ICAO REVIEW:

SUSTAINABLE ALTERNATIVE FUELS FOR AVIATION

ACT GLOBAL

ICAO: UNITING AVIATION ON CLIMATE CHANGE

Produced by the **Environment Branch**
of the **International Civil Aviation Organization (ICAO)**

INTRODUCTION BY JANE HUPE

CHIEF, ENVIRONMENTAL BRANCH

*The **International Civil Aviation Organization (ICAO)** develops a range of standards, policies and guidance material for the application of integrated measures to address aircraft noise and engine emissions.To enlarge its knowledge base and bring new facets to its work in minimizing the environmental impact of aviation, ICAO regularly organizes workshops to seek further advice on new and emerging issues such as the impact of alternative aviation fuels on the sustainability of future industry growth and their potential to reduce greenhouse gas emissions.*

*At the conclusion of the **ICAO Aviation and Sustainable Alternative Fuels Workshop** held from 18 to 20 October 2011, one thing that was clear is that we are no longer talking about the technical possibility of aviation using drop-in sustainable alternative fuels in the future. We are now talking about how it will happen. Given the rapid pace of developments, including commercial flights operating with biofuels in 2011, it is timely that we share the knowledge, good practices and concrete examples of what we are doing and learning.*

The purpose of this report is to take stock of the information and knowledge gained to date and shared during the workshop that helps us assist each other, identify the challenges ahead, and explain how we intend to reach our global goals. Moreover, disseminating our progress to the widest possible audience encourages a wider debate among policy-makers and other stakeholders, and informs the public of how ICAO is addressing its environmental responsibilities.

As the pace of change quickens, it is important to take stock of the developments made up to October 2011 and register the achievements in all areas concerned, such as:

- *Research and development*
- *Qualification and certification*
- *Deployment*
- *International cooperation*
- *Legal and regulatory framework*
- *Sustainability criteria*
- *Accounting*
- *Financing*

It is also necessary to identify the next set of challenges, which will surely include the scalability and cost of sustainable alternative fuels for aviation and sustainability criteria. This workshop gave us the opportunity to hear the views from member States and international organizations. Increasing support and political will are crucial if we are to successfully navigate the remaining hurdles and challenges. ICAO is particularly interested in identifying the expectations of stakeholders so that it may determine how the Organization can continue to support and facilitate international efforts and maintain momentum in this field.

Since the conference on aviation and alternative fuels in 2009, ICAO has been facilitating, on a global basis, the promotion and harmonization of initiatives that encourage and support the development and deployment of sustainable alternative fuels for aviation.

Sustainable alternative fuels will be a key element of the basket of measures available for inclusion in State action plans, to move international aviation collectively closer to a sustainable future.

*This publication has been compiled by the **ICAO Environment Branch** based on the proceedings of the workshop and we hope you find it helpful.*

*We invite you to review the presentations and supporting documentation from the workshop which are available at the web portal: **www.icao.int/SUSTAF***

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SUSTAINABLE ALTERNATIVE FUELS FOR AVIATION

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ADDRESS BY MR. RAYMOND BENJAMIN

SECRETARY GENERAL OF ICAO

ICAO Aviation and Sustainable Alternative Fuels Workshop

Montréal, Canada, 18 October 2011

Good morning Ladies and Gentlemen

*I would like to welcome you all to **ICAO** and to begin by telling you a story this morning.*

*Two years ago, **ICAO** organized its first-ever **Aviation and Alternative Fuels Workshop**, followed by a world conference in Rio de Janeiro. Some of you were there. We wanted those meetings to be a global wake-up call for the aviation sector about the potential of alternative fuels in addressing our common challenge on climate change.*

At that time, we raised a few eyebrows and provoked some pretty intense debates. But as we look back, the progress achieved was much greater than we could have ever envisaged… Just think…

There are five major consortia established and working on alternative fuels for aviation.

Commercial flights using alternative fuels are no longer just a concept. Almost 30 test flights have successfully taken place and, this year, some commercial scheduled flights using these fuels are in full operation. It means we are already flying with alternative fuels!!

*Since late 2009, **ICAO** has identified over 300 initiatives on alternative fuel production and deployment. This is a powerful testament to their feasibility. It is an even greater indication of the progress that can be made by a single sector when there is the willingness to take advantage of a valuable opportunity for collective action towards a common goal.*

*Nevertheless, there is still a long way to go, given the industry's fuel requirements, let alone what will be needed to stabilize international aviation's CO_2 emissions, in line with the goals agreed by **ICAO**'s last Assembly.*

*With this in mind, I am delighted to welcome you to the second **ICAO Aviation and Sustainable Alternative Fuels Workshop**, which is also the first of a series of **ICAO** activities leading up to next year's United Nations Conference on Sustainable Development – the **Rio+20***

As we move ahead this week, I suggest we embrace a more holistic view of sustainability.

Aviation delivers enormous economic, social and cultural benefits to our global society. Accordingly, our discussions must consider the interdependency between environmental conservation, economic growth and development and social well-being. That is why we need a broader definition of "environmentally sustainable". In this sense, the widespread use of sustainable alternative fuels for aviation has the potential to move aviation closer to sustainability as a sector in all three of these dimensions.

*I am pleased to say that **ICAO** has put everything in place to provide a stimulating context for discussions.*

First of all, we made sure that we invited all of the key stakeholders that were paramount for the successful global implementation of sustainable alternative fuels for aviation. This means research professionals, growers, fuel producers, fuel distributors, airports, aircraft manufacturers, airlines, financial institutions and regulators. I am very happy that all of you answered our call.

ICAO Aviation and Sustainable Alternative Fuels Workshop *(Continued)*

BY MR. RAYMOND BENJAMIN

Second, considering the vital need to exchange information, we have included extended networking time to help foster cooperation and establish new connections. For many of you in the room this event marks a unique opportunity to meet face-to-face directly with stakeholders, such as fuel producers and financial institutions.

And to stimulate conversations and exchanges during the networking opportunities, you will hear about the vision for sustainable alternative fuels from States, international organizations, and consortia operating in all corners of the globe.

You will also be informed on the current state of research and the qualification of new processes for making jet fuel - what it takes to deploy an alternative aviation fuel, including legal and financial considerations.

You will hear many perspectives and real-life experiences from around the world. We hope you will find that some of these are relevant to your situation and can inspire you in designing your own strategies.

Our ultimate objective is a sustainable future for international aviation, a future in which alternative fuels are a key component.

*At the **Rio+20** meeting in Brazil next June, the international community will be asked to reassert its commitment to the goal of sustainable development. To achieve this goal, clear objectives will need to be established and a strong framework to address new energy challenges must be developed. The availability of renewable energies will be critical in meeting the sustainable development objectives of not only international aviation, but other sectors as well.*

And now, it is my privilege to introduce our guest speaker,

***Mr. Sha Zukang**, UN Under-Secretary General for Economic and Social Affairs, and the Secretary General of the United Nations Conference on Sustainable Development. In that capacity, he is responsible for guiding and coordinating international efforts to generate the necessary political will of the global community towards a successful outcome in Rio next year.*

***Mr. Zukang** is more than familiar with the challenge that "sustainable" development poses to our society and the level of cooperation and coordination that will be required among all of the stakeholders concerned.*

*In particular, **Mr. Zukang** has looked to his partners and colleagues in the UN system to lead the international community towards **Rio+20**. As he says, and I quote: "Countries will look to the UN system… for guidance on the kinds of policies they can adopt to move along a green development path…The ultimate goal for the UN system should be the ability to present a concrete menu of policy options that assists all countries… The UN system has to lead by example."*

UNITED NATIONS NATIONS UNIES

MESSAGE BY MR. SHA ZUKANG

UNDER-SECRETARY-GENERAL FOR ECONOMIC AND SOCIAL AFFAIRS
SECRETARY-GENERAL FOR THE UN CONFERENCE ON SUSTAINABLE DEVELOPMENT

ICAO Aviation and Sustainable Alternative Fuels Workshop

Montréal, Canada, 18 October 2011

Ladies and Gentlemen,

It is my pleasure to address this distinguished group of experts.

You have gathered to discuss a very important topic on the Sustainable Development agenda: ***Aviation and Sustainable Alternative Fuels****.*

I would like to thank the ***International Civil Aviation Organization (ICAO)*** *for the kind invitation to address you.*

Transport is a major sector of economic growth.

The development of an effective and efficient transport system is essential to secure sustainable development.

Over the past three decades air travel has grown faster than any other mode of transportation.

In addition to business travel, domestic and international tourism have also grown dramatically. Many trips now involve air travel.

I am sure that achieving a balance between accelerating future growth and limiting environmental impacts is a major priority for the world aviation industry.

I also know you are focused on transforming barriers into opportunities.

This is particularly relevant with respect to the challenge of climate change.

There have already been some impressive achievements in this regard:

- ***a 40 per cent reduction in engine fuel consumption;***
- ***a 70 per cent reduction in aircraft fuel burn per seat; and***
- ***declining trends in operational fuel consumption rates.***

The International Civil Aviation Organization *is playing an important role in these efforts. You are actively promoting the reduction of aviation environmental impacts through appropriate operational measures standards and market-based options.*

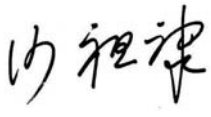
The ***UN Conference on Sustainable Development****, or* ***Rio+20****, will be held in June 2012. A green economy in the context of sustainable development and poverty eradication is one of the two themes* ***Rio+20*** *will focus on. Your work will be a significant contribution to the discussions on green economy.*

I hope you will report the outcome of this workshop and inform the intergovernmental process of your findings, valuable efforts and forward-looking activities.

Your active participation in ***Rio+20*** *would be greatly appreciated.*

I wish you all great success in this important workshop.

Thank you very much*.*



WORKSHOP SPEAKERS

The contents of this review are based on the presentations delivered during the **ICAO Aviation and Sustainable Alternative Fuels Workshop** (18 to 20 October 2011, Montréal, Canada) and the ensuing discussions.

Special thanks should be given to all the panellists and moderators who contributed to the successful outcome of this event:

INTRODUCTORY MESSAGES

Mr. Raymond Benjamin, Secretary General, ICAO
Mr. Sha Zukang, UN Under-Secretary-General for Economic and Social Affairs and Secretary-General for the United Nations Conference on Sustainable Development

Chapter 1 SETTING THE SCENE

Ms. Jane Hupe, Chief, Environment Branch, ICAO
Mr. Ted Thrasher, Environment Officer, ICAO

Chapter 2 A VISION FOR THE SUSTAINABILITY OF ALTERNATIVE FUELS FOR AVIATION: STATES

Ms. Jane Hupe, Chief, Environment Branch, ICAO
Ambassador Jorge Taunay, Representative of Brazil on the Council of ICAO
Mr. Zheng Xingwu, Professor, Institute of International Economics, Civil Aviation University of China
Mr. Gilberto Lopez Meyer, Director General, Airports and Auxiliary Services, Mexico
Ms. Maryam Al Balooshi, Manager, Environment Studies, General Civil Aviation Authority, United Arab Emirates
Dr. Lourdes Maurice, Executive Director, Office of Environment and Energy, Federal Aviation Administration, United States
Mr. Peter Bombay, Representative of the European Union to ICAO

A VISION FOR THE SUSTAINABILITY OF ALTERNATIVE FUELS FOR AVIATION: ORGANIZATIONS

Ms. Jane Hupe, Chief, Environment Branch, ICAO
Mr. Jeff Gazzard, Aviation Environment Federation
Mr. Paul Steele, Executive Director, Air Transport Action Group
Mr. Michael Hurd, Director, Environment Strategy, Boeing
Mr. Matthew Rudolf, Regional Manager, Americas, Roundtable on Sustainable Biofuels

Chapter 3 CONSORTIA

Mr. Sandy Webb, Managing Director, Environmental Consulting Group, Inc.
Mr. Guilherme Freire, Director, Environmental Strategies, EMBRAER, and Executive Director, ABRABA
Mr. Alexander Zschocke, Aviation Initiative for Renewable Energy in Germany
Dr. Nicolas Jeuland, Head of Department, Fuels and Lubricants, IFP New Energies
Mr. Richard Altman, Executive Director, Commercial Aviation Alternative Fuels Initiative
Ms. Linden Coppell, Head, Environmental Affairs, Etihad Airways, for the Masdar Institute Sustainable Bioenergy Research Consortium
Mr. Philippe Novelli, Coordinator, SWAFEA European Study

Chapter 4 RESEARCH

Mr. Jim Rekoske, Vice President and General Manager, Renewable Energy and Chemicals Business Unit, Honeywell UOP
Dr. Christiane Bruynooghe, Directorate-General for Research and Innovation, European Commission
Dr. Jennifer Holmgren, CEO, Lanzatech
Dr. Delia Dimitriu, Manchester-Metropolitan University
Mr. Frederic Eychenne, Programme Manager, New Energies Airbus
Mr. Andy Kershaw, Manager, Environmental Policy, British Airways
Mr. Dirk Kronemeijer, Managing Director, SkyNRG
Dr. Andreas Sizmann, Head, Future Technologies and Ecology of Aviation, Bauhaus-Luftfahrt
Dr. Fayette Collier, Project Manager, Environmentally Responsible Aviation (ERA), NASA

Chapter 5 QUALIFICATION

Mr. Ted Thrasher, Environment Officer, ICAO
Mr. Mark Rumizen, Aviation Fuels Specialist, ASTM/ Commercial Aviation Alternative Fuels Initiative
Mr. Kevin Weiss, CEO, Byogy Renewables Inc.

Chapter 6 DEPLOYMENT

Mr. Philippe Novelli, Coordinator, SWAFEA European Study
Mr. Thilo Zelt, Business Development Agent, Platform for Sustainable Aviation Fuels, Leuphana University
Mr. Cesar Velarde, Observatory of Sustainability in Aviation, SENASA
Mr. John Plaza, President and CEO, Imperium Renewables
Mr. John Lo, General Manager, Operations and Technical, Shell Aviation
Mr. Jim Rekoske, Vice President and General Manager, Renewable Energy and Chemicals Business Unit, Honeywell UOP
Mr. Xavier Oh, Senior Manager, Environment and ICAO Liaison, Airports Council International
Ms. Nancy Young, Vice President for Environmental Affairs, Air Transport Association of America
Mr. David White, Manager, Sustainability and Climate Change, Virgin Australia Airlines

Chapter 7 PARTNERSHIPS AND COOPERATION

Mr. Richard Altman, Executive Director, Commercial Aviation Alternative Fuels Initiative
Dr. Lourdes Maurice, Executive Director, Office of Environment and Energy, Federal Aviation Administration, United States
Ms. Amy Bann, Director, Environment Policy, Boeing
Mr. Cesar Velarde, Observatory of Sustainability in Aviation, SENASA
Mr. Alejandro Rios, Director, Fuel Services, Airports and Auxiliary Services, Mexico

Chapter 8 LEGAL AND REGULATORY FRAMEWORK

Mr. Ruwantissa Abeyratne, Senior Legal Officer, Legal Affairs and External Relations Bureau, ICAO
Mr. Alejandro Rios, Director, Fuel Services, Airports and Auxiliary Services, Mexico
Mr. Nathan Brown, Alternative Fuel Project Manager, Federal Aviation Administration, United States
Mr. Andy Kershaw, Manager, Environmental Policy, British Airways

Chapter 9 ACCOUNTING, LIFE-CYCLE ANALYSIS, SUSTAINABILITY

Mr. Ted Thrasher, Environment Officer, ICAO
Ms. Nancy Young, Vice President for Environmental Affairs, Air Transport Association of America
Mr. Matthew Rudolf, Regional Manager, Americas, Roundtable on Sustainable Biofuels
Dr. Chris Malins, Clean Fuels Program Lead, International Council on Clean Transportation
Mr. Russell Stratton, Department of Aeronautics and Astronautics, MIT

Chapter 10 FINANCING ALTERNATIVE FUELS

Mr. Donald P. Schenk, President, ACA Associates Inc.
Mr. Arnaldo Vieira de Carvalho, Lead, Sustainable Energy Specialist, Energy Division, Inter-American Development Bank
Dr. Ravin Appadoo, Aviation Fuel Solutions, Inc.
Ms. Cindy Thyfault, President, Westar Trade Resources
Mr. Salim Morsy, Bioenergy Analyst,Bloomberg New Energy Finance

WORKSHOP WRAP-UP

Ms. Jane Hupe, Chief, Environment Branch, ICAO

Setting the Scene

International civil aviation is an essential component of our global society. For all countries, it is a driver of economic, social and cultural development. For land-locked and smaller island States, it is an economic lifeline, often the only available link to the global marketplace. More specifically, it creates or supports millions of jobs, brings people together for leisure or business activities and, in many instances, ensures rapid and effective delivery of humanitarian aid where it is most urgently needed.

Although total air transport including domestic and international operations, currently represents 2% of global CO_2 emissions, traffic is expected to increase at an annual average rate of 4.5% over the next 20 years, which will put tremendous pressure on the sector to find ways to limit and ultimately reduce its impact on climate change.

In October 2010, the ICAO Assembly adopted a comprehensive Resolution on aviation and climate change that made international aviation the first transportation sector with a shared global commitment to the environmental goals of increasing fuel efficiency and stabilizing its global CO_2 emissions in the mid-term. The Resolution also included: development of a CO_2 Standard for aircraft aiming for 2013, a framework for market-based measures, and concrete steps to assist States in contributing to global efforts in achieving these goals.

To realize these ambitious goals, a basket of measures to address the impact of international civil aviation operations on climate change is available to States. These measures include: aircraft technologies and Standards, operational measures, market-based measures and sustainable alternative fuels for aviation. The Resolution invited States to submit action plans to ICAO describing the basket of measures they intend to implement toward meeting the goals set forward by the Assembly Resolution, as well as to identify any assistance needs.

In fact, drop-in sustainable alternative fuels are practical solutions as they are chemically indistinguishable from conventional jet fuel, so no changes are required in the aircraft, distribution infrastructure or storage facility. It can be mixed interchangeably with jet fuel. It is expected to be a key component of the response of aviation to climate change, which is the reason for this ICAO Review which is dedicated entirely to the topic. In **Figure 1**, the blue shaded area illustrates the range of possible CO_2 reductions from improvements in aircraft technology and operations, while the orange line depicts the aspirational goal of 2% annual fuel efficiency improvement. The green shaded area starting in the year 2020 depicts the gap that exists between what aircraft technology and operational changes can deliver and the ICAO aspirational goal of keeping the net CO_2 emissions from international aviation at the same level, beginning in 2020. This gap will need to be filled with a combination of other additional measures, and alternative fuels will need to play a prominent role in this strategy to reduce the impact of international aviation on the environment. For these fuels to be effective in contributing to this objective, they must be produced in a sustainable way.

With the July 2011 approval of ASTM D7566, aviation fuels produced from hydroprocessed esters and fatty acids (HEFA), such as derived from feedstocks such as, camelina, jatropha, algae, and cooking oil waste, are now permitted for use on commercial flights. **Figure 2** shows the routes of flights using biofuels as of October 2011. The challenge ahead is to be able to scale-up production, at an affordable price, using sustainable practices.

