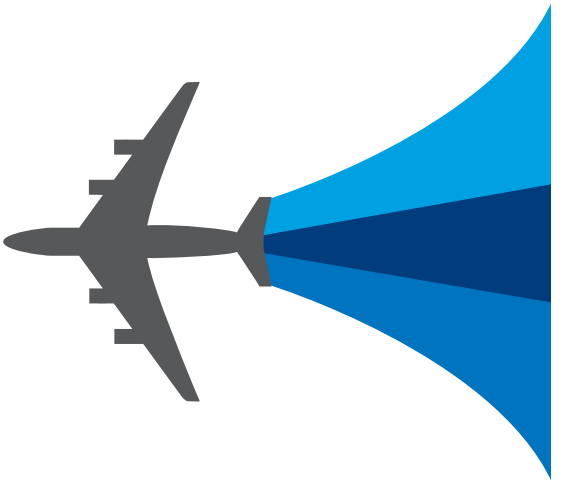

PART III

TECHNOLOGY DEVELOPMENT STRATEGY

14 CONCLUSIONS

Augusto Barbosa Cortez [et al.]. "Conclusions", p.219-226. In: Luís Augusto Barbosa Cortez (Editor). **Roadmap for sustainable aviation biofuels for Brazil — A Flightpath to Aviation Biofuels in Brazil**, São Paulo: Editora Edgard Blücher, 2014.
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14 CONCLUSIONS

The Sustainable Aviation Biofuels for Brazil Project proposed and implemented an enriching experience involving important stakeholders from different sectors of Brazilian society: government sector, agriculture, aviation industry, regulatory agencies, NGOs, universities and research institutions. The Project proved to be an endogenous creative output, a Brazilian contribution to a sustainable aviation industry.

The following conclusions and correspondent actions were drawn from the several activities of the Sustainable Aviation Biofuels for Brazil Project.

Why Brazil?

Past Brazilian experience on feedstock for modern and sustainable production of biofuels has shown the fundamental importance of large scale for economic competitiveness with fossil fuels. Brazil has accumulated technical experience in agriculture and industry, institutional capacity, and great popular acceptance. This makes it an excellent environment to begin the new jet biofuel industry worldwide.

After the Brazilian ethanol program was created in 1975, it did not only help this country to alleviate its fossil-fuel dependence but also helped to modernize Brazilian agriculture. Since 1975 Brazil has become a net exporter of agricultural goods, including grains, meat and other products. Brazil is one of the world´s best examples of the potential for reconciling sustainable biofuel production with food security.

The current production of bioenergy in Brazil is much larger, in energy terms, than total jet fuel consumption in the country, a fact that will compel jet biofuel to conform to feedstock prices already established in the market.

Brazil only utilizes 8% of its land for agriculture (60 million ha out of 850 million ha total), much below industrialized nations such as USA's 15%, and the 30-40%.in most European countries. The report concludes that the country has abundant available land for bioenergy through increasing productivity on existing agricultural lands, which could be an example for the world, if land use is optimized in this way.

Aviation Industry Goals

The Brazilian aviation industry, including EMBRAER, Brazilian main airlines, Petrobras Aviation and all involved regulatory agencies and related institutions, has demonstrated deep commitment to the introduction of jet biofuels in aviation in Brazil.

Air transportation is indispensable in modern life, so a stable and safe supply of jet biofuel at competitive cost is crucial for the aviation industry to grow in an environmentally sustainable manner, meeting industry goals for carbon emissions reduction.

Aviation biofuel processing will possibly have to be integrated at least with liquid biofuels for road, rail and water transportation, if it is to be competitive in economic terms with fossil

fuels. Scale and chain optimization are crucial for the fuel business and the cost of drop-in jet biofuel is higher than that of road biofuels.

Although expensive, the ASTM certification procedure and the associated drop-in concept reduce barriers to introduce aviation jet biofuels and should be taken into account strictly.

Which Feedstocks to Use in Brazil?

There is no single, perfect feedstock to produce a jet biofuel in Brazil. The stakeholders agree that work should continue on a variety of feedstocks to ensure the greatest likelihood of adequate availability and getting to scale.

A diversity of feedstocks is available for different growing conditions. Eucalyptus can use land with high slopes. Sugarcane grows in the tropical and subtropical zones while different crops are suitable to different latitudes such as palm in south Pará State; starch and oil crops can be grown in most of Brazil, and these includes non-food crops such as camelina and jatropha, and other feedstocks with promising futures, if more R&D is implemented.

Brazil's past experience with biofuels also shows that crops which can supply feedstock for diverse applications, for instance food, fuel, pulp, have a larger chance of success.

