation of conclusion number seven, move to better establish the risks and measures to reduce or transfer risks by organizing a set of deployment pilot or demonstration projects.

7. The summaries for the second set of concurrent groups presented recommendations and discussions of their three most critical regional issues. These issues related to extensions of scientific concerns from the first set of concurrent or breakout groups, and to specific questions of the Air Force and commercial airlines about value chains and their applicability for finding the right sources and locations for the biofuels for aviation industry,

Recommendation: Develop a guidance group or committee to review the possibilities for aviation biofuel production from different feedstock alternatives in different areas of the nation. Make (perhaps 5) selections and proceed with the development of several pilot establishments. Involve federal and local governments and the private sector in these selections. In the process of developing the pilots use a value chain approach and focus as well on the development of business models that can be generalized to other feedstock and location alternatives.

8. There are a number of analytical studies that could be completed by the Air Force and commercial airlines to narrow the necessity of guess work for deployment of aviation biofuels.

Many of these involve prices and coherence among prices, inventories as a hedging strategy and questions of prices and profits that would be necessary to elicit feedstock production for biofuel in the amounts required to meet the Air Force objectives.

Recommendation: Initiate studies of the price/profit/inventory relationships currently used and apply the results to support both deployment actions and to propose adjustments in current procurement practices. Some of the results may suggest changes in regulations for purchase of biofuels by the Air Force and other military entities. These studies could be completed currently, provide beneficial recommendations for actions or changes under the current procurement strategies, and move the deployment decisions and activities along faster.

9. There were calls throughout the Summit for an integrated systems analysis of biofuels for aviation production opportunities at desired locations. Much could be learned from the first few of these types of value chain analyses.

Recommendation: Initiate the first set of the value chain studies on the basis of recommendations of potential feedstocks from this Summit. Share the results of these first attempts, and move the process of value chain analysis forward to encompass unanticipated aspects of its customization for applications to biofuels for aviation.

10. The Air Force and the commercial airlines need a special suite of policies and regulations particular to their issues about the introduction of biofuel for aviation and problems of feedstock selection, logistics, processing, location of new plants, price instability and national security.

Recommendation: Develop an expert group to identify the suite of polices and regulations and communicate them to the appropriate authorities. This will be an ongoing process, but it should be initiated. Many times these recommendations will need to be communicated as a set of policies and regulations not just on a single measure basis. This interaction of policies and regulations is a reason to develop a fairly complete set of ideas for the suite before initiating actions to change specific policies and regulations.