The remaining sections of this review discuss the progress made to date by key stakeholders in each of these areas. ■

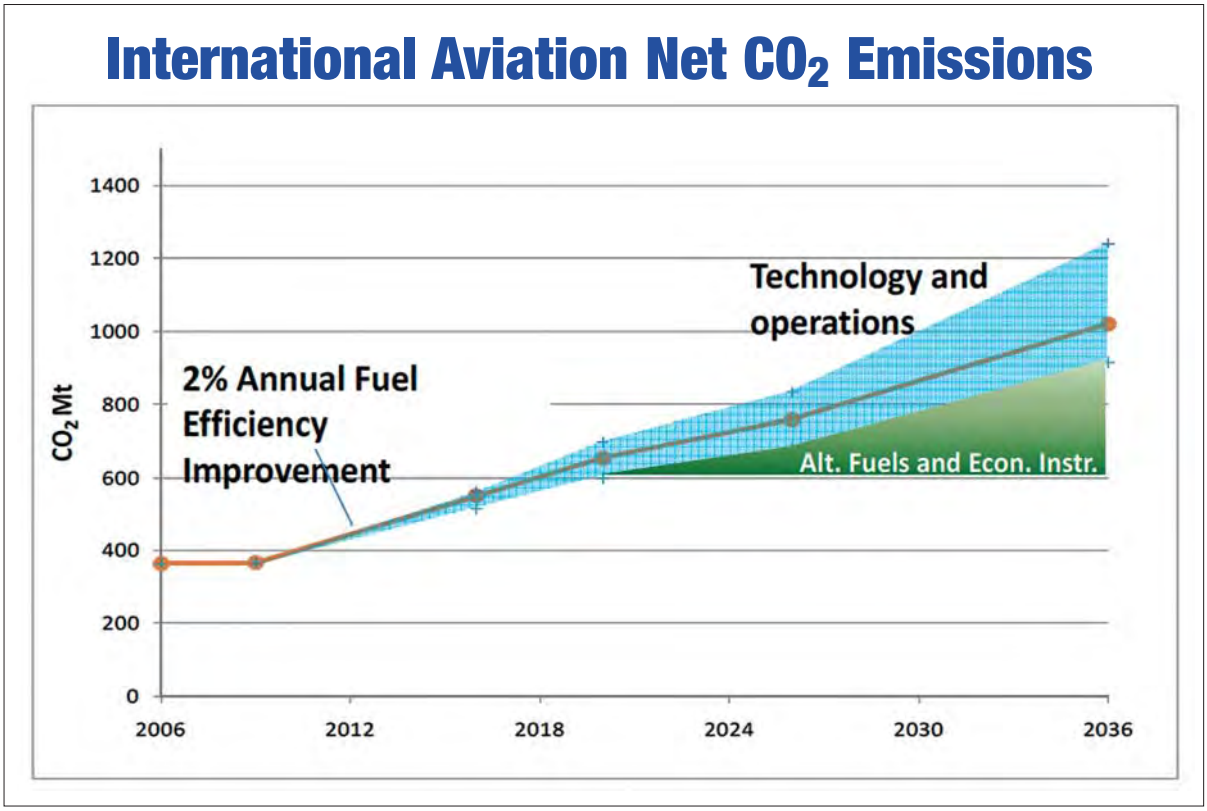


***Figure 1**: International Aviation Net CO_2 Emissions.*

Date	Carrier	Route	Feedstock
22 June 2011	KLM	Amsterdam – Paris (B737)	Used cooking oil
15 July 2011	Lufthansa	Hamburg – Frankfurt (A321)	Mix of feedstocks
18 July 2011	FINNAIR	Amsterdam – Helsinki (A321)	Used cooking oil
21 July 2011	interjet	Mexico City – Tuxtla Gutierrez (A320)	Jatropha
1 August 2011	AEROMEXICO	Mexico City – Madrid (B777)	Jatropha
3 October 2011	IBERIA	Madrid – Barcelona (A320)	Camelina
6 October 2011	Thomson Airways	Birmingham – Arrecife (B757)	Used cooking oil
13 October 2011	AIRFRANCE	Toulouse – Paris (A321)	Used cooking oil

***Figure 2**: Commercial flights using biofuels, as of 27 October 2011.*

The View From the States

The growth of the international aviation sector, the need to tackle the environmental effects of aviation, and the need for fuel price stability, are expected to be driving forces behind the expanded development and deployment of sustainable alternative fuels. States have expressed their strong support for drop-in sustainable biofuels for aviation. Representatives from Brazil, China, Mexico, the United Arab Emirates, the United States and the European Union were invited to share their vision during the ICAO worshop. These six States have been actively involved in promoting the development of sustainable biofuels for the aviation sector.

View from Brazil

Like many other countries, Brazil is continually searching for ways to diversify its sources of energy, including from renewable sources. More than 45% of all the energy consumed in Brazil already comes from renewable sources. For comparison, the average share of renewable sources in the energy profile of developed countries falls short of 15 %.

For the last 30 years, Brazil has led the world in the production of biofuels. Brazilian policy-makers are aware that many other producers, as well as States will need to be involved, if biofuel supplies are to be reliable worldwide. International cooperation is essential to ensure that biofuels are offered globally and sustainably in order to develop their full economic, social and environmental potential.

Following are the key developments to date in Brazil's experience with biofuels:

- Brazil performed the first experimental biofuel powered flight in Latin America using aviation fuel derived from jatropha.
- The Brazilian Airline TAM, in partnership with the Brazilian Association of Producers of jatropha, acquired that Brazilian grown raw material and used it in the production of biofuel; a project which had spin-off socio-economic benefits for jatropha growers on family farms.
- Research aimed at improving fuel quality is being undertaken across all areas of the biofuel supply chain. Socio-economic research and environmental studies are being conducted in different regions of Brazil.
- Since 2005, EMBRAER has been selling the IPANEMA agricultural aircraft, the first production aircraft to be powered by ethanol. More than 300 of these aircraft are now in service.
- The Brazilian Oil Company PETROBRAS, and its Research Centre (CENPES), are conducting studies into the use of biofuels for civil aviation.
- Brazil and the United States signed a Memorandum of Understanding (MOU) to launch a Partnership for the Development of Aviation Biofuels in order to develop sustainable biofuels for aviation. This cooperation will include enhanced dialogue between ABRABA and the Commercial Aviation Alternative Fuels Initiative.
- BOEING AND EMBRAER, together with the Inter-American Development Bank, announced in July 2011, that they will finance a study on the sustainability of sugar cane-derived biofuels for aviation. The study will be published in early 2012.

Prospects for the Development of Jet Biofuels in China

The rapid growth of air transportation in China is generating a high demand for jet fuel in that country. In 1990, the consumption of jet fuel in China was 1.2 million tonnes. By 2010, annual fuel consumption had reached 15.3 million tonnes, an average annual increase of 13.6 %. During the same 1990 to 2010 period, jet fuel efficiency increased at an average annual rate of 2.6 % cent; making the 3.6 million tonnes saved more than the total amount of fuel consumed by the air transport industry in China in 1997. Due to the pressure to mitigate and adapt to the climate change, the air transport industry in China has set a domestically binding goal of reducing its CO_2 emissions per revenue tonne kilometre by 3% on average, over the next five years, compared to 2010 levels.

In 2009, the China-US energy cooperation program was launched. This partnership focuses on China-U.S. business development in the clean energy sector. Its purpose is to promote commercially viable project development work in clean energy and energy efficiency, and to support the sustainable development of the energy sectors in both countries. In May 2010, the China National Energy Administration and the United States Trade and Development Agency signed a Memorandum of Understanding (MOU) on the development of aviation biofuels in China. Two of the key objectives of this MOU are 1.) to evaluate the possibility of establishing a sustainable aviation biofuels industry in China, and 2.) to assess the possible benefits of a sustainable aviation biofuels industry in China to the environment and the social economy.

In spite of these developments, there are still three areas of uncertainty with respect to the development of aviation biofuels. The first, is whether aviation biofuels could reduce emissions when compared with fossil jet fuels, and if so, to what extent will they be able to reduce these emissions. According to some research, biofuels could increase emissions, if land use change is involved in the production of biofuels. The second is whether it will be possible to commercialize the aviation biofuels. The third is whether incentive policies adopted by different governments will create trade-disputes in the future.

China believes that ICAO could play an important role in the development and promotion of jet biofuels in the future, and that ICAO should coordinate or facilitate:

- Feasibility studies;
- Technical Standard development;
- Airworthiness certification;
- Training programmes and workshops;
- Technical and capacity building support to developing States.

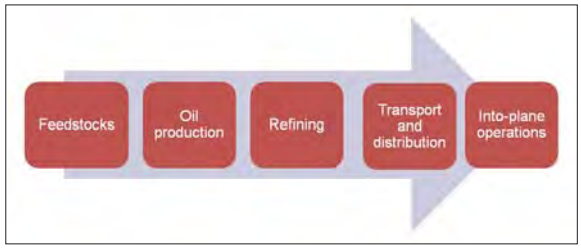
Flight Plan Towards Sustainable Aviation Biofuels in Mexico

Mexico has made significant efforts to promote the development of a sustainable aviation biofuels industry and has completed a comprehensive exercise called the “Flight Plan Towards Sustainable Aviation Biofuels in Mexico”.

The purpose of the Flight Plan was to identify and analyze the existing and missing elements in the supply chain of aviation biofuels. It involved all interested stakeholders.

The Mexico Flight Plan sought to:

- Focus efforts of civil, governmental, private and research organizations, on the production of aviation bio-fuels.
- Analyze the legal framework, raw materials availability, refining facilities, supply processes, and economic viability.
- Integrate the talents and knowledge of participating sectors.



The availability of suitable sustainable feedstocks is the most important bottleneck in the supply chain. To succeed, it is mandatory to achieve a competitive price compared to fossil fuels.

Sustainability is a KEY element for the viability of alternative aviation fuels.

A VISION FOR THE SUSTAINABILITY OF ALTERNATIVE FUELS FOR AVIATION

United States Vision and Approach

Sustainable alternative fuels are key to meeting U.S. aviation environmental goals.

U.S. principles for sustainable alternative aviation fuels are:

- The Government's role is to address key barriers to development and deployment.
- Seek fuels that are drop-in, have equivalent safety. and better environmental performance than existing petroleum based fuels.
- Enable all possible fuels that meet these criteria.
- Work through public-private partnerships.
- Address the whole supply chain; a broad array of agencies and stakeholders must be involved.
- Leverage expertise and programmes nationally and internationally.
- Enable aviation as a lead user of alternative fuels.
- Share lessons learned internationally.

Recent developments in the United States:

- FAA funds alternative fuels testing under CLEEN program (June 2010).
- U.S. Department of Agriculture (USDA), Air Transport Association (ATA), and Boeing Farm to Fly Partnership (July 2010).
- FAA and USDA agree to work on feedstock development (October 2010).
- U.S. – Brazil Partnership (March 2011).
- ASTM International Approval of biofuel (July 2011).
- USDA, U.S. Department of Energy (DOE) & Navy $510M commitment to advanced biofuel production (August 2011).
- DOE grants $4M to Virent and Lanzatech for jet fuel process development (August 2011).
- U.S. – Australia Cooperation Agreement (September 2011).
- U.S. Air Force announces tests of alcohol to jet fuel (September 2011).
- USDA $131M for 5 regional biofuel feedstock development efforts (September 2011).

The FAA goal: 1 Billion gallons of alternative fuels by 2018.

The United States foresees a number of important challenges to making sustainable alternative aviation fuels a commercial reality:

- Developing and producing appropriate feedstocks for aviation biofuels.
- Developing, testing, and approving additional sustainable alternative fuels.
- Accurately quantifying the environmental impact of these fuels.
- Accessing investments in production infrastructure.

The View From the United Arab Emirates

Aviation is one of the industrial sectors experiencing the most growth in the United Arab Emirates (UAE). However, the number of actors and stakeholders involved in the aviation industry have also increased in recent years, making it increasingly challenging to ensure the sustainability of such significant growth. In light of this expansion of the aviation industry, ensuring that a harmonious balance is achieved among the three interdependent pillars of economic, social and environmental sustainability, will present one of the biggest challenges for the UAE.

In addition to its role of facilitating information sharing, the UAE sees an additional role for ICAO in the development and deployment of sustainable alternative fuels. Amongst others, this could include supporting the development of a model legal framework that would assist Member States in ensuring that alternative fuels are earmarked in sufficient quantities for the aviation sector. ICAO could also engage further participation of Member States in alternative fuels development.

The View from Europe

Europe has a clear and ambitious goal for the reduction of greenhouse gas (GHG) emissions, including in the context of international civil aviation. The European Commission adopted a transport white paper earlier this year, which stressed the need to reduce overall emissions from the transport sector by 60% by the year 2050.

A VISION FOR THE SUSTAINABILITY OF ALTERNATIVE FUELS FOR AVIATION

The white paper gives biofuels a prominent role in the achievement of the European Commission's emissions reduction target. It sets an ambitious goal of biofuels accounting for 40% of the aviation fuel market by 2050. For the European Commission, biofuels are an important part of a long-term strategy to reduce emissions.

A starting point for projects on alternative fuels in Europe has been to concentrate on the sustainability of these fuels. The Sustainable Way for Alternative Fuels and Energy for Aviation (SWAFEA) study confirmed the need for swift action on the issue of alternative fuels, in order to reach the goals set.

A strategic approach to financing alternative fuels initiatives will be required. Extensive investment, from a variety of different sources will be necessary to ensure that sufficient resources are available. The aviation sector will need support from governments to effectively deploy biofuels on the required scale.

National and local land projects are emerging in Europe, as a result of increasing cooperation among the aviation sector, policy-makers, fuel producers, the energy sector, and other stakeholders. Since biofuels is a global issue, not linked solely to aviation or to transport, strengthening the partnership between the aviation and energy sectors will be necessary. Sustainability criteria need to be developed that cover multiple uses of biofuels, in addition to the aviation sector.

To promote and accelerate the development of advanced biofuels, a "European Biofuels Flight Path" project was launched in June 2011, with the objective of developing a variety of aviation biofuels for Europe in the coming years. The Flight Path initiative is part of the implementation of an overall bioenergy programme involving fuel producers, the energy sector, and other actors.

Working with industry, the European Commission Directorates-General for Energy and Transport, and Research and Innovation are launching a number of initiatives towards the development and further refinement of this initial road map, including technological, funding and financing issues. ■

Recent Developments and Next Steps: Organizations

A viable future for sustainable alternative fuels for aviation will depend upon broad cooperation among a number of different actors, including States, international organizations and non-governmental organizations; all working at the national, regional and international levels. Accordingly, in addition to States; organizations representing the interests and objectives of NGOs, the aviation industry, manufacturers and standards organizations, were also invited to present their varying perspectives on the issue of sustainable alternative fuels to the SUSTAF workshop. Four of the most prominent players within these groups, the Aviation Environment Federation (AEF), the Air Transport Action Group (ATAG), Boeing, and the Roundtable on Sustainable Biofuels (RSB), respectively, highlighted the views and work being undertaken by each of their organizations and members towards addressing the development and deployment of alternative fuels for aviation. Their presentations clearly demonstrated that there are differing views on the path towards commercial sustainable biofuels for aviation among the various organizations and stakeholders concerned with aviation environmental protection and the sustainability of aviation operations.

The View from NGOs

Sustainable alternative fuels are a serious issue for environmental non-governmental organizations (NGOs). While the objective in developing sustainable alternative fuels for aviation is to address the industry's emissions, and reduce the carbon footprint of international aviation operations, the debate on whether these fuels will be able to deliver on these intended objectives is still ongoing. There is indeed more than one side to the issue, and a number of important considerations must be taken into account when determining whether to adopt an alternative fuels strategy.

For instance, it is crucial that biofuels should not compete with food crops, so as to avoid creating or exacerbating insecurity about food supplies. It is a reality that there is a need for food programmes all around the world. Agricultural and social policies need to adapt to avoid any conflict with the food production chain. In addition, appropriate standards and robust criteria must be set to ensure the usability and sustainability of these fuels for the aviation industry.

A clear strategy for the development and deployment of alternative fuels will be required, including, identifying potential viable sources of financing. A crucial issue is "where will the money come from". The International Energy Agency has developed a road map for the transport sector's reduction of fossil fuel usage. However, significant levels of investment and funding will be required to make the cost of biofuels competitive with conventional fuels, and is currently estimated to require some $13 trillion across all modes of transport. This financial burden highlights the challenge for alternative fuels in terms of their scalability and cost.

To move forward, a number of challenges must be addressed in the short and medium term:

- Fuel source: is there enough biomass, and where will it come from?
- Funding: where the money will come from?
- Timing: Concrete actions need to start now; not 2015, or 2050.
- Agro fuels not biofuels; the social and environmental realities associated with the commercial production of alternative fuels need to be addressed.

In addition, while the focus has been largely on CO_2, more needs to be done to address the emissions of other gases, such as NO_x, and cloud contrails.

While there is potential for alternative fuels, the scale at which they will be required is daunting, both in terms of investment, and the sustainability issues involved.

Where We Are Now With Biofuels: ATAG's View

While many challenges persist with respect to the development and cost-effective production of biofuels, a great deal of progress has already been made. As a result of the high costs of fossil fuel, airlines have an important financial incentive to become fuel efficient. IATA has included economic measures in its outlook, and has advocated the importance of developing a harmonized industry, which operates the same equipment around the world. Such harmonization could create better control over fuel supply.

In 2008, the first ever flight using biofuels took place. It was the first in a series of tests that will be done to validate the feasibility of biofuels for aviation. An important feature of drop-in biofuels is that there is no need to adapt existing fleets or equipment. The first milestone in 2009 was the approval of biomass-to-liquid biofuel and in the summer of 2011, Hydrotreated Renewable Jet (HRJ) was approved.

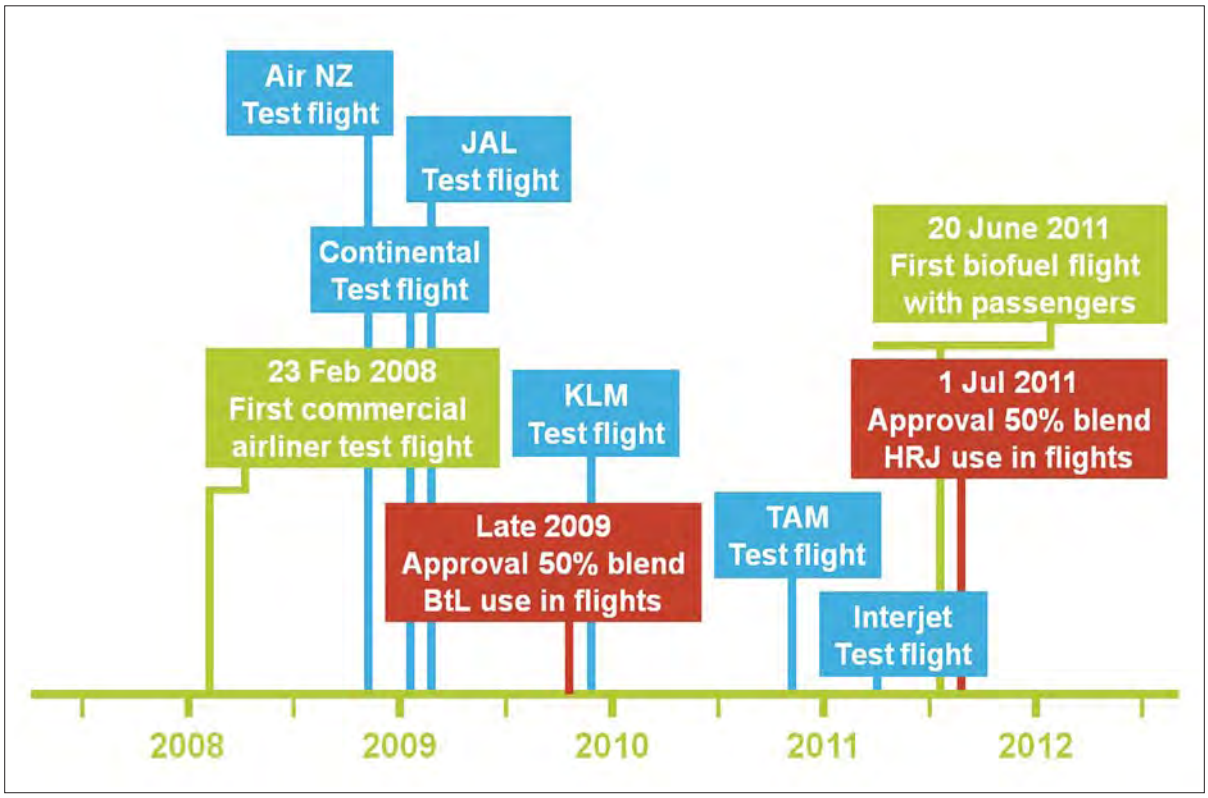


Figure 3: *Test flights, fuels certification and passengers' flights since 2008* *Source: ATAG*

With some commercial flights already using these biofuels, the aviation industry has gained considerable experience with them. However, a number of challenges related to using biofuels remain, including: issues regarding feedstocks, research on the outputs and efficiency of these biomass fuels sources, sustainability criteria, and others. Commercialization in particular, is a major challenge. A large number of initiatives around the world are bringing together the private and public sectors to launch projects and processes to explore the various issues. The aviation industry has already sent strong signals that should the quantities of biofuels needed for the industry be produced sustainably, in the right place, at the right price, there would definitely be a strong demand for these fuels.

Aviation is an ideal sector to implement biofuels to reduce carbon levels, for the following reasons:

- Aviation fuel is already highly controlled.
- Limited distribution system (1,700 airports = 95% of traffic).
- Drop-in fuels mean no change in equipment.
- Strong customer demand to shift to low-carbon fuels.
- The industry is high profile.

Facilitating the Commercialization of Biofuels for Aviation: A View from Boeing

The mission of Boeing is to be a catalyst for the development of sustainable biofuels for aviation.

The near term goal at Boeing is, through their actions as a catalyst to accelerate commercialization, to see 1% augmentation of the global aviation fuel supply with sustainable biofuel by 2015. This target would translate into 500 – 600 million gallons per year, globally. Boeing has identified four critical areas on which to focus their efforts in this direction:

- Feedstock pathways;
- Fuel approval;
- Support and advocacy; and
- Commercial production.

Pathways are an important area of focus for Boeing, since many of the remaining barriers to successful commercialization of alternative fuels are pathways-related. A large part of Boeing's action plan in this area is to help launch and participate in "comprehensive regional assessment," projects, worldwide. Each assessment is a rigorous study that identifies prospective regional feedstocks and conversion pathways, and thoroughly assesses and documents them, with an emphasis on economic and social sustainability principles. These comprehensive assessment projects are conducted using a stakeholder-driven process model, that involves airlines, regional SAFUG members, feedstock growers, fuel developers, policymakers, environmental groups and others. The results of some of these assessments are already available in the public domain. While this consultative process for undertaking these assessments is time and labour intensive, it is expected that it will facilitate the development of supportive policies, and lead to faster commercialization.