Just to demonstrate how important agriculture productivity is, sugarcane bioethanol uses only 0.5% of Brazilian territory and represents around 35% of all fuels used for light vehicles in Brazil, besides bioelectricity production. Sugarcane total contribution to primary energy used in Brazil is almost half that of the petroleum. Using ethanol or sugar from sugarcane to produce jet biofuel, less than 0.3% of Brazilian territory would be enough to substitute all jet fuel currently used in Brazil.

Considering the 2020 horizon, the most productive sources of bioenergy from the standpoints of crop yield and energy balance are sugarcane and forestry. These would be the option of choice for aviation biofuels if this was the final criteria. But the problem is much more complex, and the optimization of the country´s ample land resource may contemplate other crops as well.

Therefore the following methodology is proposed to evaluate feedstock substitution:

For each promising feedstock (for diverse applications or only for biofuel), and applicable refining process, the best identified site for producing enough feedstock to substitute should be chosen, let us say, 2% of jet fuel consumption, and, for that special situation, the effects of producing feedstock for biofuel on the local agriculture and its sustainability for the next generations should be analyzed. The following issues should be fulfilled for the substitution to be valid:

a. Evaluate the present economic benefits of the specific site and compare them to the benefits that would be obtained if the new feedstock (even if only for energy) was to be grown there. Consider the prices for one or two decades ahead bearing in mind the maximum feedstock price compatible with an energy price of biofuel equal to the price of conventional fuel. Neglect eventual land valorization and food price increases resultant directly from the implementation should not be considered as benefit. The results should be favorable to feedstock for biofuel production;

b. Evaluate the social and environmental impacts in the region, including small properties and family agriculture, and compare the sustainability indicators with

the ones for the present occupation. The results should be favorable to feedstock for biofuel production.

Which are the Identified Pathways?

Considering pathway as a combination between a given feedstock and a refining technology, 13 pathways were identified in the *Sustainable Aviation Biofuels for Brazil Project*.

Of course, there are many combinations of feedstock and process likely to be feasible alternatives for aviation biofuel production in the medium-long term.

Given that not a single solution could be selected, the *Sustainable Aviation Biofuels for Brazil Project* has recommended the most promising and sustainable alternatives for implementing more R&D efforts.

Promising short-term possibilities include the use of sugarcane sucrose and ethanol, since they can benefit from low sugarcane production costs and good sustainability indicators in Brazil. However, in the medium to long term, it appears that fiber cellulosic feedstocks such as wood-derived products and sugarcane trash and bagasse will have better competitive possibilities due to their high sustainability values. Several other feedstocks may have medium and longer term potential for cost effective production.

What are the Impacts? What about Sustainability Issues?

The basic reasons for the increasing global interest in aviation biofuels are: to reduce volatile fossil energy costs, to improve energy security and to mitigate GHG emissions.

The most critical jet biofuel features are the potential to mitigate GHG emissions and to be produced at competitive costs. Alternatives that supply low costs and high emissions or low emissions and high costs are not, strictly speaking, considered sustainable solutions, even though some positive externalities could justify their acceptance.

Another important finding of the *Sustainable Aviation Biofuels for Brazil Project* was the difficulty to access reliable data on Life Cycle Analysis (LCA) and production costs for the different analyzed pathways under Brazilian conditions. Further R&D is considered essential to overcome the identified gaps, see **Table 37** below.

In the Brazilian context of abundant opportunities to increase the productivity of existing agricultural lands, biofuel production can be accelerated without endangering food security, if the relevant policies are implemented, as we have validated in the Sustainability Indicators section above.

The real issue is how to improve the sustainability of agriculture in general, which requires economic resources to promote the farmer's necessary cultural change. This aspect can be somewhat improved when agriculture is upgraded by economic resources transferred from urban areas, for instance to pay for feedstock for biofuels.

As presented in the sustainability workshop, the social and environmental issues should not be treated statically. Similarly to the necessary learning curve for the production cost, environmental and social performance should be improved over the long run to build-up a sustainable biofuel industry.

Because aviation is largely an international business, it is very important to utilize sustainability criteria that are agreed upon internationally, such as those of the Roundtable on Sustainable Biomaterials and Bonsucro.

To fill social and environmental gaps Brazilian institutions must identify practical ways to use the opportunity of growing energy feedstocks to push sustainability culture into the whole of Brazilian agriculture. Also, it is recognized that research initiatives are fundamental to improve performance to sustainability indicators by developing appropriate technologies, both to lower feedstock production costs and reduce unwanted impacts.

Which R&D Efforts are Necessary?

R&D is an essential element to render a possible and sustainable given pathway. Brazil has dedicated substantial R&D efforts that allowed sugarcane and eucalyptus to be competitive crops for biofuels. Therefore much more is needed for other crops and pathways.