Boeing is actively involved as a company in the HEFA fuel-specification process, and intends to continue to play a significant role in this area.

A strong policy framework will be required to provide support for the commercialization of alternative fuels for aviation. For Boeing, enhancing commercial production will rely on the success of the sector in cooperating, and in making progress in the first three areas; feedstock pathways, fuel approval, and support and advocacy. It is going to be a long journey, but the industry is off to an incredible start.

The View From the Roundtable on Sustainable Biofuels (RSB)

Biofuels sustainability is a complex topic but one useful distinction to make is between direct and indirect impacts. The levers that can be used to address direct impacts may differ from those that most effectively deal with indirect ones. For example, when unintended issues arise, there may be a desire to find fault. Yet, in the case of indirect impacts, it is much harder to assign blame to an individual farmer, or biofuel producer, as they are just small players in a globally connected market. Policy-makers are increasingly including sustainability provisions with biofuels mandates and incentive programs. Due to its complex nature, some policy-makers may chose to "outsource" the verification of sustainability, while setting their own minimum criteria.

Global Aviation Biofuels Road Mapping Activities

The goal of these mapping activities was to identify the local feedstock, infrastructure, and technology needs, in order to develop a sustainable aviation biofuels industry. Through all of these activities, the RSB has attempted to establish itself as a good partner for ensuring sustainability for the aviation industry. For the RSB, the aviation sector is a close ally, and key supporter of its work. Close ties between the RSB and the aviation sector makes sense for a number of reasons:

- The aviation sector needs a global sustainability tool that is recognized in different geographic regions.
- The RSB is flexible, and intended to be generic enough to work with all feedstocks and biofuel types, and it allows for crop specific adaptations when that is not possible.
- The RSB shares the commitment of the aviation sector to address sustainability issues, including carbon emissions reductions, protection of biodiverse areas, and food security through credible and verifiable means.
- The RSB certification system will ensure comprehensive, consistent, credible, transparent, effective and efficient implementation of these three main objectives.

According to international norms (i.e. ISEAL, ISO, IAF, etc.) the functions of standard setting, standards implementation, and verification against standards, must be done independently of one another and clearly separated, to avoid any possible appearance of conflict of interest. This division of roles and responsibilities is equivalent to the distribution of power (legislature, executive branch, judiciary branch) in democratic governance systems.

Many countries have existing regulations that address the same issues as the RSB. In order to facilitate certification, the RSB has been looking into what kind of evidence could be produced by operators from their existing systems to demonstrate compliance with the RSB standards. However, even when there is local documentation available, there will be no free ride, and all operators must still be in full compliance with RSB standards. Nevertheless, it is believed that the RSB could help both operators and auditors by identifying examples of regulations in the local regions that could help demonstrate compliance. With trained auditors on the ground right now, the RSB is in the process of putting the internal infrastructure in place so it can begin to conduct real audits. ■

Consortia For Alternative Aviation Fuels

The establishment of consortia for sustainable alternative fuels for aviation around the world has been crucial in enabling the significant amount of progress that has been made in this field in such a short period of time. They have successfully served to enhance and entrench collaboration among different stakeholders in the aviation biofuel industry, including research bodies, biomass and fuel producers, aircraft manufacturers and policy-makers. Six of the most influential consortia from around the globe were invited to make presentations to the SUSTAF workshop. The Brazilian Alliance for Aviation Biofuels in Brazil (ABRABA), Aviation Initiative for Renewable Energy in Germany (AIREG), AlfaBird and the Sustainable Way for Alternative Fuels in Aviation (SWAFEA) from the European Union, the Sustainable Bioenergy Research Consortium from the United Arab Emirates, and the Commercial Aviation Alternative Fuels Initiative (CAAFI) from the United States, showcased the impressive advances that have been made internationally on sustainable biofuels for aviation, and the sustained and ongoing efforts of these organizations to continue this rapid pace of progress. Moreover, they drew attention to the gaps that must be filled in terms of financing, standards, sustainability criteria and agricultural and land processes, among others, in other to effectively and sustainably produce and use biofuels for aviation.

Aviation Biofuels Development in Brazil

http://www.abraba.com.br/en-US/Pages/home.aspx

In May 2010, ABRABA, the Brazilian Alliance for Aviation Biofuels, was launched in Sao Paulo, Brazil. It was formed through the cooperation of Brazilian airlines, biofuel researchers, biomass producers and aircraft manufacturers. The objectives of the alliance are to: 1) support the aviation industry commitment to act on climate change; 2) foster the development of sustainable biofuels; and 3) support biofuel production scale-up. ABRABA is investigating several pathways for producing drop-in biojet fuel from different biomass feedstocks including:

- Biomass gasification (BTL) of waste, algae, and jatropha;
- Hydroprocessed esters and fatty acids (HEFA) derived from jatropha, algae, and camelina;
- Direct sugar-to-hydrocarbons from sugar cane;
- Alcohol-to-jet processes from sugar cane and wood chips.

As part of the development programme, Embraer and GE flew a series of test flights with an Embraer 170 using HEFA fuel produced from camelina, in a 50% blend with conventional jet fuel.

ABRABA believes alternative drop-in fuels are technically proven and it is encouraging the certification of new fuel production pathways using different feedstocks and processes. The alliance also supports harmonizing sustainability standards for alternative aviation fuels.

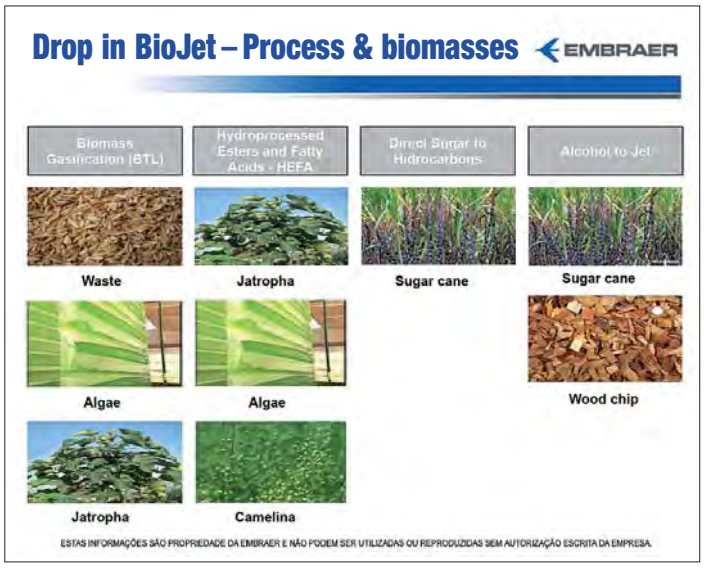


Figure 4: *Alternative Feedstocks and Processes for Drop-In Jet Fuel.*

Aviation Initiative for Renewable Energy In Germany

http://www.aireg.de/

AIREG was launched in June 2011, when its founding organizations decided to join forces to advance science, research, and ecology. They decided to combine their expertise along the entire fuel supply chain to build a German network for aviation biofuels with the objective of identifying the most efficient path to achieve ambitious emission reduction goals and raise public awareness of the industry's efforts. The organization has five work areas, covering the core needs of the industry, from crop to tank:

1) **Feedstock** – Determine the most promising feedstocks, identify regions for mass-production, and assess sustainability to ensure a sufficient and economical biomass supply.

2) **Fuel production** – Identify the most efficient conversion processes, quantify the ecological impact of these processes, and create a roadmap for large-scale fuel distribution to supply biofuels that are equivalent to Jet A1, which will remain the standard aviation fuel.

3) **Fuel utilization** – Scientifically verify "no impact" biofuels, assess future German demand, determine whether emission reduction goals are feasible, and strive for an ETS exemption to confirm that fleet and infrastructure adaptation are unnecessary.

4) **Fuel quality and certification** – Assure that biofuels comply with standards, support the certification of new aviation biofuels, safeguard the qualification of new market participants, create platforms for knowledge transfer, and coordinate the inclusion of companies in the ASTM process; as are required for a self-regulated standardization for biofuels.

5) **Sustainability** – Implement sustainability criteria along the value-creation chain, further develop sustainability criteria, identify research requirements and the need for political action, and evaluate incentive systems for emission reductions; as are needed to ensure that biofuels are ecologically and economically beneficial.

***Figure 5**: AIREG five core work areas.*

AlfaBird: Alternative Fuels and Biofuels For Aircraft Development In Europe

http://www.alfa-bird.eu-vri.eu/

AlfaBird, the Alternative Fuels and Biofuels for Aircraft Development consortium, was created in July 2008 with a four-year term to June 2012. Its objective is to develop the use of alternative fuels in aeronautics with a long term perspective. The consortium intends to reconsider the whole aircraft system, including fuel, engine, and external environment. In the four-year AlfaBird work plan, there are 14 work packages, 44 tasks, 52 deliverables, and 9 milestones. There are three key steps in the project:

1) **Prepare an overview of potential alternative fuels** – Identify and evaluate possible alternative fuels consid ering the whole aircraft system.
2) **Assess four alternative fuels** – Assess the suitability of four fuels with aircraft requirements based on a series of tests and experiments.
3) **Evaluate fuel performance** – Evaluate the environmental and economic performance of the selected alternative fuels.

Sustainable Aviation Fuels: Defining and Implementing the Next Steps in the United States

http://caafi.org/

CAAFI, the Commercial Aviation Alternative Fuels Initiative was originally founded in the United States by the Federal Aviation Administration (FAA), the Air Transport Association of America (ATA), the Aerospace Industries Association (AIA), and the Airports Council International – North America (ACI-NA). It now involves 600 global sponsors and stakeholders, including 17 government agencies and laboratories, 14 aircraft, engine, and subsystem OEMs, 21 airlines, executive jet, military, and airport organizations, 45 fuel producers, 8 universities, 4 oil service providers, 3 international finance organizations, and 15 think tanks and consulting firms. CAAFI has been working to develop sustainable alternative aviation fuels for several years as a means to "win the future" for aviation.

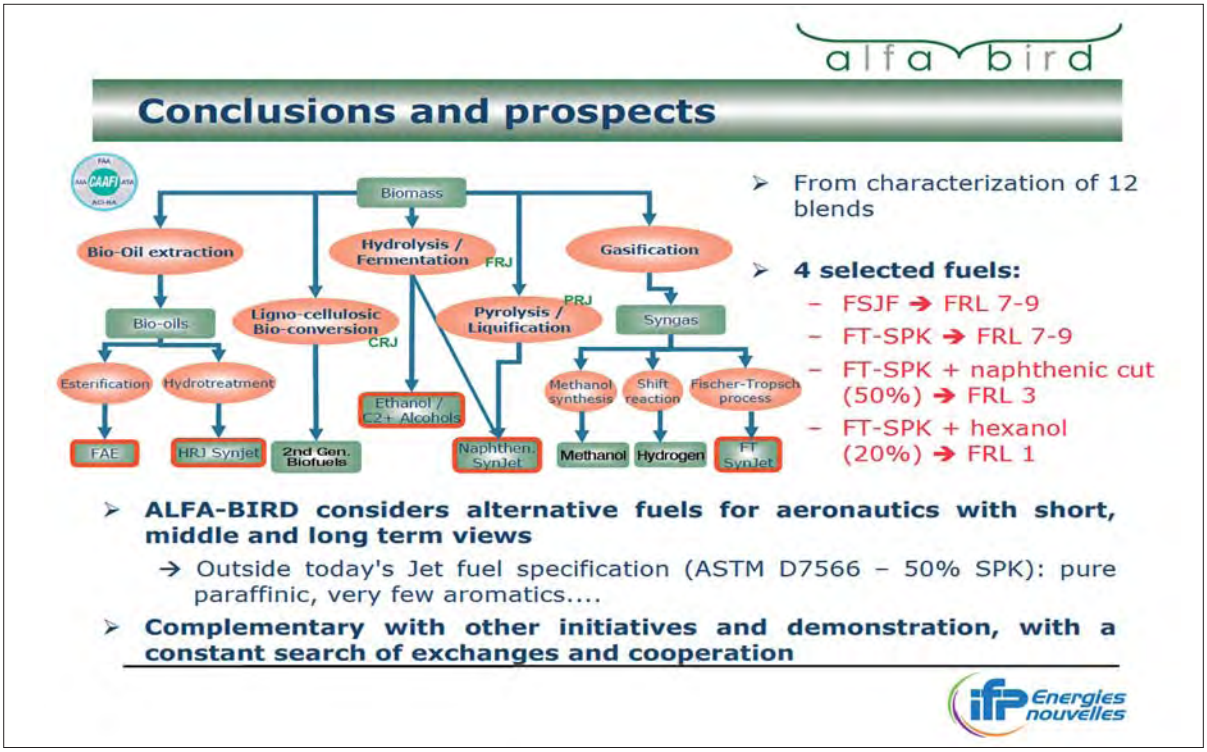


***Figure 6**: AlfaBird Priorities.*

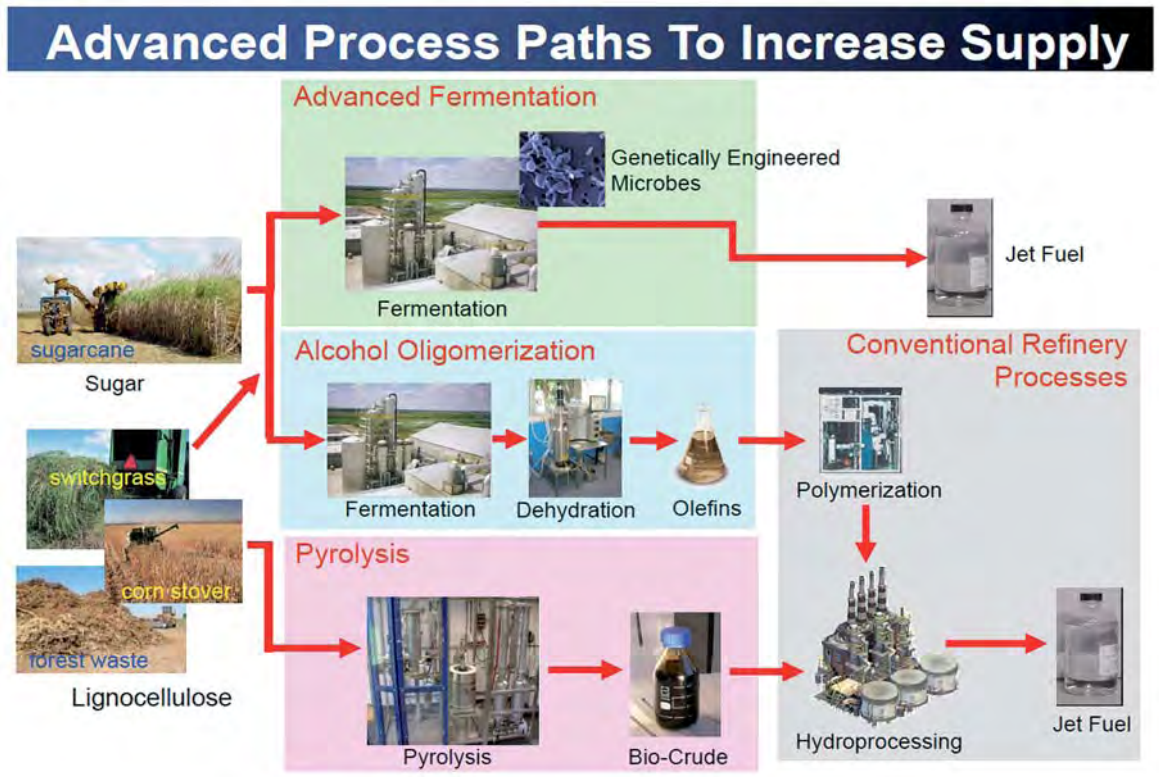


***Figure 7**: CAAFI Advanced process paths to increase supply.*

The focus of the current CAAFI work programme is to:

1) Add processes/feedstocks pathways that will increase supplies.
2) Execute feedstock readiness and manufacturing technology for cost gains.
3) Develop and deploy via multiple states and nations.
4) Increase environmental analysis certainty.
5) Attract private sector financing to support a viable business sector.
6) Build awareness of the opportunity for sustainable alternative aviation fuels.

Saltwater Tolerant Biomass As A Source of Aviation Fuel: A Way Forward For Abu Dhabi

Abu Dhabi has very strict technical requirements for biomasses needed to produce sustainable alternative aviation fuels locally including: the requirement for no fresh water and the ability to tolerate very high temperatures. On the other hand, it offers substantial land availability. Resulting products must be sustainable, consistent with SAFUG principles and RSB criteria, and must offer community benefits.

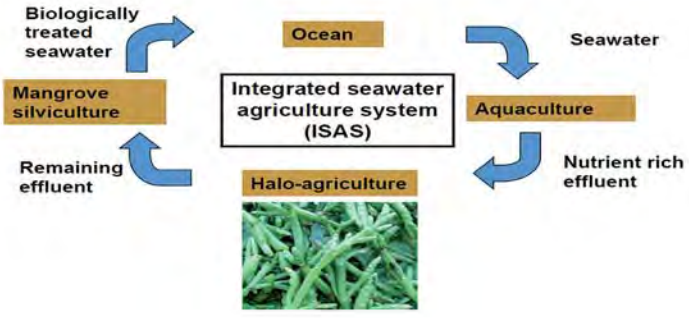


***Figure 8**: Integrated Seawater Agriculture System (ISAS).*

Abu Dhabi's early life-cycle analysis quantified inputs and outputs, and evaluated site management alternatives. Results indicated a high potential for carbon storage and emission reductions compared with fossil fuel. Current challenges include improving yields, land requirements and ability to scale-up, and finding ways to deal with hypersalinization and eutrophication. They have identified a significant potential for biofuels as part of an integrated aquiculture system with net benefits through carbon soil sequestration. If they can confirm that such a system works in Abu Dhabi, it will open many more coastal desert environments to such development (there are approximately 50 million hectares of potentially arable coastal desert around the globe).

SWAFEA : European Study For Alternative Fuels In Aviation

www.swafea.eu

SWAFEA, Sustainable Way for Alternative Fuel and Energy in Aviation, is a study funded by the European Commission. The study ran from February 2009 to April 2011, when the final report was published. The purpose of the study was to conduct a feasibility analysis and impact assessment on the use of alternative fuels for aviation. The broad-based team of 20 organizations conducted a comparative assessment of possible options and a possible vision and roadmap for deployment with the ultimate goal of providing information and decision elements for policy-makers. The work was done with the aim of ensuring suitability, sustainability, and economic effectiveness.

The study found that significant greenhouse gas emission reductions are achievable with biofuels, but that cultivation practices are of major importance. Soot emissions are also reduced using biofuels and there is a resulting impact on contrail formation. In the quest to successfully produce biofuels, economic competitiveness will be a challenge in the short term. Biomass production is likely to be a bottleneck in the mid to long term, which indicates a need for research and innovation. To successfully produce sustainable alternative fuels for aviation, a determined policy will be required. Elements of such a policy will need to include: a defined sectoral goal for 2020, promotion of many "end-to-end" projects, and combined incentive policies. Development of a comprehensive policy can be facilitated by: using emission trading scheme (ETS) revenues to fund the initial deployment plan, supporting research and innovation, and harmonizing sustainability rules at the international level. ■

The Current State of Research on Alternative Aviation Fuels

Research and development (R&D) is necessary to ensuring a sound and comprehensive understanding of the fundamental components of a strong sustainable alternative fuels strategy for aviation. R&D can help to identify and examine new possibilities, as well as the viability of existing ones. Several of the key research initiatives currently underway were presented during the SUSTAF workshop. The European Commission, Lanzatech, Romania, British Airways, SkyNRG, Bauhaus-Luftfahrt and NASA each highlighted their work programmes and the status of their research on various aspects of the alternative fuel production process.

European Commission Framework For Sustainable Aviation Biofuels: Associated Initiatives and R&D

The European Commission has adopted binding climate targets for the period from 2020-2050. They include a 20% emission reduction target by 2020 and an 80% emission reduction goal by 2050. To achieve these targets, Europe's emissions will need to be about 40% below 1990 levels by 2030 and 60% below 1990 levels by 2040, with all sectors contributing. As an incentive for developing sustainable alternative fuels for aviation, the EU Emissions Trading System (ETS) will grant biofuels a 0% CO_2 emissions rating.

The European Advanced Biofuels Flight Path 2020 initiative is an important element for meeting these targets for the aviation industry. It is a joint initiative of the airline and biofuel industries, and the European Commission. The goal of Flight Path 2020 is to achieve yearly production of 2 million tonnes of sustainable biofuels, to be used by the EU civil aviation sector by the year 2020. That represents approximately 4% of total EU airlines' fuel needs, or about 10% of the needs of a major EU airline. The effort is currently focused on establishing appropriate and effective financial mechanisms to support the construction of industrial "first of a kind" advanced biofuel production plants. There are currently seven elements to that plan:

1) Facilitate the development of standards for drop-in biofuels and their certification for use in commercial aircraft.
2) Work together with the entire supply chain to further develop worldwide acceptance of sustainability certification frameworks.
3) Agree on biofuel implementation arrangements over a defined period of time and at a reasonable cost.
4) Promote appropriate public and private initiatives to ensure market acceptance of paraffinic biofuels by the aviation sector.
5) Establish financing structures to facilitate the realization of second generation biofuel projects.
6) Accelerate targeted innovative research into advanced biofuel technologies, especially algae.
7) Take concrete action to inform the European public of the benefits of replacing kerosene by certified sustainable biofuels.

One of the key projects is the development of an integrated biorefinery, referred to as the EuroBioRef. As depicted in **Figure 9**, the EuroBioRef will bridge the gap between the agricultural and chemical industries by integrating the whole biomass chain into a multi-feedstock, multi-process, multi-product, commercially viable production facility.

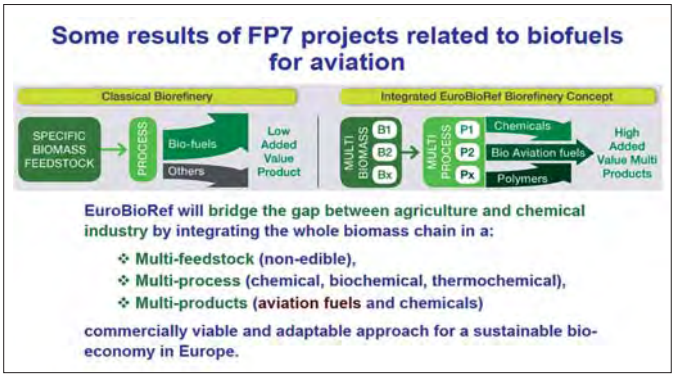


***Figure 9**: Conceptual biorefinery - EuroBioRef.*

Mill to Wing: Low Carbon Route to Aviation Fuel

The LanzaTech Process is a novel gas fermentation technology that captures waste CO-rich gases from industrial processes, such as at mills, and converts the carbon into fuels and chemicals. These gases, which are currently burned-off, converting the CO to CO_2, would become the sole source of energy under the new process. Using these waste gases represents the potential to make a material impact on the future energy pool in the order of more than 100 billion gallons of fuel per year, without a net addition of CO_2 to the atmosphere, and they are completely outside of the food value chain. The process allows for the direct production of fuels and chemicals (e.g., 2,3 Butanediol, Isoprene, Propanol, Butanol, MEK) as well as the multi-step production of chemicals and chemical intermediates (olefins). Thermochemical opportunities include 2,3 Butanediol produced through the LanzaTech Process, which can be used to make true drop-in hydrocarbon fuels such as gasoline, diesel, and jet fuel. LanzaTech sees a fast path to commercialization working with its partners who include Boeing, Swedish BioFuels, Imperial College, RSB, and Virgin Atlantic. They are planning for commercial production by 2013.

The Romanian Camelina Value Chain: Case study of Land Use Change

The purpose of this trial project in Romania is to develop a sustainable biofuel supply chain capable of producing 100,000 tonnes of camelina-based biofuel by about 2015. The stakeholders hope to strengthen the project and link it with the European Advanced Biofuels Flight Path 2020 initiative, which has a goal of producing 2 million tonnes of biofuels in Europe by 2020. A test and demonstration flight using a TAROM airlines aircraft is planned for the first half of 2012.

Some of the camelina plant crop is being grown on one of Europe's most polluted properties to assess its ability to mitigate prior environmental degradation. The trial is dedicated to investigating metal traceability from soil to plant, seed, and oil, with a focus on vanadium. Stakeholders intend to develop

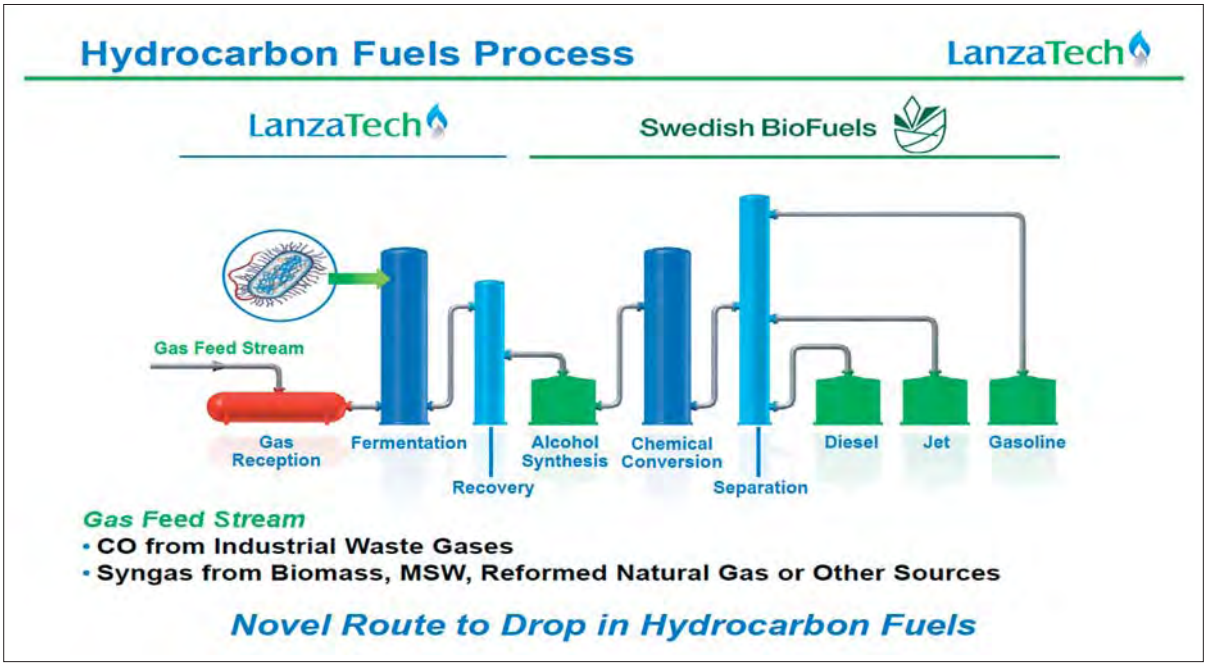


***Figure 10**: Waste gas fermentation process to produce a drop-in hydrocarbon fuel.*

a process to collect data, measure results, and propose corrective actions, all of which will be the basis for the design of a quality assurance system for the entire value chain.

Throughout the project, sustainability assessments and life-cycle analyses will be performed. To accomplish these goals, the Romanian agricultural system needs to implement a programme to support camelina growers with incentives of various types, and coordinate with the various ministries involved in the camelina value chain. An objective of the project includes making it profitable and sustainable for Romania to create regional "centres of competence" for camelina growers, including associations of farmers and distributors. The government must also develop a policy for commercialization of camelina by-products such as animal feed cake, and it needs to involve neighbouring countries wherever helpful.

More broadly, Romania hopes this project will provide numerous benefits including:

- General economic development and growth.
- Creation of new jobs and revenues for farmers.
- New production for existing refineries and transformation facilities.
- New opportunities for internal and external investors.
- New ideas for the efficient use of existing capabilities in Romania
- New uses for uncultivated and marginal land.

The London Biojet Project

The Green Sky project, developed by British Airways and Solena, is Europe's first advanced technology waste-biomass-to-biojet-fuel plant. It will produce 16 million gallons/year of renewable biojet fuel from 592,000 tonnes/year of waste, requiring an investment of $350 million. It will also produce 10 million gallons/year of renewable naphtha that can be used as a chemical feedstock. The production process is based on Fischer-Tropsch gasification technology. The plant is forecast to employ a staff of 1,000 during construction, and 200 during continuous operation.

The project's business case is supported by carbon pricing, based on the EU ETS, and landfill taxes of up to $100/tonne. It received credit for reducing methane off gassing from the landfill. Steam and biosyngas, by-products of the production process, are used to generate green electricity. Also, delivery trucks will run on green fuel.

British Airways has signed a letter of intent to purchase all the fuel produced by the plant. Use of the biojet product is forecast to reduce CO_2 emissions by 95%. The plant will be located east of London, UK Final site selection is pending based on proximity to an adequate waste supply and related supply infrastructure.

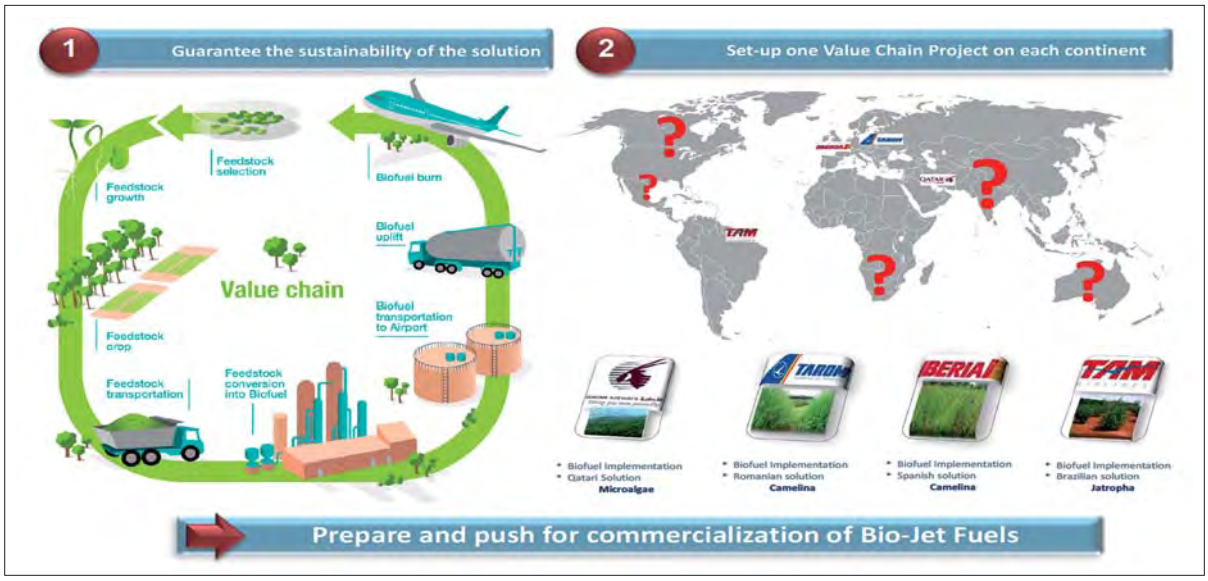


***Figure 11**: Developing a sustainable biofuel supply chain*

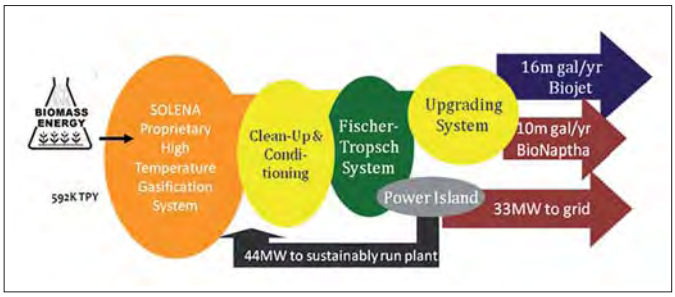


***Figure 12**: Waste-biomass-to-biojet-fuel production chain*

SkyNRG and Sustainable Jet Fuel

SkyNRG strives to be a "one stop shop" that guarantees delivery, sustainability, and competitive prices for biofuel supplies for airlines, anytime and anywhere. This includes sustainable sourcing, logistics, refining, blending, quality assurance, and aircraft fuelling, as well as regulatory compliance where needed. So far, they are supplying biofuels to KLM, Finnair, Thompson Airways, and Air France on commercial routes and they anticipate 5-10 additional airlines will be using these fuels in the near future.

Considering that it was actively involved in the biojet fuel market early, SkyNRG hopes to be able to accelerate the development of that market. To make this happen, it will be critical to engage all stakeholders including: airlines and their customers, governments, suppliers, the R&D community, and NGOs. A second objective is to drive the price down by taking various actions such as: quicker scale-up and aggregation, supplier engagement, and stakeholder education. SkyNRG benefits directly from the process by: participating in the ASTM process, gaining a better understanding of sustainability considerations, and working on supply chain efficiencies.

SkyNRG has already learned several important lessons. Among other things, it has found that feedstock is the single biggest cost component and has the highest price volatility. Logistics and blending are already priced competitively since existing infrastructure can be used for drop-in fuels. It was also noted that segregated fuel handling and related systems are expensive, but are still needed at the current stage of development. This requirement will eventually disappear. Refining costs are also significant but they can be reduced further – perhaps as much as 30%.

Long-Term Renewable Energy Perspectives in Aviation

Bauhaus-Luftfahrt was founded in 2005 by the Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology, EADS, Liebherr Aerospace, and MTU Aero Engines. It was established as a non-profit research institution undertaking a holistic approach using science, economics, engineering, and design. They have conducted a study into the long-term renewable energy opportunities in the aviation sector, focusing on global bioenergy potential and found that the technical feasibility of biofuel usage in aviation is proven. However they also found that the economic feasibility of using bioenergy depends on various factors including: oil and carbon prices, competition with other sectors for biomass, cost-effective production methods, and investment risk mitigation.

Bauhaus-Luftfhart has investigated several alternatives to biofuel development that is being carried out by others. Their studies have included an analysis of the possible use of all-electric aircraft, which would represent a radical change to the aircraft energy system by offering emission-free mobility. This all-electric approach offers numerous benefits including: flexibility of choice of renewable primary energy, zero-emissions with fully renewable power, and potential aircraft integration benefits. Capacity limitations of existing battery technologies are a significant disadvantage, however. As a result, further exploration of the theoretical innovation potential of battery technology and hybrid power architectures is being undertaken.

NASA's Integrated Systems Research Program (ISRP)

The US National Aeronautical and Space Administration (NASA) is also conducting research into the long-term opportunities for improving aviation's environmental performance. NASA's ISRP project is to address the aviation industry's aspirational goal of reducing its carbon emissions footprint by 50% by 2050 compared to 2005 levels. NASA is working with US engine and aircraft manufacturers on conceptual aircraft designs that will dramatically reduce noise, gaseous emissions, and carbon outputs, simultaneously.

There are several key technologies that NASA intends to develop to maturity in order to reduce the carbon footprint. Aircraft mission fuel burn can be decreased by: reducing

fuselage drag, aircraft weight, and engine fuel consumption. This must be done while maintaining a high degree of safety, and also reducing community noise. Drag reduction is achieved best by laminar flow, a technology that reduces skin friction drag. The focus for weight reduction is on the use of stitched composites for aircraft body construction. Strategies for reducing specific fuel consumption include advanced high bypass ratio engines that can reduce fuel burn by 20% to 25%.

NASA has a number of contracts underway to identify key aircraft technologies that may be able to provide integrated solutions and, are close to maturity now. Based on their findings, they plan to provide cost estimates and schedules for building and flying a technology test bed or demonstrator aircraft. By the end of the year, NASA expects to have completed the current phase of the work, providing them with the information needed to make informed decisions about the feasibility of building and proving significant reductions in noise, gaseous emissions, and fuel burn. ■

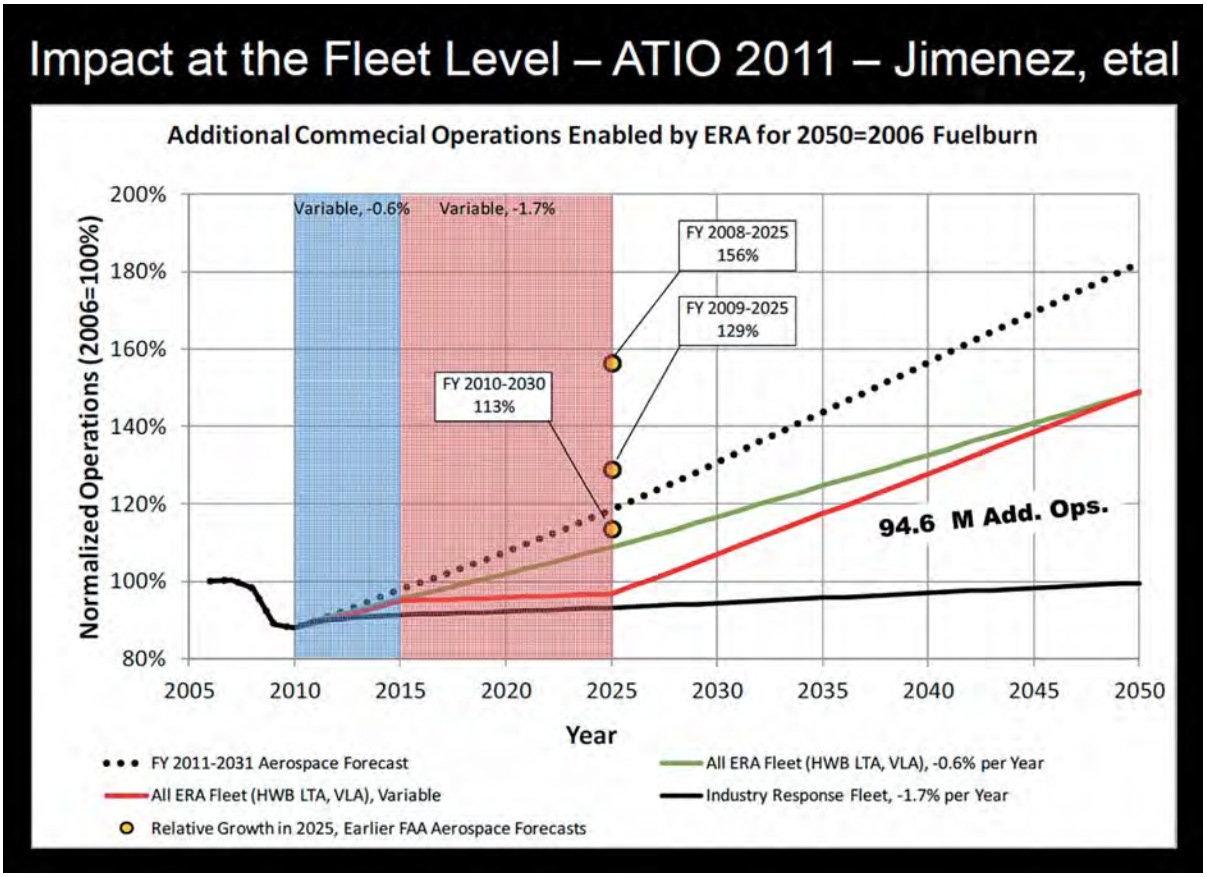


***Figure 13**: Impact at the level – ATIO 2011 (Source: Jimenez, et al.)*
Additional Commercial Operations Enabled by NASA's Environmentally Responsible Aviation Project

Qualification of Alternative Aviation Fuels

Clear processes and steps for approving or certifying new sustainable fuels for aviation have been established by international standards organizations. Fuel specification and fuel certification are key in bridging the needs and objectives of the fuel producer, and the civil aviation industry, and are intrinsic to the ability of these communities to meet the demands of their consumers. The Commercial Aviation Alternative Fuels Initiative (CAAFI) and Byogy Renewables, delivered presentations on the subject of fuel qualification during the SUSTAF workshop. Their presentations provided the workshop with an understanding of the progress that has been made so far and, the complexity of the process. They also explained the next steps that they and the biofuel industry are taking to ensure the relevance of these fuels as alternatives to conventional fuel for aviation over the long-term.

Fuels Currently In The Qualification Process

The aviation industry has made steady progress in qualifying alternative fuels. In September 2009, ASTM D7566 was approved as a drop-in fuel specification. At the same time, fuels produced using the Fischer-Tropsch process were also qualified. In July 2011, fuels made from hydroprocessed esters and fatty acids, referred to as HEFA fuels, were qualified. This important milestone is what enabled the commercial flights on biofuel that are highlighted in the Setting the Scene section of this paper.