Among the production pathways, the Hydro-processed Esters and Fatty Acids (HEFA) and Synthetic Paraffinic Kerosene by Fischer-Tropsch (SPK FT) processes are already in place. Alternatives based on sugar/lignocellulosic feedstock, as Alcohols to Jet Fuel (ATJ) and some advanced biobased processes (Synthetic Kerosene from Metabolic Process), all still in pilot phase, also present good potential. A properly designed R&D program in aviation biofuel is necessary to screen the several pathways for feedstock and processes, which should be evaluated mainly for prospective economic competitiveness, LCA and other environmental and social impacts.

Technological gaps and actions – improve agricultural productivity of identified feedstocks and research to find new ones; improve energy efficiency of processing technologies and develop new processes; study the best location and incentivize the construction of demonstration and first commercial plants for the main identified routes for jet biofuel production; extend the installed competence for testing and certification of jet biofuel throughout the country.

Which Infrastructure Actions are needed in Brazil to Allow an Adequate Logistics of Feedstocks and Biofuels?

Brazil has important bottlenecks in logistics and needs, both for feedstock and biofuel transportation, to overcome the barriers and help making a competitive biofuel. Although they require attention, blending logistics and specs regulation issues seem to be properly outlined by ANP´s Resolution Nr. 20/2013 and, due to the "drop-in" concept, do not represent insurmountable obstacles to aviation biofuels. However, explicit investments will be necessary in storage and blending facilities.

Jet fuel consumption is specially concentrated in the country's southeast, but in general in cities not far from the seashore. On the other hand, there is abundant agricultural inexpensive land available in the interior of the country, far from the consumption centers (distances larger than 1000-2000 km). Therefore, improvement of feedstock and jet biofuel logistics is a significant need for economic competitiveness of the various pathways for production of jet biofuel. On the other hand, the diversity of available feedstock and specific consumption sites in different regions of the country can impel the materialization of niche solutions taking

advantage of long distance and high logistics cost, depending on installed competence for testing and certification of aviation fuels.

Economical gaps and actions – develop logistic studies for investment on railways and waterways taking into account feedstocks for biofuels in general and jet fuel specifically; make sure that the cost advantage of Brazilian agriculture products in international markets be reflected in aviation biofuels production. similarly to other biofuels; take actions to ensure that the cost difference of aviation biofuel to conventional fuel in Brazil be smaller than in other countries, in a way that the possible exportation of jet biofuel through international flights can lift the competitiveness of the aviation biofuels industry established in the country.

Is Brazil ready to build the new biofuels for aviation industry?

After decades of regular use of ethanol and mandatory biodiesel blends since 2005, with the active participation of government, Brazil offers a real experience on how to introduce a biofuel in the market. However, despite the previous experiences with production and use of biofuels in Brazil, there are important and relevant institutional issues when the construction of the new biofuels for aviation industry is considered.

Under this scenario, the Sustainable Aviation Biofuels for Brazil Project has identified the main institutional issues relevant to aviation biofuels development in the Brazilian context:

a. the development of the aviation biofuel production in Brazil, associated or not with the current biofuel industry, is able to open a new and innovative chain of sustainable bioenergy, with a growing global demand. Thus, it should be considered strategic and evaluated not only from the immediate point of view, but taking into account its potential to foster economic, environmental and social benefits;

b. institutional conditions are decisive for promoting aviation biofuels, especially with regards to incentives and financing mechanisms, imposing well designed and coordinated public policies. Government actions in this direction are observed in Brazil, but more is needed, especially in terms of energy policy, to define the role expected for this renewable fuel in the future and for this new industry;

c. aligned with the principles of “drop-in” and adopting a worldwide specification, implemented with regular balloting with stakeholders, ANP is providing solid backing to aviation biofuel development and implementation in Brazil, in cooperation with the civil aviation agencies, ANAC and SAC;

d. it seems relatively premature to recommend targets for mandatory blending of aviation biofuels in Brazil, but studies in this direction are advisable and should be done in order to assess the alternatives, evaluating their implications, costs and benefits;

e. there are several financing mechanisms that can be directed to promoting aviation biofuels R&D activities and demonstration projects;

f. biofuels production and use involve necessarily several ministries and interests (Agriculture, Energy, Environment, Science and Technology, Defense, etc.) and aviation biofuels of course include another group of agencies and issues. Thus, all stakeholders and decision makers should be included in the discussion and evaluation of alternatives and aims. Since R&D are the prevalent activities at this point, it is recommended that, at least in the pathways screening stage, the leading role must be kept by science and technology agencies at federal and state levels, in

an active collaboration with all stakeholders to set practical parameters and identify needs that drive R&D towards effective implementation.

What are the Main Policies and Actions Required to Implement the New Jet Biofuels Industry in Brazil?

Public policies are essential to develop agro-industrial technology for aviation biofuels, as well as to implement financial and regulatory measures able to support aviation biofuels production and use. In this context, how to share the costs and benefits of aviation biofuel adoption should be analyzed and discussed.