An important distinction to understand is that regulatory authorities do not certify fuel; they certify airplanes and engines to operate on specified fuels, which are produced via

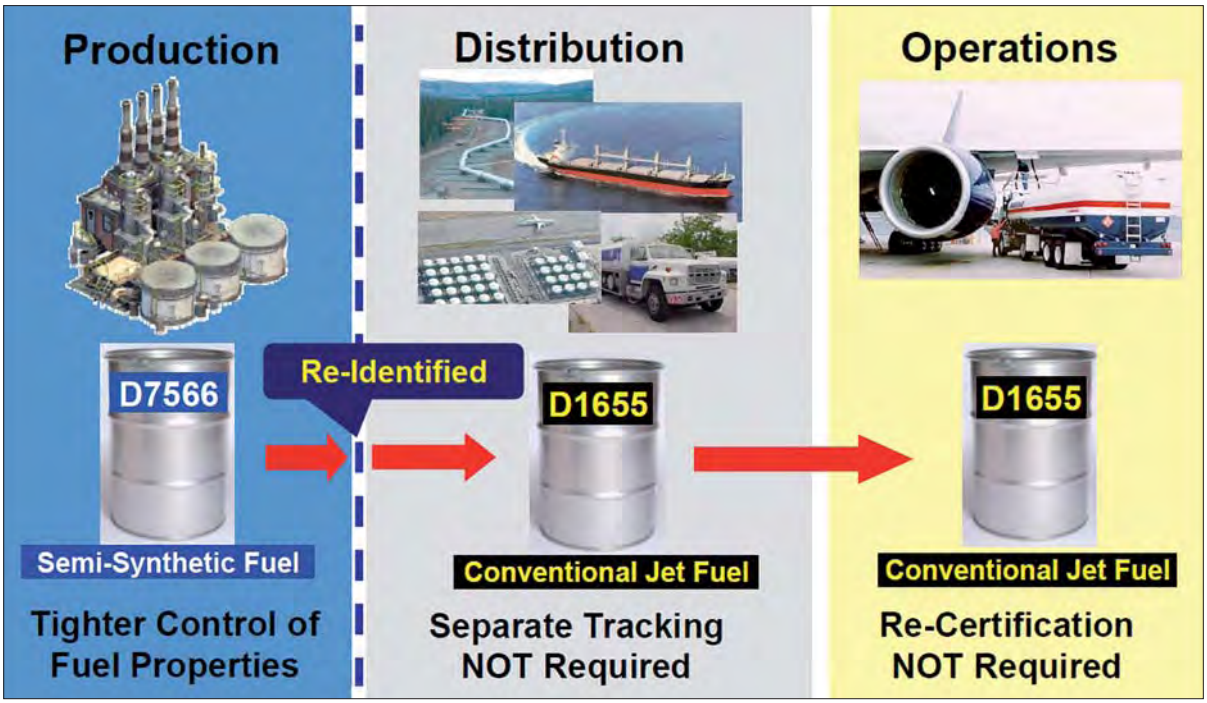


***Figure 14**: Tracking Certified Alternative Fuels.*

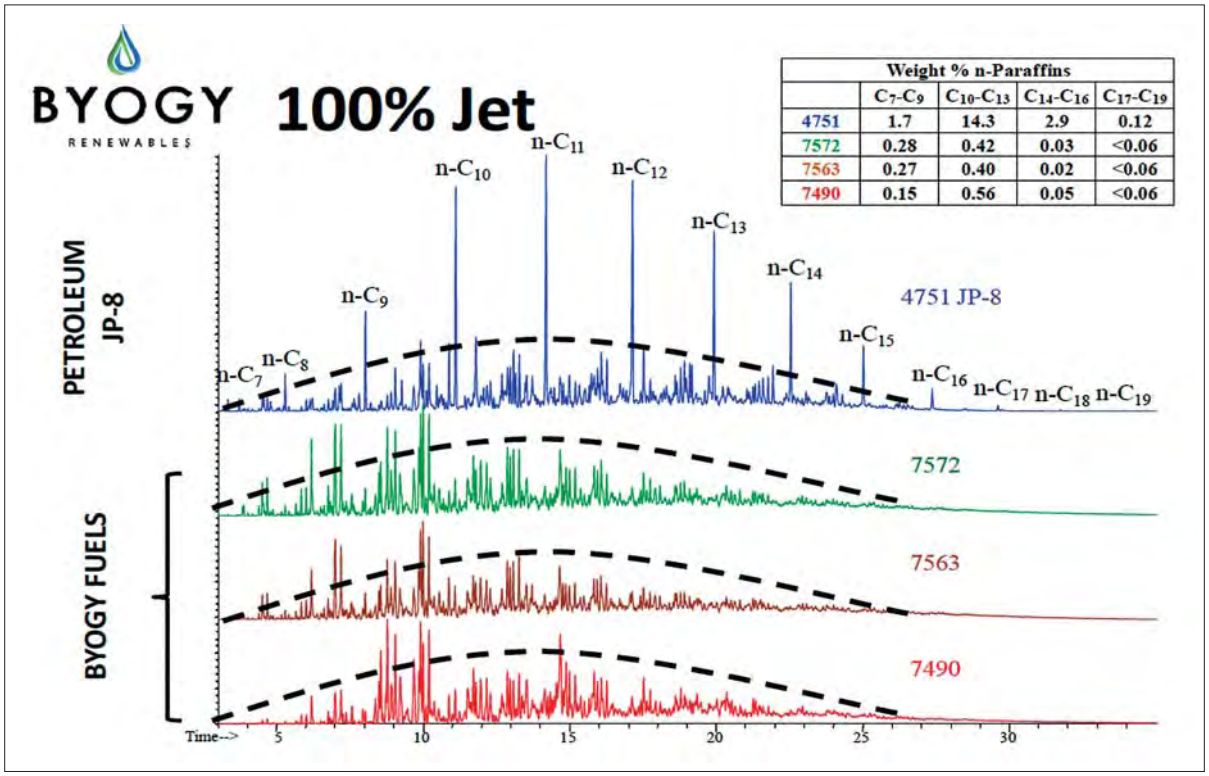


***Figure 15**: Alcohol-to-Jet alternative fuel quality.*

specific production pathways. Also, once an alternative fuel has been determined to meet the new specification, it can be re-identified as equivalent to conventional jet fuel and handled exactly the same way as any other jet fuel. Future fuel production pathways are being evaluated for qualification. Currently, jet fuels produced from lignocellulose and sugar are both being evaluated. Future pathways, such as alcohol-to-jet and pyrolysis, are being considered and review may be initiated in the near future.

Alcohol-To-Jet ("ATJ"): Emerging through ASTM

The alcohol-to-jet (ATJ) process is not about producing "alcohols", rather it is about the conversion of alcohols into jet fuel. This process does not rely on microbes or special enzymes for fermentation since it begins with alcohol that has already been produced through fermentation. All steps necessary to convert alcohol to jet fuel are based on processes that are currently used at commercial scale in the petrochemical industry. It is a catalytic process that is capital efficient and scalable, and the process does not require external hydrogen and hydroprocessing. There are many different feedstocks (alcohols) that can be used, including conventional materials such as fermenting sugars or starches. There are also new pathways to alcohols using industrial microbiology, such as using algae as the feedstock. ATJ typically follows a four-step process: ethanol dehydration, oligomerization, distillation, and hydrogenation. Qualification of these fuels by ASTM is expected in late 2013, or the first half of 2014. ■

Deployment of Sustainable Alternative Aviation Fuels

There are numerous challenges facing the global deployment of sustainable alternative fuels for international aviation. The availability of sustainable, economically feasible feedstocks, the harmonization of sustainability criteria, compatibility issues, access to financing, strengthened and coordinated partnerships, and an array of other issues must be resolved in order to effectively commercialize these fuels for use by international aviation. Several leading research institutions, fuel producers, airlines, and international organizations, all of which are involved in addressing these challenges, provided presentations to the ICAO Aviation and Sustainable Alternative Fuels Workshop. These included: the Platform for Sustainable Aviation Fuels, the Observatory for Sustainability in Aviation (OBSA), Imperium Renewables, Shell Aviation, Honeywell UOP, the Airports Council International (ACI), the Air Transport Association of America (ATA) and Virgin Australia Airlines. While their presentations highlighted the obstacles to the wide-scale deployment of alternative fuels for aviation, they offered possibilities for tangible solutions, which their respective organizations are striving to create and implement.

Aviation Biofuel Feedstock Supply – Challenges, Strategies and Recent Developments

The international aviation industry has very significant production targets for biofuels (i.e. carbon neutral growth by 2020), posing a deployment challenge, especially regarding the aviation fuel feedstock supply (i.e. around 18 mt of biojet) and cost. Hydroprocessed renewable jet fuel (HRJ), which is the only biofuel currently qualified for aviation use, represents the only pathway ready for larger scale deployment by 2020. This implies the use of a vegetable oil feedstock. One sustainable alternative for supplying vegetable oil feedstock is jatropha, which is suitable for a wide range of climates,and is ideal for growing in large land areas in subtropical regions. Also, land use change can be carbon-positive with jatropha. To meet this need, Germany's Leuphana University and its partners recently created the Platform for Sustainable Aviation Fuels, for the purpose of developing concepts for sustainable feedstock production for aviation biofuels.

The issues and topics which the Platform for Sustainable Aviation Fuels is dealing with are mainly focused on sustainable feedstock development. Currently planned steps include: evaluation of feedstocks, developing innovative concepts, conducting field trials, sustainability assessments, developing a strong business case, evaluating overall project development, and forming industry partnerships. The Platform is currently focusing on vegetable oil production with both annual and perennial plants, as well as alternatives. The study, "Growing Oil on Trees," will serve as an updated overview of alternative oil tree projects and their potential. Preliminary results of the study will be available by the end of 2011. Additional analysis of the economics and investment aspects of the aviation biofuels industry will follow publication of the project report.

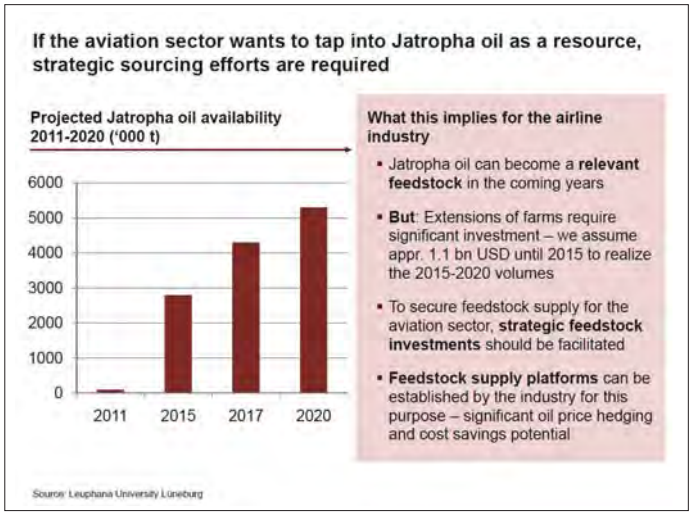


***Figure 16**: Jatropha oil requirements to meet future biojet targets.*

The European Advanced Biofuels Flight Path Initiative

The European Advanced Biofuels Flight Path Initiative is a roadmap with clear milestones designed to achieve an annual production of two million tonnes of sustainably produced biofuel for aviation by 2020. This "Biofuels Flight Path" is a shared and voluntary commitment by its members to support and promote the production, storage and distribution of sustainably produced drop-in biofuels for use in aviation. It also targets establishing appropriate financial mechanisms to support the construction of industrial "first of a kind" advanced biofuel production plants.

The implementation plan proposed to address the critical issues identified thus far (i.e. type of biofuel plants that need to be built, constructing a reliable financial mechanism, etc.), will take place in two steps. The first phase will be the opening of the first of its dedicated production plants by 2015. Then the second series of plants should start construction by 2016 and be operational by 2018. The 2015 milestones include a reliable supply chain for certified sustainable resources, conversion of HVO plants to produce aviation-class biofuels, and commissioning of three plants producing lignocellulosic-based aviation biofuels. The 2018 milestones include four plants producing lignocellulosic-based aviation biofuels and at least 2 HVO plants producing algae and microbe oil-based biofuels.

It is expected that by 2020, commercialization of the biofuel production technologies will result in the production of at least 2 million tonnes of biofuels per annum for aviation in the EU, with several EU airports operating with biofuel blends.

Developing Renewable Fuels for the Future

Imperium Aviation Fuels of the USA has begun a new biorefinery project. The new facility is to be co-located at the company's existing biodiesel asset in Washington state and will produce renewable aviation fuels. Imperium intends to supply HRJ fuel to the US Department of Defence (DOD) and the global airline industry. The biorefinery will produce drop-in fuels for multiple markets including DOD/RFS2/EU. The current design is for a 100 MGY facility (6,500 BBL per day) with an output of renewable aviation fuel of 25 to 40 MGY. The company views this project as no-risk since they have an engineering, procurement, and construction (EPC) contract available for construction. In addition to the renewable drop-in jet fuel, the plant will produce renewable drop-in diesel fuel. Feedstocks will come from current oilseed crops (i.e. canola,

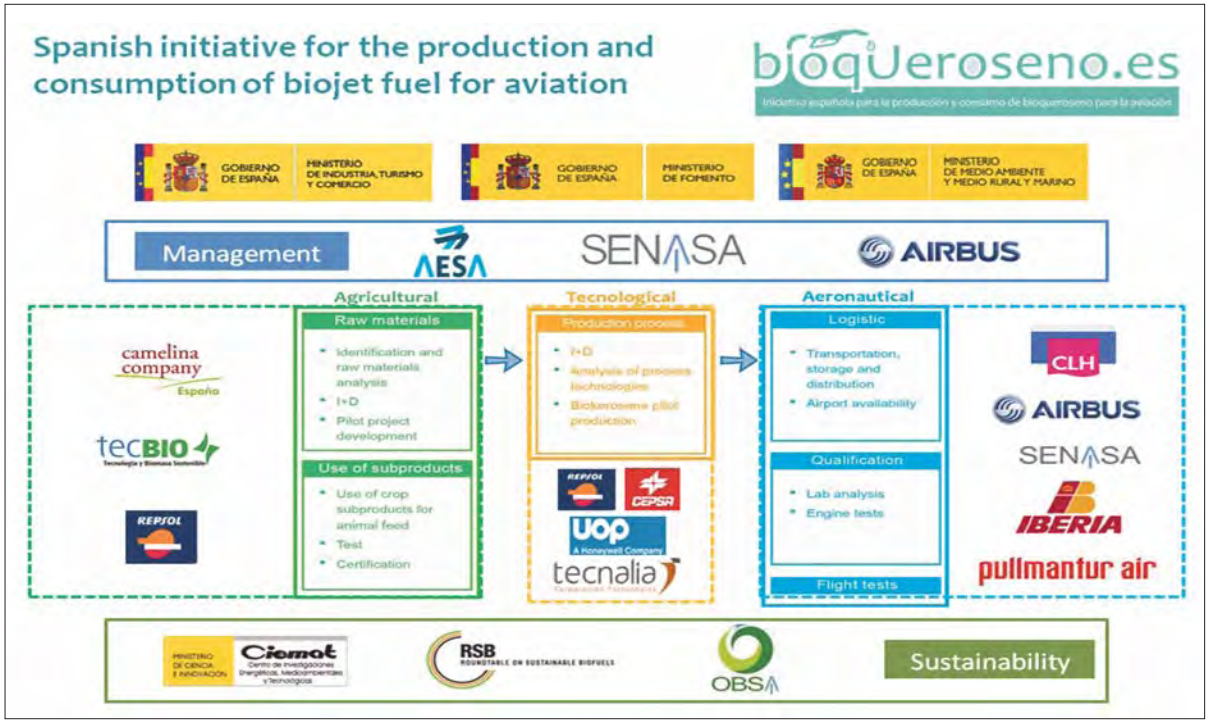


***Figure 17**: EU Advanced Biofuels Flightpath Initiative.*

soy), animal fats, and used cooking oil. In the future, feedstocks could come from oilseed crops such as camelina and jatropha, as well as algae, depending on availability.

Feedstocks are the key to the success of all renewable fuels from both pricing and environmental perspectives. Current feedstocks that are available in commercial quantities for HRJ production are based on the development of oilseed crops over the last 50 years. Future oilseed/lipid-based feedstocks are on the cusp of development but are not yet available at commercial volumes. Even with future feedstocks, all lipid-based biomass feedstocks are going to be difficult to reduce in price. To address feedstock costs, biomasses such as municipal solid waste (MSW), woody residues, and dedicated energy crops will be needed. These feedstocks are more economically viable because they can be derived in a more sustainable manner; thus leveraging existing approaches to recycling/managing land and water, and not creating competition for food acreage.

For the industry to achieve its future goals, the following conditions need to be operative:

- Commercial-scale facilities must be built in multiple locations to bring competition and regional solutions to the aviation industry.
- Continued efforts need to be made to understand the importance of sustainability and economic viability of feedstock supplies.
- Science and actual data, rather than speculation, must be used to determine the best path forward for all fuels, including biofuels.
- Policies need to be focused on success of the industry on a global basis.

Jet-A is a global fuel, and renewable jet fuels must follow the same path to be a solution for the aviation industry.

***Figure 18**: Imperium Aviation Fuels biorefinery project.*

Alternative Aviation Fuels: Practical Deployment Hurdles

Renewable aviation fuels are a challenge. Hydroprocessed esters and fatty acids (HEFA) fuels are a possible solution for the near term, but they are not a cheap source of energy and are limited by various supply constraints, such as competition with biodiesel. For example, the jet fuel component in the refinery has lower yields than the diesel component and these fuels are more costly and are limited in supply (only 2 million tonnes in production). There are also sustainability concerns with respect to land use changes. Ensuring sustainability is not simple. The biofuel supply chain is complex and sustainability must be traceable and auditable. Sustainability principles and criteria need to include and take into account: responsible business practices, labour conditions, community relations, responsible environmental practices, soil and water management, crop and biodiversity protection, and establishment of new plantations/operations.

Although production volumes will be low initially, the industry has made an impressive response to the CO_2 challenge. Solutions will likely include several feedstock/process combinations since there is no obvious single solution that is most cost-effective for airline customers at the moment. In the longer term, biomass and waste are likely to be better feedstock options. Assuring quality (and sustainability) in new supply chains will be essential, and new tracking and auditing schemes will be needed for recording biojet use and associated CO_2 credits. Also, since aviation is not the only game in town, there will be competition for the bio hydrocarbons assumed to go into aviation.

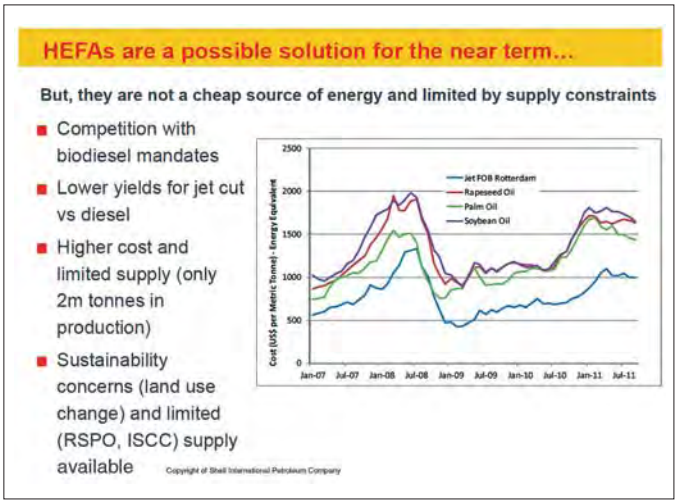


***Figure 19**: Vegetable oil costs compared with jet fuel.*

Building the Value Chain to Build the Business

In the United States, UOP has developed a technology for the production of HEFA-based renewable jet fuel. They have produced biojet fuel that has been used in over eight commercial and demonstration flights. They have supplied fuel used by DOD (Army, Navy and Air Force) for HEFA-certification of their fleets of traditional airplanes, helicopters, UAVs, tanks, and ships.

Producing sustainable alternative fuels for aviation is a complex business. Whole value chains need to be constructed from scratch. However, momentum has never been stronger, and industry's appetite to put all of the necessary pieces in place is growing. Ignoring any part of the value chain in any project – or the industry as a whole – will mean certain failure. For that reason, partnerships are absolutely essential for success.

Fuel Infrastructure at Airports: The Challenges

Airports Council International (ACI) conducted a fuel infrastructure survey of airports. They received 24 responses from airports of various sizes and locations, worldwide. All respondents had fuel farms, on or near the airport property. There was a mix of ownership and operational responsibilities.

The main observations obtained from the survey on delivering fuel to aircraft are:

- Whether upstream or at the fuel farm, jet fuel from different suppliers will generally be mixed.
- The same blend of fuel(s) is loaded onto all aircraft.
- Current jet fuel supply streams are handled interchangeably.

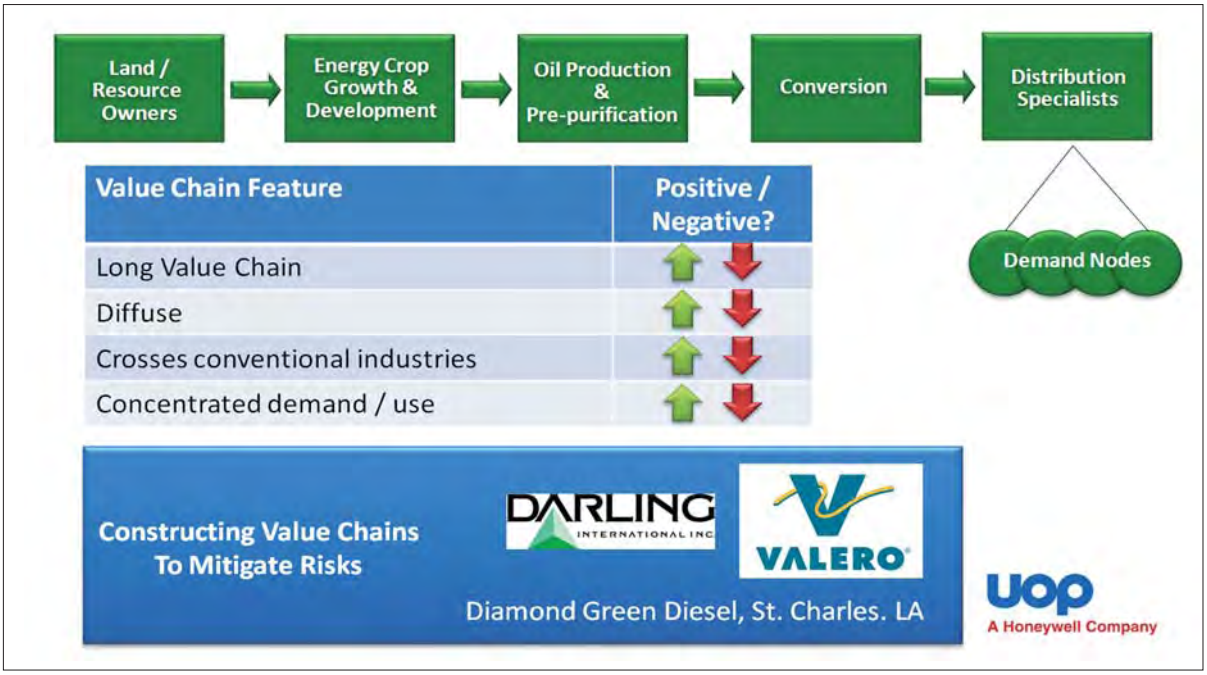


***Figure 20**: Sustainable Alternate Aviation Fuel Value Chain.*

There are a number of questions that arise when it comes to introducing biofuels:

- Where will biofuels be blended with conventional jet fuel? At the refinery (initial blending) or the fuel farm (secondary blending)? There are potential challenges in tracking the exact mix (% biofuel) in the fuel farm.
- How will the 50% maximum be monitored (i.e. in the interim before 50% biofuel is used throughout system)?
- If an airline purchases biofuel, but loads it through an airport fuel farm, will it be possible to track the exact fuel mix that is used on a particular flight?
- Will fuel suppliers and airline users want to keep track of different streams of biofuel blends?
- How will rates of biofuel used by airlines be monitored or verified? Will this affect accounting systems such as an airline CO_2 inventory or the EU ETS?
- Will official biofuel usage be based on purchase agree ments, or airport measurements, or some other mechanism?

Buying and Flying Sustainable Alternative Aviation Fuels

There are three important criteria that airlines need to meet before deploying alternative aviation fuels:

1) **Safety** – Addressed through the jet fuel specification and application of procedures to assure that fuel quality is maintained. This can be achieved right now.
2) **Environmental benefit** – Addressed through life-cycle greenhouse gas emissions and sustainability review. There needs to be a mechanism for regulatory and contract acceptance.
3) **Commercial viability** – Needs cost competitiveness and supply reliability. These issues are the major hurdles at this stage.

Airlines are committed to deploying alternative aviation fuels that yield environmental benefits, relative to traditional fuels; that is, alternative fuels which produce life-cycle emissions benefits without inducing other environmental problems. There are still many challenges which can impede deployment. Those challenges include: life-cycle emissions benefits must be creditable, accounting and crediting must be consistent with the way airlines buy and fly their fuel, and country-specific, end product "sustainability" requirements must not act as barriers. In addition, alternative jet fuel must be price competitive.

Power Generation in New Zealand (2010)

› Hydro-electricity	55%
› Thermal (incl coal, oil)	21%
› Geothermal	13%
› Co-gen (nat gas & industrial heat)	7%
› Wind	4%

Many companies generating and distributing but only one national grid.
Consumers can purchase from specific suppliers (eg. a wind farm), but then draw power from the one grid.

***Figure 21** : Analogous model for biojet collection and distribution.*

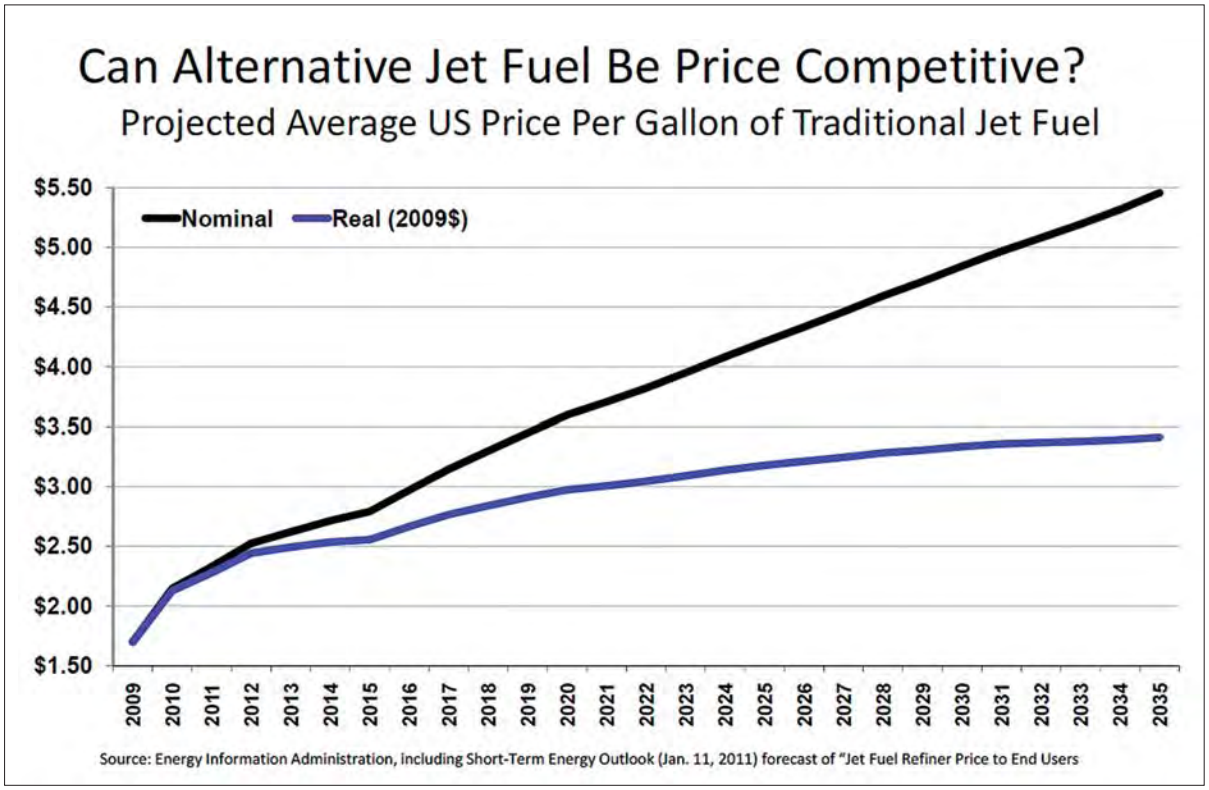


***Figure 22**: The price challenge for alternative jet fuel.*

Sustainable Alternative Aviation Fuel Development

Virgin Australia's approach to sustainable alternative aviation fuel is to work with the aviation industry to encourage development of a sustainable aviation biofuel industry. They also engage with governments to identify and remove impediments to facilitate the greater adoption of aviation biofuels. Governments play a vital role in supporting R&D and addressing impediments and market failures in the commercialization and scale-up of biofuel supplies. The Australian government is currently formulating a biofuels strategy that identifies scenarios and options that address regulatory and market barriers for the diversification of the transport fuel mix to 2030 and beyond. Virgin is also strategically supporting research that will accelerate the commercialization of competitively priced aviation biofuels. This important step cannot be overlooked.

Virgin supports the establishment of a biofuel sustainability standard that is tailored to Australian conditions. This is a vital step since such a standard will guide decision-making on the choice of projects and will give confidence to stakeholders. Finally, Virgin will strategically support biofuel development projects that utilize realistic technologies in fulfilling industry requirements. No single feedstock and technology will fulfil these needs. There will be a range depending on location, conditions, logistics, and other factors. Airlines can play an important role in lending expertise to projects, and ultimately entering into purchase agreements.

Globally, aviation represents about 11% of total current transport fuel demand. In contrast, road transport is the largest fuel consumer at 71%, and history shows that road users have a high willingness to pay higher fuel prices to maintain personal mobility and access to business freight services. Compared to aviation, road and rail transport have a greater variety of alternative fuels and energy modes available. ■

Partnerships and Cooperation

Partnerships involving civil organizations, government institutions, private sectors and research centres, among others, are integral to ensuring the achievement of a robust and coordinated strategy for the development and deployment of sustainable alternative fuels. Three presentations on the subject of Partnerships and Cooperation were delivered during the SUSTAF workshop. The presentations were made by the United States, Boeing and a Mexico-Spain joint initiative, prominent actors in the promotion of local, regional and international partnerships, all of which are actively engaged in high-profile collaborative projects. They all highlighted the importance and value of national and international cooperation and gave the current status of alternative fuels development efforts which have been made possible through partnerships and alliances. They also outlined the objectives of future collaborative work programmes.

Alliances in the United States to Support Sustainable Alternative Fuels

The Federal Aviation Administration (FAA) and the United States government have initiated several public-private partnerships on alternative fuels, both within the US and internationally. The Commercial Aviation Alternative Fuels Initiative (CAAFI) is a good example of these types of partnerships which are used to leverage additional resources from industry. Another example is the Continuous Lower Energy, Emissions, and Noise (CLEEN) programme, which is a technology development partnership agreement with a one-to-one cost sharing with industry. PARTNER, which includes life cycle and Local Air Quality (LAQ) analysis is a collaboration among FAA, industry and academia, and again there is a one-to-one cost share amongst participants. Each of these programmes allows for the pooling of resources and the sharing of common goals between the US and international partners. Likewise, significant interagency cooperation within the US on alternative fuels exists in order to facilitate access to resources.

The partnerships initiated by the US, have been both formal and informal. Regarding formal agreements, the US has made non-binding agreements with the governments of Australia and Brazil, and additional agreements with other countries are currently under discussion. Partnerships are important when addressing the entire supply chain, which normally involves a wide array of stakeholders. Such agreements allow the leveraging of resources and funds, and avoid the duplication of work. Most importantly, public-private partnerships ensure that industry is directly involved in the development of alternative fuels technology. The primary role of governments is to facilitate the removal of barriers which allows industry to drive the development of technologies.

Global Collaboration On Aviation and Sustainable Biofuels

The Boeing sustainable aviation biofuel strategy demonstrates how far global research and collaboration in sustainable biofuels has come, in a short period of time. Boeing convened a regional assessment project in the Northwest United States (SAFN – Sustainable Aviation Fuel Northwest), which conducted: the assessment of opportunities and challenges across multiple biomass feedstock supply chains, the identification of sustainable principles and practices, and the production of collaborative and consensus-driven action plans. SAFN stakeholders assessed feasibility of regional supply chains, who would need to be involved, feedstock options, and opportunities and challenges. The top six SAFN recommendations are similar to global themes and reflect the need for long-term stable policy and continued collaboration. Projects with China on biofuels have also been significant and have included: feedstock and technology evaluation studies, inaugural flights, trans-pacific flights, and algae research by the Qingdao Institute of Bioenergy and Bioprocess Technology (QIBEBT).

The next steps in biofuel development include a continued emphasis on sustainability and a focus on research into the expansion of feedstocks and development pathways. Some of the future challenges include scaling-up to commercial level of production at a competitive cost. Significant progress has been made in biofuels development but there are still plenty of challenges ahead, which require global collaboration. There is no one feedstock or technology that will be the solution to the development of sustainable biofuels in aviation on a worldwide basis-rather, a portfolio of options based on regional practicality. Currently, global efforts are comprised of local, regional and global initiatives, all of which are essential for success.

Mexico-Spain Partnership: Biofuels Deployment

While most countries develop national partnerships, Mexico and Spain have developed a successful country-to-country framework agreement on air transport, safety and sustainability. The agreement was achieved through the identification of areas of common interest, and topics covered include: emissions reduction action plans, sustainable production agricultural potential, employment generation, and energy dependence reduction. In addition, an agreement was reached on cooperation in aviation biofuels development and usage with the aim of boosting the deployment of sustainable fuels. This cooperation includes: common use of information and tools, data sharing, application of the Roundtable on Sustainable Biofuels (RSB) sustainability criteria and analysis of social impacts. The country-to-country framework has also fostered collaborations with civil organizations, government institutions, private sectors and research centres. For example this includes a cooperation on the 'Flight Plan' programme between Honeywell's UOP, ASA (Airports and Auxiliary Services) and Boeing. The goals of this agreement are 1% national use of biofuels by the year 2015 and 15% by 2020.

Each of the two countries has its own particular issues and requirements, but some common sustainability criteria on biofuels production are applicable across both countries and to different feedstocks. There is increasing emphasis on analysis of opportunities for the use of underdeveloped or abandoned rural areas (~685,00 hectares in Spain), as well as on how to make land more productive to meet the needs of biofuels for aviation. For these two countries, the biofuels industry is also likely to provide substantial economic benefits. For example, the Spanish initiative for the production and consumption of bio jet fuel for aviation (Bioqueroseno), which is a collaboration between AESA (Agencia Estatal de Seguridad Aerea), SENASA (Servicios y Estudios para la Navegación Aérea y la Seguridad Aeronáutica), Airbus and OBSA (Observatory of Sustainability in Aviation) aims to grow 100,000 hectares of feedstock on abandoned land. This will be an important new source of employment and wealth creation, as approximately 2,200 jobs, and USD $70M are expected to be generated. ■

Legal and Regulatory Framework

As with many aspects of alternative fuels, the legal considerations cannot be exclusively considered within the bounds of international aviation. It is important that legal and regulatory instruments be considered in the context of other industries such as energy and agriculture. Strong inter-industry collaboration needs to be undertaken at national, regional and global levels.

During the ICAO Aviation and Sustainable Alternative Fuels Workshop, four presentations on this subject were delivered. The presentations from ICAO, the United States, Mexico and the Sustainable Aviation Fuels Users Group (SAFUG) highlighted the necessity of implementing robust legal and regulatory frameworks, on a national, regional and international scale. These are key to facilitating cooperation among stakeholders, as well as for creating a legal environment conducive to the development of sustainable alternative fuels.

Facilitating International Cooperation for Sustainability: The Role of ICAO

ICAO's work in the field of environmental protection involves cooperation with several other UN bodies (i.e. UNCFCC, WMO, UNEP, IMO, FAO, UNCSD, CSD, IPCC and UNDP) and is a good example of cooperation at a global level. These UN agencies are working together toward the UN Conference on Sustainable Development, or RIO+20, in order to present a common UN message to the international community. ICAO expects RIO+20 to set a clear policy direction for renewable energies, which will take into consideration individual sector challenges, particularly, the specific constraints of the aviation sector.

The development and deployment of alternative aviation fuels is an important part of ICAO's climate change policy, which includes several key objectives:

1) To reach global aspirational goals for the international aviation sector to improve its annual fuel efficiency by 2% and stabilise its global CO_2 emissions at 2020 levels, and perform further work to explore the feasibility of a long-term global aspirational goals.

2) To develop a global CO_2 certification standard by the year 2013.

3) To continue to facilitate the development and deployment of sustainable alternative fuels for aviation.

Legal and regulatory frameworks can address three important issues: the supply of alternative fuels to aviation, sustainability requirements, and price. They can act as incentives or enforcement mechanisms, but importantly should not become barriers. Sustainable aviation fuels are considered an important means of reducing aviation emissions and ICAO, as a facilitator, has a role to compile and disseminate the information to States, and to respond to their questions. There are many areas where policy and legal frameworks can facilitate the development and deployment of sustainable alternative fuels for aviation and a variety of expertise is necessary for future work. ICAO needs to build on experiences and current practises to aid the development of appropriate policies and legal frameworks. This will require a concerted global effort which must consider the many national and international policies and regulations. These two policy levels interact strongly, with the thousands of international policies developed by ICAO influence national regulations. The same can also be true in reverse, in fact there are many standards in ICAO which have been born from national regulations. The development of these policies and regulations requires a concerted global effort. ICAO's role as a facilitator, is to encourage States to develop policies and regulations which can accelerate the development of sustainable alternative fuels. ICAO provides the forum where aviation is united as one on many topics and States look to ICAO for guidance on the development of sustainable alternative fuels.

Mexico Case Study: Strategies for Getting Aviation Biofuels to Market

In Mexico, PEMEX (Mexican Petroleums) is the sole producer of jet fuel and ASA (Airports and Auxiliary Services) is the sole supplier. In terms of aviation fuel supply, Mexico is self-

sufficient, and currently 4% of the fuel volume PEMEX produces is aviation fuel. However, as demand for air transport increases, Mexico may well become a net importer of aviation fuel. Currently, ASA manages all 60 fuel farms in Mexico which together produce 10 million litres of aviation fuel per day. To put this number into context, Los Angeles Airport (LAX) sells more fuel than this per day. The future use of biofuels in Mexico is important if that country is to meet the future demand for aviation fuel and the challenges posed by the goal of environmental sustainability. Work is currently ongoing to modify the Mexican legal framework (through the Flight Plan exercise, which has identified 54 relevant and sometimes contradictory laws) in order to enable the production and supply of aviation biofuels.

There are currently a number of biofuel plantations established in Mexico, including; jatropha (>30,000 hectares), and palm oil (>60,000 hectares). However the majority of these operations are outside of the current legal framework. Feedstocks will only be taken from sustainable plantations, and therefore there is a need to license biofuel plantations, and a complication is the bureaucratic process which requires any producer to hold licenses from three different government departments (Energy, Environment and Agriculture). The current effort on the legal framework in Mexico is to reduce this bureaucracy. Also, to meet demands, the production of smaller farmers (Ejidos) must be considered. It is proposed that these be managed through cluster type organizations to produce the feedstocks. To achieve this, while at the same time meeting demand, policies must be drafted to promote biofuel production at an appropriate scale. To service 1% of the aviation fuel demand by 2015, Mexico needs to produce 40 million litres of alternative fuel.

The role of the Mexican government is to close the gap between fossil fuel and biofuels, in terms of cost. For example, Mexico undertook a full alternative fuel production pilot study which produced biofuels with a market cost of 300 Pesos per litre, which is 30 times more expensive than the current aviation jet fuel price (of 10 Pesos per litre). This gap can be narrowed through mechanisms such as: mandates, fiscal incentives, loan guarantees, uptake agreements, and subsides. Innovative public policies are needed to promote the development of the different parts of the supply chain, an activity in which governments must take an active role.

Creating an Enabling Environment for Production and Use of Biofuels in the United States

The challenges involved indeveloping new technologies is aptly described in the 'Valley of Death' analogy, as shown in **Figure 23**. It is a frame of reference which shows the risks associated with taking technologies through the development phases to commercialization. For alternative jet fuels the important questions are, among other things: Is there a market? Is the fuel approved for use? What is the cost? The challenge is to minimize the various areas of risk and to overcome any barriers, in order to make a technology development bridge.

***Figure 23**: Bridging new technologies 'Valley of Death' (Chart courtesy of W. Harrison, U.S. Air Force)*

The barriers to the development and use of alternative jet fuels in the US are: feedstock availability, the competitive cost of alternative fuels, performance and safety approvals, environmental impact uncertainties and investment risks in creating production infrastructure. To generally address these issues, the United States government policies fall into two major categories, (1) public R&D investments (i.e. funding and cost sharing, testing and analysis) and (2) public deployment policies (i.e. fiscal incentives, public financing, regulation and government procurement of fuel).

It is clear that R&D and deployment policies will be more successful if they are coordinated. This can be done by specifically addressing each link in the supply and technology development chain and by creating an enabling environment. It is important to acknowledge that there is no one-size-fits-all policy, rather, there is a menu of policies which need to be applied to the relevant barriers and the fiscal situation.

Government Support for Biojet: The SAFUG Experience

The objective of the Sustainable Aviation Fuel Users Group (SAFUG) is to accelerate the development and commercialization of sustainable aviation fuels. All members of SAFUG have signed a sustainability pledge to:

- Meet a sustainable standard with respect to land.
- Use water and energy at sustainable levels.
- Not displace or compete with food crops.
- Exhibit minimal impact on biodiversity.
- Provide a positive socio-economic impact.

The guiding principles of SAFUG are designed to: act as a temporary support mechanism, ensure high sustainability standards, maintain competitiveness and parity with other sectors, and focus on reducing the risks associated with biojet investment.