Presenting simultaneously favorable conditions to foster biofuels production, a large experience with automotive biofuels and an active aviation industry, Brazil is exceptionally well posed to put forward a program of aviation biofuels, with clear targets, clear supporting mechanisms and participation of all stakeholders. It is important to recommend policies to support the deployment of new technologies pathways from, for example, start-up companies. Nowadays, Brazil lacks such policies in this area.

Long-term biofuels policies, which integrate fuels for all motorized transportation modes and recognize the particular need of aviation for sustainable fuel alternatives, will have to be established to make aviation biofuel economically viable due to the extra cost of producing a "drop-in" fuel.

Institutional gaps and actions

a. improve the Brazilian set of regulations relative to aviation fuels to explicitly recognize the role of biofuel producers in the country;
b. establish the "drop-in" sites as far as possible downstream in the distribution chain without compromising fuel quality and certification requirements of aviation sector;
c. observe closely and anticipate regulatory actions by ICAO in such a way to take advantage of international regulations to promote a jet biofuel industry in Brazil;
d. establish a governmental long-term program for integrated use of biofuels in all transportation modes in the country, to neutralize the cost difference of producing a "drop-in" fuel versus a product for biofuel-adapted engines as is the case for road transportation.

Table 37 presents a tentative list of limiting factors and policy recommendations for Aviation Biofuels development, to answer those questions taking into account the particular Brazilian context. This table is a preliminary summary, since a deeper reflection and discussion on these perspectives, involving stakeholders, will address these needs in a more complete way. However, other relevant and more specific recommendations have been addressed and detailed in all *Sustainable Aviation Biofuels for Brazil Project* workshops.

In conclusion, the substitution of fossil fuels for aviation represents a very import niche for sustainable biofuels and Brazil has a great opportunity in this area to become a global player. There are important challenges to be overcome to create the basis for this new emerging industry and Brazil cannot afford not to participate.

Table 37 Limiting factors and policy recommendations for Aviation Biofuels development.

Issue	LIMITING FACTORS			POLICY RECOMMENDATIONS		
	CURRENT	FUTURE	RELEVANCE/ PRIORITY	IMMEDIATE/SHORT TERM	MEDIUM TERM (2020)	LONG TERM (2050)
Feedstock	• Limited information about species with potential for bioenergy • Limited information on land zoning for bioenergy • High costs for producers to comply with environmental and social regulations	• Risk of constraints in natural resources supply (water, chemicals, etc.) for efficient biomass production • Risks of expanding biofuels production with high impacts on land use change	Medium/ High	• Promote the development of human resources • Promote LCA studies on crops with bioenergy potential • Evaluate gaps and mechanisms to allow producers to become regularized	• Promote advanced agronomic studies on bioenergy crops • Develop assessment on residues availability and collection • Promote above trend yields increase	• Promote studies on innovative sources of biomass for bioenergy
Refining	• Lack of information about process feasibility, high technology risk.	• Technology risk associated to development of innovative process	High	• Promote the development of human resources; • Support (financing) for pilot and demonstration	• Support (financing/ regulatory) aviation biofuel demonstration programs and commercial use.	
Logistics	• Infrastructure constraints		High	• Evaluate needs of regions with potential for biofuel production.	• Promote logistics improvements; • Assess new productive schemes, reducing transport of bulky biomass.	
Sustain-ability	• Need for successful enforcement of social and environment laws.	• Protect workers, and avoid potential loss of Brazil´s major natural resources.	High	• Establish legal mechanisms to ensure that incentives for aviation biofuels are only available where national laws and regulations, especially natural forest and other habitat protections, land use zoning and worker protections, are demonstrated to be fully implemented.		

Table 37 Limiting factors and policy recommendations for Aviation Biofuels development (continued).

Issue	LIMITING FACTORS			POLICY RECOMMENDATIONS		
	CURRENT	FUTURE	RELEVANCE/ PRIORITY	IMMEDIATE/SHORT TERM	MEDIUM TERM (2020)	LONG TERM (2050)
Sustainability	• Need for monitoring of performance of aviation biofuels to international social and environment standards.	• Prevent difficulties to Brazil's aviation biofuels production and trade.	High	• Consolidate the sustainability certification process.		
				• Research and incentives only for feedstocks systems which increase overall productivity of energy and food/feed/fiber on same land.		
General	• Lack of co-ordination among governmental agencies and stakeholder in fostering aviation biofuels; • Lack of information about aviation biofuels among decision makers and public.	• Heterogeneity and lack of clarity in the sustainability evaluation of biofuels.	High	• Launch an aviation biofuel program, with a clear agenda of strategic actions; • Promote information campaign on potential, benefits and implications	• Assess and issue regularly indicators of the aviation biofuels program; • Consolidate the sustainability certification process.	