Within the European Union (EU), the target for renewable energy use is set by the EU Renewable Energy Directive (RED). The overall target is currently set at 20% of energy to come from renewable sources by 2020, and the target is 10% for all forms of transport. From the perspective of the EU SAFUG, policies such as the EU RED (as well as national implementations, such as the UK RTFC), which exclude aviation, prevent a level playing field with road transport. Furthermore, mandating a biofuel blend would distort the market and should not be applied. The way forward should be through the application of a long-term stable policies and through government support for scaling-up production and deploying biojet. A source of revenue for government support could be the EU Emissions Trading Scheme (ETS). Although the EU ETS is helpful in stimulating movement towards biojet use, it is only a modest incentive. The EU SAFUG currently perceives inadequacies with respect to the current reporting mechanism of the EU ETS, and specifically with regard to the reporting of how much biofuel is used in every flight. The EU SAFUG would rather see a move towards purchase-based reporting, as shown in **Figure 24**. ■

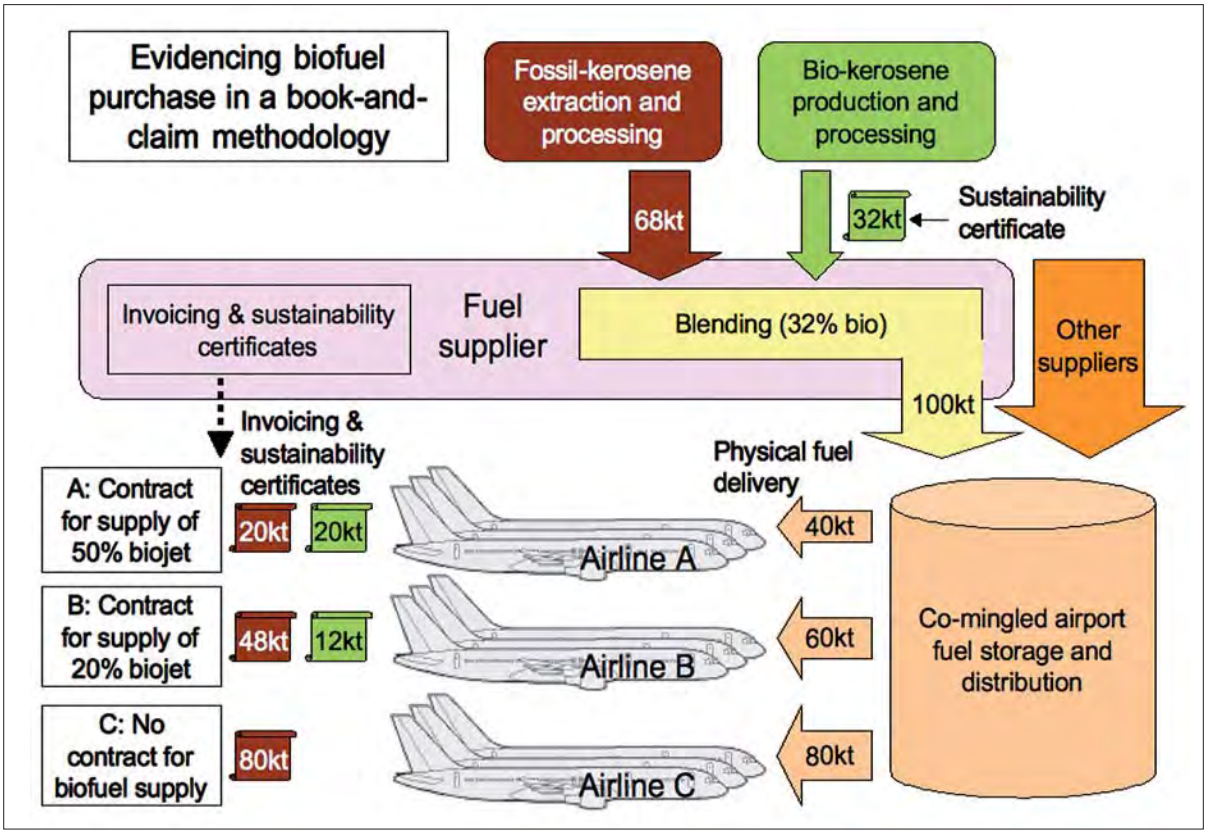


***Figure 24**: Purchase based reporting*

Accounting, Life-Cycle Analysis, Sustainability

Life-cycle analysis greenhouse gas accounting is intrinsic to the management and control of carbon emissions and is vital for taking stock of the environmental impacts of environmental protection programmes and green initiatives. While significant efforts have been made towards establishing clear analysis and sustainability criteria, the aviation biofuel community currently lacks an agreed upon set of tools and metrics to account for life-cycle carbon emissions, and the overall sustainability of biofuels. At the SUSTAF workshop, four organizations that have been instrumental in the ongoing development, identification and refinement of an accounting framework and sustainability criteria gave presentations on their work in this domain. The presenters were: Air Transport Association of America (ATA), Roundtable on Sustainable Biofuels (RSB), International Council on Clean Transport (ICCT) and PARTNER, of the Massachusetts Institute of Technology (MIT).

Accounting, Life-Cycle Analysis and Sustainability and the Role They Play in the Deployment of Aviation Alternative Fuels

The commitment of airlines to the development and sustainability of biofuels has grown rapidly, as demonstrated by the establishment and agreement of voluntary commitments, such as the Global Sectoral Approach (GSA) targets. ATA member airlines are seeking alternative fuel sources with reduced emissions profiles relative to traditional fuels. The industry is working to ensure that alternative jet fuel will meet accepted criteria to be more environmentally friendly than traditional jet fuel. In particular, it is seeking a reduced emissions profile on a life-cycle basis, without compromising critical uses of relevant feedstocks. There are also regulatory requirements that will work towards similar outcomes for sustainable biofuel production. Two examples include the U.S. Renewable Fuels Standards (RFS) and the European Union Emissions Trading Scheme (EU ETS).

Life-cycle analysis is emerging as an important tool to support these commitments. Steps in this direction have already been established, and there is currently an understanding of how to apply them to aviation. Yet, there are still areas where agreement is needed, such as, how and when to consider land use changes, and the appropriate means of certifying compliance. Several means for this are now available, including: U.S. RFS programme, third-party certification programmes, Roundtable on Sustainable Biofuels, and others. However, factors such as ease of use, availability, cost, application thresholds, and other issues, are still challenges. Thus, there remains a need for international compatibility and acceptance.

With regard to sustainability considerations, airlines have stated that they do not want to induce environmental harm. However, there are differing views as to the practical implications of this approach with regard to such issues as: scope, criteria, thresholds, applicable environmental standards, which parties in the supply chain carry what portion of the responsibilities, and international compatibility and acceptance.

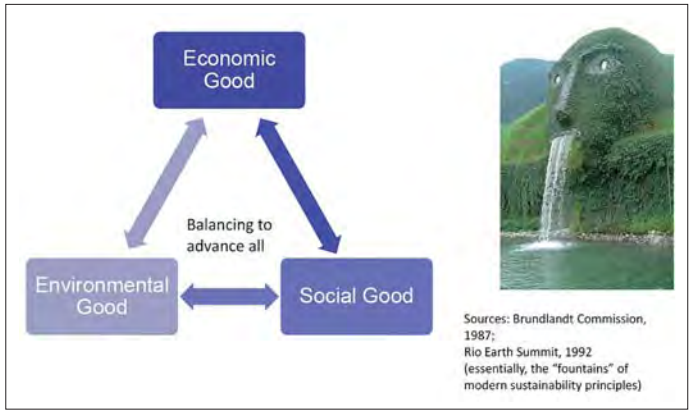


***Figure 25**: Understanding sustainability.*
(Source: Bruntland Commission, 1987; Rio Earth Summit, 1992).

Significant work is underway to address these issues. For example, both the Global Bioenergy Partnership (GBEP) and the Commercial Aviation Alternative Fuels Initiative (CAAFI) are working to strengthen methods, models, modeling, data/analyses, and guidance. CAAFI is producing a side-by-side comparison of various frameworks. Sustainability considerations are also being addressed, working with existing initiatives, sources, and experts to develop guidance on environmental progression, and to potentially develop mechanisms to confirm performance criteria. Ultimately, for the international aviation industry, positive progress is being made.

Biofuels Sustainability Certification By Third Party Verification

Voluntary standards are used to improve production practices in many industry sectors. With regard to biofuels, such standards are not consistent. For that reason, certification helps to distinguish between good and bad practices. The Roundtable on Sustainable Biofuels (RSB) has developed a structured mechanism for making these distinctions. The RSB certification process follows seven discrete steps as follow:

Step 1: Define the Scope;
Step 2: Self-Evaluation, Self-Risk Assessment, and GHG Calculation;
Step 3: Apply to RSB Services;
Step 4: Receive your RSB Code;
Step 5: Engage an Accredited CB;
Step 6: Independent Audit;
Step 7: Certificate Issuance Decision.

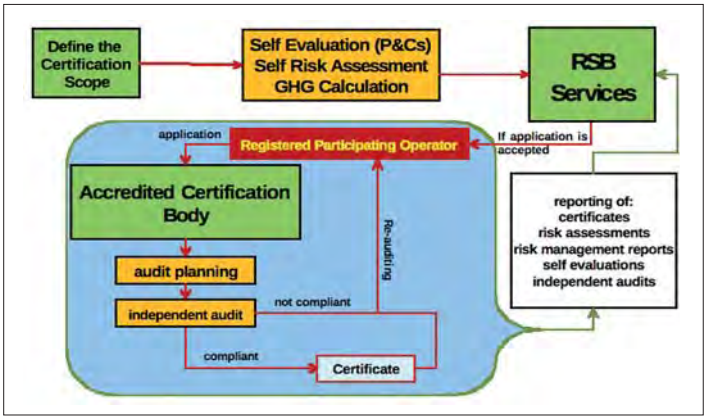


***Figure 26**: RSB certification process.*

Step 2, self-evaluation, is the backbone of the RSB Standard, which is guided by 12 Principles that cover the main aspects of sustainability and apply to almost all industries. Under each Principle are several criteria and "minimum requirements", each one with associated Compliance Indicators. Participants in the process are required to conduct their own self-evaluation against the RSB's Principles and Criteria as a first step in the certification process. Going through each of the indicators individually forces the participants to familiarize themselves with the standard, and provides an idea of where participants place in relation to the Standard.

RSB has developed a multi-methodology greenhouse gas (GHG) calculator for biofuels. It is freely available to the public and measures emissions of biofuels for each lifecycle production step, from farming to final fuel distribution. The calculations inherent in the methodology support various established programs including: RSB Method, EU Renewable Energy Directive (RED), CH (MinOEV) Swiss standard (for tax-relief), USA RFS2 (with default data), and the California Low Carbon Fuel Standard (with default data).

Although the concept of risk management is not new, the RSB is one of the first certification systems to use risk management as a central feature of the system. During their self-assessment, participants are assigned a risk class. On average, participants will be subjected to annual audits. RSB also maintains a strong chain of custody requirements to ensure that only biomass/biofuel that complies with the RSB standard is associated with RSB compliance claims made by participants.

The Indirect Effects of Biofuels: Identifying Truly Sustainable Alternative Aviation Fuels Pathways

It is expected that over the next 40 years, to the year 2050, biomass resources will be under increasing demand for road transport, power, food, and a number of other competing priorities.

While the ICCT recognizes that biofuel development will have a direct impact on emissions from farm fuel, fertilizer application, fuel processing, and distribution, they also emphasise that a large-scale transition to biofuel use will have significant indirect impacts, affecting the net GHG balance. These indirect impacts could include: indirect land use changes (iLUC) that result in carbon emissions, biodiversity loss, and social

impacts. Other possible indirect effects include: creation of competition with food crops resulting in increased food prices, displaced 'waste' streams that are already productively used, or competition with the heat and power sector for biomass. Consequently, in order to address these potentially problematic indirect impacts of biofuels, the demand for biofuel crops must be met by some combination of a number of factors including: increased production on existing agricultural land (yield increase), reduced consumption in other sectors (food vs. fuel), reduced global stocks (unsustainable), and bringing new areas into production (iLUC).

These are complex issues which are difficult to quantify. However, these indirect effects must be taken into account in the development of a long-term strategy for the use of biofuels for aviation. Using non-food crops, or even wastes, will not necessarily provide a steadfast solution. Aviation is not the only sector that could use these resources, and therefore a broad agreement on where such resources can be most effectively applied is warranted. Given both sustainability concerns and the other pressures on land use and biomass resources in 2050, the ICCT sounded a note of caution about whether the industry's target of 80% aviation CO2 emissions reduction from biofuels by 2050 was achievable. Price alone is likely to be unsatisfactory as the sole basis upon which biofuels should be selected, since doing so may lead to inappropriate or unsuitable choices.

Understanding Variability in Life-Cycle GHG Inventories of Alternative Jet Fuels

According to PARTNER, variability, although inherent in life-cycle assessment, is often not explicitly considered, and analysis results are typically reported as point values. This approach does not allow the development of new data sets that target the sensitivity of specific factors, which could help to determine best practices for reducing life cycle GHG emissions. For these reasons, a new methodological approach was developed using screening level life-cycle analysis (LCA) methodologies to understand how variability impacts LC-GHG inventories of transportation fuels. Screening level analyses provide preliminary assessments of technology alternatives with the intent of informing research funding and decision-makers. They also allow analysts to identify pivotal factors defining the LC-GHG emission profiles of fuel production for each life-cycle step and each feedstock.

Pathway	Feedstock	Availability	Scalability	Indirect impacts?
Thermo-chemical (Fischer-Tropsch)	Pretty much anything	Limited, to date	Cellulosic biomass pathways will be scalable when commercially viable	Dependent on feedstock and criteria. For energy crops on good land could be high.
Hydrogenation	Camelina oil	Very limited	Unproven	Could be low for responsible projects, but on high value land comparable to other crops
	Babassu oil	Very limited	Unproven	
	Jatropha oil	Very limited	Poor record to date	
	Algal oil	Hardly any	High – if it ever happens!	Low if avoids high value land and minimises water consumption
	Palm oil	Enormous	Proven	Without further controls, severe (no net carbon saving, biodiversity loss, social conflict)

***Figure 27**: Impacts of Alternative Fuel Production Pathways*

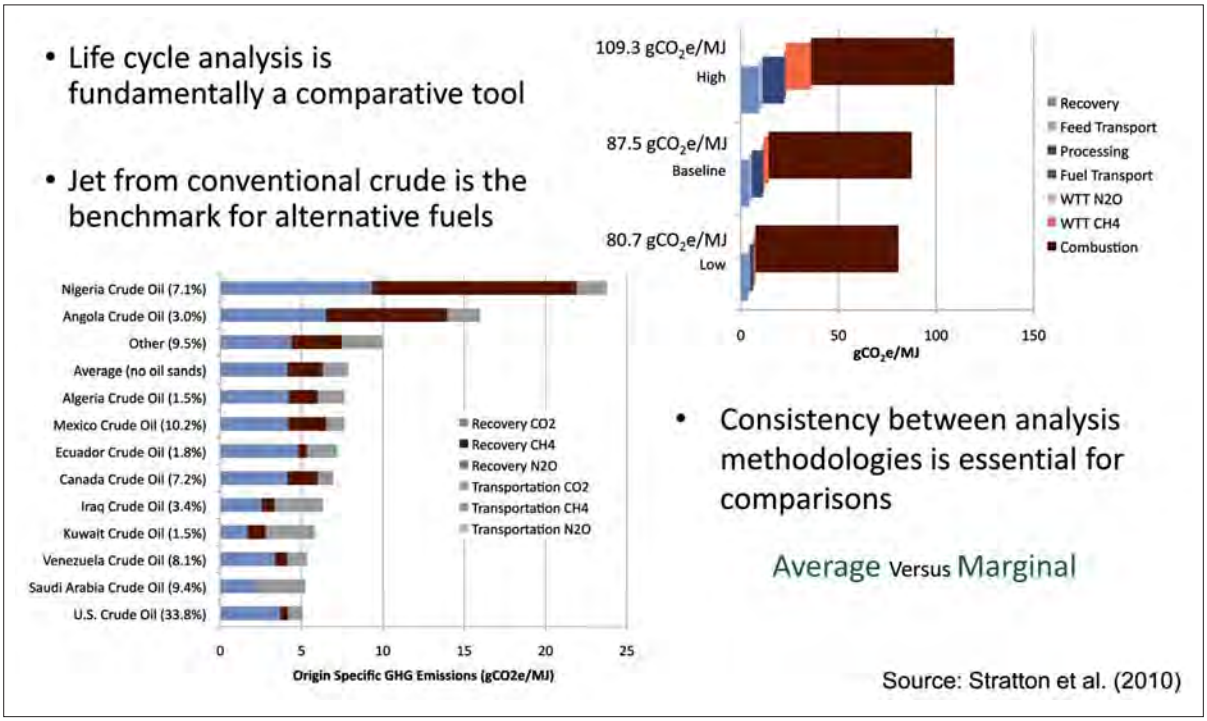


***Figure 28**: Variability of GHG Emissions by Process Pathway*

Multiple fuel production pathways were studied and specific types of variability were analyzed and quantified with the results being defined across a range. Jet fuel from conventional crude oil was used as the benchmark against which the other fuel production pathways were compared. The study found that feedstock type, biomass weight per cent, and carbon capture and storage (CCS) efficiency were very important to the amount of GHG emissions produced, while process efficiency and energy inputs were less important. Co-product allocation and land use changes were also found to be very important to the LC-GHG emissions.

Three key conclusions derive from the potentially dominating influence of these factors of variability, as follows:

1. Minimizing variability across LCA results by maximizing methodological consistency is essential to making useful comparisons between fuel options.
2. The absolute result from attributional LCA's may have a diluted physical meaning and is therefore most effective as a comparative tool.
3. Decision-makers and the general public should be presented with LC-GHG inventories as a range. This approach emphasizes the importance of understanding the key aspects that determine the LC-GHG emissions from fuel production and use. ■

Financing Alternative Fuels

Access to financing for aviation biofuels represents one of the biggest hurdles to the commercial deployment of sustainable biofuels. The time, expense and risk involved in sustainable biofuels production can serve as potential barriers to investment in the development of these fuels, on a commercial scale. However, possible solutions to overcoming these challenges are being developed by organizations worldwide. Such organizations include ACA Associates, Inter-American Development Bank (IDB), Aviation Fuel Solutions, Inc., Westar trade resources, and Bloomberg New Energy Finance, all of whom were invited to the SUSTAF workshop to share their insights on the economic and financial aspects of the development and production of alternative fuels.

Financing Alternative Fuels

According to ACA Associates, the International Air Transport Association (IATA) estimated that 2010 global jet fuel consumption was about 70 billion US gallons. As traffic grows over time, jet fuel consumption is also expected to grow. The current potential market for alternative aviation fuel is estimated at around 35 billion US gallons (or 50 per cent of total 2010 consumption) and the capital required to satisfy demand was evaluated at as much as US $1,000 billion.

Project identification and development is time-consuming, with multiple factors at play such as: diverse stakeholders, feedstocks, technologies, economics, etc. Governments and development banks can help finance the initial steps, but harmonization and consistency of regional rules are critical. Stakeholders need to be confident that ground rules are defined and stable for many variables including: fuel specifications, definition of sustainability, lifecycle assessment, regulatory framework, etc.

So far, substantial progress has been made towards making aviation alternative fuels a reality. Fuel specifications have been set and analytical toolkits made available. Banking standards have been established and feasibility issues are known. Financing solutions are being developed (US Government, IDB, etc.) and FT and HEFA production facilities are operational. However, additional work remains on harmonization of sustainability, and life-cycle analysis (LCA) criteria.

Importance of Harmonization: Hard Work Ahead

Current Status of Ground Rules

- **Fuel specification:**
  - Global agreement on ASTM 7566 Specification.
  - FT and HEFA approved.
- **Definition of sustainability:**
  - U.S. RINs governed by Renewable Fuel Standards (RFS).
  - EU covered by Renewable Energy Directive (RED).
  - Roundtable on Sustainable Biofuels (RSB) sets voluntary standards (IATA supports).
- **LCA analysis:**
  - Not consistent across RFS, RED, RSB.
- **Consistency of regulatory framework:**
  - International rules governed by ICAO.
  - Domestic rules set by each government.

Evaluation Tools

- Fuel Readiness Level (CAAFI) (ICAO adopted tool kit).
- Feed Stock Readiness Level (CAAFI).
- ACRP 02-18 (Metron/ACA) handbook for airports considering AAF.
- ACRP 02-36 (Metron/ACA) handbook for airports considering distribution of all alternate fuels.

Inter-American Development Bank (IDB): Support To Biofuels

The IDB was established in 1959 and now has 48 member countries in the Latin American and Caribbean region. It finances both private and public sector projects, with or without sovereign guarantees. It supports the sustainable development of countries in the region. The IDB provides funding of about US $8.6 billion per year (average over the period 2001-2010).

Available IDB Instruments To Support Biofuel Development Projects

The IDB offers a full spectrum of Public-Private Structures to meet the needs and expectations of member countries.

In addition, the IDB offers attractive financing conditions, depending on project needs (e.g. low interest rates, longer grace periods, and longer maturity periods – some cases, 40 years).

Available support instruments include loans and guarantees (US $12.5 billion in 2010, for all sectors) and non-reimbursable technical cooperation (US $830 million in 2010, for all sectors).

Examples of IDB-Supported Biofuel Projects: Including for Aviation

- In July 2007, IDB approved US$120 million to Usina Moema Acúcar e Alcohol Ltda., a major sugar, ethanol and bio-energy producer based in the State of São Paulo, for a biofuel project in Brazil. It was its first private sector financing of a bioenergy project in Brazil.
- In July 2008, IDB loaned US $269 million for three Brazilian ethanol plants.
- In January 2009, IDB supported the establishment of a regional financing facility for sugar and bio-energy, focusing on North-eastern Brazil, Mexico and Central America.
- In December 2009, the IDB provided US $25 million in funding to a combined ethanol refinery, sugar plantation and electricity plant in Peru; an initiative of Maple Energy Plc.

Biofuel Export Guarantees: Trade Finance Facilitation Program (TFFP)

The IDB's TFFP has issued guarantees for over US$600 million in support of hundreds of individual trade transactions.

Some Technical Cooperation (TCs) projects funded by the Sustainable Energy and Climate Change Initiative (SECCI) of the IDB:

1. **Haiti, Guatemala and Honduras**: National Biofuels Programs Feasibility Studies (BR-US MOU; $750k; BR-T1086; Mar 2007)
2. **Guatemala**: Action Plan (MEM; $400k; GU-T1095; Dec 2007)
3. **El Salvador**: Action Plan (MINEC/CENTA; $750k; ES-T1096; Mar 2008)
4. **Brazil**: MG Sustainable Energy Development (BDMG; $160k; BR-T1103; Jun 2008); Sugarcane workers requalification (UNICA; $500k; Jul 2009)
5. **Honduras**: Action Plan (SP; $600k; HO-T1101; Oct 2008)
6. **Chile**: Advanced Biofuels (For Energy; $1.000k; CH-T1096; Sept 2009)
7. **Colombia**: Innovation in Science and Technology applied to Biofuels (Colciencias; $830 k KPK/SECCI; CO-T1059; $1.5M CO-T1052 MME-DNP-MADR; Feb 2008)
8. **Guyana**: Expanding opportunities on Bioenergy (MAG; $925 k; JSF/SECCI; GY-T1041; Mar 2008)
9. **Peru**: Strategic Plan for Sustainable Energy & Bioenergy (MEM; $1M; SECCI; PE-T1146; Apr 2008)
10. **Retainer**: Expedite support to bioenergy through KPMG ($1M; SECCI; RG-T1554; Jan 2009)
11. **Sustainable Aviation Biojet fuels in LAC**: Regional initiative to support studies and analysis on potential technologies (SECCI; RG-T1904; Jul 2011)

Commodity Price Volatility: Impact on Biofuels Production and Supply- Aviation Fuel Solutions

According to Aviation Fuel Solutions, volatility in the biofuels market is caused by rising commodity and food prices, the fluctuating demand for biofuels, as well as increased speculation. This instability is amplified by the growing interconnectedness between energy and commodity markets and the increasing unpredictability of commodity markets.

First-generation biofuels like bioethanol and biodiesel rely on commodities such as sugar cane, corn, and rapeseed. Energy producers compete directly with animal-feeding operations and food processors for their respective commodities.

Greater integration between oil prices and agricultural commodity prices is likely to result in more pronounced price instability for cereal grains. However, the increase in food prices is not only due to its links to biofuels.

Demand for biofuels is also affected by crude oil prices. If oil prices are high, then biofuels can compete, and the demand for biofuels would therefore increase. A decline in oil prices increases demand for crude oil and reduces the demand for biofuels.

Biofuels Impact on Land Use

According to a study conducted for the government of the United Kingdom in 2009, the full replacement of jet kerosene by 2050 would require:

- 37 million hectares for new oil crops (camelina, jatropha, algae).
- 194 million hectares for woody energy crops (for BTL).
- A total 231 million hectares of land which represents 16% of all arable land.

Meeting these challenges will require instruments such as sustainability standards and planning regulation.

Second and third generation biofuels are promising, posing less competition for land and water needed for food production, and making a greater contribution to energy security. The feedstocks for these include jatropha and other oil-bearing, non-food shrubs that can grow on marginal land with little rainfall. However, questions regarding possible yields and required inputs, as well as the economics of growing these perennial poisonous shrubs for fuel production remain. Some studies have reported that, when jatropha is grown on arid and infertile soil, the oil yields are too low to be economic. It has been said that, "If you grow jatropha in marginal conditions, you can expect marginal yields."

Risk Assessment

An analysis of biofuel-related risks and their impact on project financing was conducted by Elobio et al in April 2010, with the following results:

- **Technology risk**: Relevant for new technologies which have a short track-record (or even none) in large-scale production operations producing a product of consistent quality, for a longer period of time.
- **Market risk**: Mainly refers to fluctuations in feedstock and biofuel prices and the correlation between the two, or lack thereof.
- **Regulatory risk**: As most biofuel production still requires policy support, it is important whether investors and lenders consider this support as adequate and stable, or insufficient and unreliable.
- **Geopolitical risk**: Relevant for production based on feed stock from regions with an unstable political environment, where export taxes or bans can be adopted without sufficient prior notice.
- **Stakeholder acceptance risk**: Refers to negative publicityreceived by biofuels during the food crisis of 2007/2008, which was seen as real threat to the reputation of finance providers who were associated with biofuel production; has caused some lenders to categorically deny funding to any kind of biofuel projects.

Table 29 illustrates the variations in risk levels for key risk factors, for both first and second generation biofuels.

Risk Type	First Generation	Second Generation
Technology risk	Low-medium	High
Market risk	High	Medium
Regulatory / Policy risk	High	Medium
Geopolitical risk	Medium	Low
Stakeholder acceptance	High	Low

***Table 29**: Risk profile of first and second generation biofuels.*

Risk Mitigation

Some of the risk mitigation options may include investing in multi-feedstock plants, hedging, and securing long-term contracts. The biorefinery concept maximizes the use of the biomass resource and generates revenue from different markets, lowering the risk of a slump in one of them. Although market risk remains high, these mitigation options make it less uncontrollable and thus, a lesser issue compared with technology risk.

Financing Barriers and Solutions – Westar trade Resources

The following table is an attempt to compile a comprehensive list of the known barriers to alternative aviation fuel development and production with a list of the possible mitigative solutions.

Barrier	Description	Solution
Current and Future Production Capabilities	Lack of equity market to fund development of pilot and demonstration plants.	Continued government support for new technologies to create a sustainable and exportable financial base and provide energy security.
Ability to Finance	Only a small number of technologies receive loan guarantees each year to build commercial facilities.	Government should evaluate and fund more sustainable technologies.
Where Facilities Could Best be Sited	Finding land within a region where primary and supplementary feedstocks are readily available or easily supplied for long term use	Seek facilities in marginal lands and other grassland areas such as "military bases or airports," for energy crop production and conversion.
Time from Project Inception to Plant Start-up	Average time for plant start-up is 3 to 5 years with extended gaps between final approval and funding commencement in financing programs.	Streamline process timing to help companies move through the process in a reasonable and affordable time frame.
Public-Private Investment Opportunities	Standardization for all companies without considering regional feedstock differences, technology advancements, and regional fuel requirements.	Evaluate each technology and determine economies of scale that provide maximum sustainable model and most consistent, long-term price for the fuels.
Start-up Costs to Begin Production	Start-up costs are formidable $5 to $12 million : • site development, engineering and design fees, environmental fees, permitting costs; • Feasibility study and business plan development, investment banking and legal fees, and corporate overhead and travel expenses.	Find and utilize a wide variety of government enhanced funding programs and alternative funding sources.
Fuel Certification	Time, expense, and risk in certifying alternative fuels hinder entry into the marketplace: • current timeline is two to three years; • demonstration plant must be built to produce the amount of fuel required for the final certification.	Processing needs to be efficient.
Unit Cost of Producing and Delivering Biofuel	Developing long-term offtake agreement on a base price not derived from fossil fuel pricing.	Directly relate price agreement to the final price paid for the feedstocks needed to produce the final products.
Importance of Long-term Off-take Contracts and Feedstock Contracts	Developing long-term offtake agreements without a pre-established market and choosing feedstocks that are regionally sustainable.	Secure long-term purchase contract and a long-term feedstock over the same term as the loan.

***Table 30**: Financial barriers and possible solutions for financing the development of alternative aviation fuels.*

Bringing Capital To Biofuels Technologies – Bloomberg New Energy Finance

Global investments in biofuels decreased from over $26 billion in 2007, to around $7 billion in 2011. The decrease is mostly a result of the financial crisis of 2008 which made access to capital difficult for a sector that was already over-extended. Recently, the situation has been improving, as the focus shifts towards next-generation technologies, as follows:

- Venture capital and private equity (VC/PE) investments have dramatically shifted from first generation to next-generation (next-gen) biofuel projects since 2006. Venture capital and private equity investments in next-gen projects now represent 95% of all VC/PE biofuel investments.
- Most VC/PE investments have gone to advanced biochemical companies in the last five years.
- Several biofuel companies have gone public over the last year. These companies have been next-gen firms using pathway technologies such as pyrolisis, enzymatic hydrolysis, and biobutanol fermentation.
- The US government has played a very strong role in providing financial support to the next-gen sector by carrying companies through the so-called "valley of death", to commercial scale production.
- By 2011, commercial scale next-gen projects were finally being financed and built, mainly in the enzymatic hydrolysis pathways.
- Enzymatic hydrolysis has received the most investments on the next generation pathway technologies; in front of advanced biochemical, gasification and pyrolisis. ■

Workshop Overview and Summary

Over three days, participants at the ICAO Aviation and Sustainable Alternative Fuels Workshop (18 to 20 October 2011, Montréal, Canada) had the opportunity to listen to and engage in conversation with more than 50 speakers on topics related to sustainable alternative fuels for aviation. It is impressive that even with the diversity of participants, there were many areas of agreement on what are challenging issues. This is due to a common vision of making international aviation a sustainable mode of transportation, shared by all. The objectives of this workshop, which were to stimulate a dynamic exchange of views and enhance dialogue among States, financial institutions, fuel producers and operators, on the role of sustainable alternative fuels for aviation in the environmentally sustainable development of the sector, were successfully achieved.

These three days were very rich in content, and I would like to walk you briefly through the broad range of discussions that were held.

I will begin with references to the welcoming remarks by the ICAO Secretary General, Mr. Raymond Benjamin and the keynote address by the UN Under-Secretary-General for Economic and Social Affairs, and the Secretary-General for the United Nations Conference on Sustainable Development, Mr. Sha Zukang. While highlighting the impressive progress made by ICAO and the international aviation sector in the area of environmental protection, and in particular, in reducing its impact on climate change, they also posed some very important questions to the audience: How will ICAO and the aviation sector work toward sustainable development, in the context of a green economy, and how will we transform what are currently barriers, into new opportunities?

Views from States and International Organizations

During the two initial panels, participants were informed of the different views of States and international organizations on the subject. They highlighted the recent developments and next steps being taken. **States** offered their perspectives on the growth of aviation and the pressure for solutions to the impact caused by such growth, as driving the need for alternative aviation fuels. They want to see a significant scale-up of biofuel production and, while they hope to see growth in the near term, they also want to be sure biofuels do not compete with food and are truly sustainable in that they reduce CO_2. They are also interested in seeing fuel price stability and identified the need for multiple biomass sources of biofuel. They are concerned about competition from other transport modes for those fuels, which could limit aviation's ability to grow, and they considered whether an aviation allocation is needed. States questioned what the best incentive policies are to stimulate the industry along these lines. To date, States have seen ICAO's role as one of information sharing. Following the rapid development of alternative fuels, they now look to ICAO for further engagement, especially in terms of supporting the development of model legal frameworks that consider incentive structures. They also look to ICAO to develop and provide guidance materials to help harmonize approaches globally, but that do not impose a heavy administrative burden, and that build upon the good work done by experts and organizations. Recognizing the need for a comprehensive global approach, States plan to engage with other States in cooperative development at the highest levels, looking to ICAO to guide these efforts and to support such activities as: economic feasibility research, training programmes and workshops. States' long term goals are substantial and will need intensive and sustained effort, cooperation, and information sharing.

WORKSHOP OVERVIEW AND SUMMARY

BY JANE HUPE CHIEF, ENVIRONMENT BRANCH

Environmental organizations see the potential in aviation biofuels, but recognize that the scale is daunting. They take a broad view and look for transparency in planning and development decisions. They caution about the need to ensure that robust, sustainability criteria are adopted by the industry and they have high expectations for comparative analysis to ensure that effective decisions are made. **Aviation organizations** note that good progress has been made and the industry has come a long way with initial steps towards a biofuel industry. The industry is committed to halving its emissions by 2020 and is well aware of the importance of sustainable biofuels to achieve this goal. They know the importance of having all stakeholders involved in developing a long-term plan and they look to public/private partnerships to be an essential component of future development. The aviation industry also emphasizes the need for global standards. **Standards organizations** acknowledge that measuring sustainability is very complicated with both direct and indirect impacts that must be considered. Biofuel legislation, such as the various renewable fuel blend standards, is developing rapidly around the world and they want to ensure that these efforts start out in the right direction. They noted that the current policy levers are effective.

Consortia

Consortia have formed around the world at the local, state, and regional levels; some are even multinational in scope. These consortia are actively evaluating the production and use of aviation biofuels. Many of them have overlapping membership and they cooperate on their common goal of developing alternative aviation fuels. Consortia have organized using a variety of models and often focus on different links in the supply chain, as well as various feedstocks, and a range of different processes. Some consortia are focused on impacts and benefits, others are looking at sustainability and certification, while others study economic feasibility issues. Some are looking at near-term development, while others are looking more to the long-term. Still others are focusing on research as they seek more fuel knowledge rather than being concerned with certifying a particular fuel or production pathway. Finally, there are some groups that are working exclusively on deployment matters. Yet, in spite of their wide range of interests, these consortia all share a common goal of bringing together different stakeholders and experts to work collaboratively and foster the development and deployment of biofuels, by building upon the synergies created by their expertise.

Research

Research into alternative aviation fuels is paramount to making progress in this area and is being conducted around the world. Targets for research arise out of aspirational goals that have been set by the States and industry groups. There is significant activity researching numerous sources of biomass and other feedstocks, as well as many production pathways. New research has begun to look at integrated biorefineries as a way to increase production efficiency and lower production costs. Funding priorities must include research, demonstration, and industrial initiatives. New research projects are addressing industrial wastes for fuel production, enhanced agricultural development, and new process integration approaches.

Qualification

There are clear institutional arrangements, processes and steps in place for approving new sustainable fuels. Two pathways have already been approved, with Fischer-Tropsch approved in September 2009, and HEFA approved in July 2011. More are planned, such as alcohol-to-jet fuel. The current mechanisms work to qualify fuels globally and are adequate for the needs of the commercial aviation industry.

Deployment

Production targets are large, and goals are aggressive, so even with as much as has been achieved so far, much more needs to be done. All speakers identified feedstock availability as a crucial issue that needs attention. Feedstocks are the key to success of all renewable fuels from both the pricing and environmental perspectives. Research, development, and deployment roadmaps are continuing to be created. Global development is needed to meet demand, promote competition, and ensure sustainably viable aviation fuels. The harmonization of sustainability criteria is a significant issue and one that needs to be addressed at the global level. To address these issues, partnerships are needed along the entire supply chain. There is plenty of demand and now a value chain is needed to meet that demand. It was noted that there are multiple fuel delivery schemes and systems for fuelling aircraft. Those used for biofuel delivery must be able to ensure proper fuel preparation and credit for sustainability objectives. Life-cycle analysis and sustainability measures need to be agreed upon, with the basic elements in these agreements being emissions factors and the means of certifying compliance. Sustainability provisions must be harmo-

nized internationally and accounting and crediting methods consistent with the way airlines and airports operate. Individual companies cannot meet the needs of global fuel production and full supply chain collaboration is needed.

Partnership and Cooperation

Formal and informal partnerships are important to accomplish the significant tasks in front of us. In a global industry, it is very important that governments be involved in these partnerships. Biomass producers, NGOs, universities, and trade associations can be important partners. Cooperation results in a wide range of benefits in addressing the big challenges the industry faces. These types of partnerships will also lead to benefits in fuel production, employment, and social well-being. It is clear from this workshop that sustainable alternative fuels are a key element in the strategy for reducing the carbon footprint of aviation. Alternative fuels could offer a complete solution. Indeed, alternative fuels will certainly figure prominently into the ability of the aviation industry to meet its future fuel demands under the three pillars of sustainability: social, economic, and environment. Sustainable alternative fuels will reduce aviation's dependence on fossil fuels, while stabilizing the economic volatility, and providing significant environmental benefits. However, important challenges still need to be resolved such as production scalability and financing issues. Regardless of these challenges, the importance of alternative fuels as part of a balanced and robust strategy towards the mitigation of the impact of aviation on the environment is beyond question.

Legal and Regulatory Framework

It is very important from the outset, to ensure that the development of a policy framework for aviation alternative fuels considers the need for integration and complementarity among local, national, international, legal, and regulatory frameworks. Cooperation is essential among States and international organizations on issues related to the production and use of sustainable alternative fuels for aviation. ICAO cooperates with many other UN bodies, especially in the environmental arena and these relationships will become even more important in ensuring the compatibility of frameworks. States acknowledge that incentives are needed, but flexibility is also important. In this context, the role for ICAO needs to be defined in a way that it supports and harmonizes the development and deployment of alternative fuels. This may include harmonization of sustainability criteria and developing model legal and regulatory policies, among others. Yet, the focus cannot remain only at the State level. Local policies and conditions must also be acknowledged and considered. Throughout all legal and regulatory levels there exist many conflicts and inconsistencies. In addition, many levels of approval are required to actually produce these important new fuels. Policies and incentives need to be targeted to deal with specific barriers in order to: enhance production efficiency, ensure global consistency, reduce investment risk, and confirm workable certification and qualification programs. Governments can and should address barriers and risks. R&D and deployment need to be coordinated and policies need to be adaptable to different situations.

Accounting, Life-cycle Analysis, Sustainability

Life-cycle greenhouse gas accounting is important to ensure that carbon emissions are controlled, and that reduction actions do not induce other environmental problems. Industry has taken steps on voluntary commitments and regulatory requirements are in place in many States. However, there remains no international agreement in this area. Work is being undertaken to prepare a comparison of various current frameworks as a step towards harmonization. There have been several rigorous programs to develop analytical tools for sustainability certification. As a result, areas have been identified where careful measurement and evaluation are needed to ensure quality results. While industry recognizes that there is currently a great deal of uncertainty about these approaches, it believes that it is important to use these tools to guide development efforts. Indirect effects, which are always present, and in many cases are responsible for the most significant limitations to expected benefits, are also the hardest to predict and quantify.

Financing

The last workshop panel, Financing, heard about initiatives and example projects of the Inter-American Development Bank (IDB) with respect to aviation alternative fuels. Its numerous investments have demonstrated its interest and concrete support for the development of these fuels. The workshop also heard about: price volatility, the influence of external factors on price and demand for biofuels, and means and sources of financing.

A significant amount of useful information has been gathered during the workshop. This information will surely assist ICAO and all aviation stakeholders in arriving at a way forward for

alternative fuels that enables the aviation sector to diversify its fuel supply base and become sustainable. This information will also help ICAO in formulating its message in international fora, such as the Rio+20 conference. To that end, a questionnaire was distributed to the participants seeking their input as to what could be the main message to take forward to Rio+20. Based on the feedback from the questionnaire, the message that was most often ranked as #1 was:

> The development of alternative fuels for aviation that will contribute to all three pillars of sustainability as follows: these fuels can have a positive effect on the environment by reducing net CO_2 emissions and improving local air quality through reduced particulate matter emissions; the creation of an alternative fuels industry provides a new source of employment and further facilitates travel, thereby delivering a positive contribution to society; and, alternative fuels can help to stabilize fuel price volatility, while providing a source of economic development in non-traditionally fuel producing regions of the world.

Broad and concerted international action will be necessary to translate into reality the potential that alternative fuels offer. Already, this Workshop contributed to the international community's efforts towards a globally harmonized roadmap for sustainable development. It has also served as an important milestone in preparation for Rio+20.

By addressing the role of sustainable alternative fuels as part of the measures available to States for inclusion in their action plans to reduce CO_2 emissions, this Workshop has moved us closer to possible initiatives towards meeting the global aspirational goals set forward by the 37th Session of the ICAO Assembly.

ICAO has successfully brought together experts and organizations from around the world to address all of the issues surrounding alternative fuels for aviation. By combining our collective capabilities and working together, we can already see the emergence of many new ideas, and the dawn of a brighter and more sustainable future for aviation. ■

Publication support

Shaun Fawcett, Text editing

Studio Idées en Page Inc., Graphic design and photomontages

All photos from BIGSTOCK®, shutterstock images®

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