70 YEARS 1945—2015
Flying better. Together.

IATA

IATA Sustainable Aviation Fuel Roadmap

1st Edition

NOTICE

DISCLAIMER. The information contained in this publication is subject to constant review in the light of changing government requirements and regulations. No subscriber or other reader should act on the basis of any such information without referring to applicable laws and regulations and/or without taking appropriate professional advice. Although every effort has been made to ensure accuracy, the International Air Transport Association shall not be held responsible for any loss or damage caused by errors, omissions, misprints or misinterpretation of the contents hereof. Furthermore, the International Air Transport Association expressly disclaims any and all liability to any person or entity, whether a purchaser of this publication or not, in respect of anything done or omitted, and the consequences of anything done or omitted, by any such person or entity in reliance on the contents of this publication.

Senior Vice President
Member & External Relations
and Corporate Secretary
International Air Transport Association
33, Route de l'Aéroport
1215 Geneva 15 Airport
Switzerland

IATA Sustainable Aviation Fuel Roadmap
ISBN 978-92-9252-704-4

Montreal—Geneva

Table of Content

List of Figures

List of Tables

Foreword

In 2015, over 3 billion passengers will have boarded an aircraft somewhere on the planet. There are many factors that drive aviation demand, from holidays to business or visiting friends and relatives, not to mention the need for the speedy transportation of perishable and high value goods to which we have grown so accustomed. And demand for aviation is not slowing. In fact, it is forecast that passenger demand will increase globally by approximately 5% per annum in the medium term. While this translates into a tremendous economic opportunity, it also exposes the rising challenge of growing in a sustainable manner.

IATA member airlines cover around 85% of all commercial flight operations. They have committed to ambitious climate change targets including carbon neutral growth from 2020 and a halving of CO_2 emissions from the sector by 2050. While technological advances will play a role in this, sustainable aviation fuels (SAF) have a crucial role to play in helping to completely de-couple emissions from growth. As both the technology and the economics of sustainable aviation fuel improve, we hope that the scale of use will increase considerably in future years.

However, there are still some obstacles to overcome on the way to a full deployment of these fuels. These are not so much of technical nature; test flights have proven as early as 2008 that SAF are safe and at least as efficient as conventional jet fuel. Three production pathways are now certified, and over 1700 commercial airline flights have occured. Challenges to implementation are more on the regulatory and commercial side. Sustainable aviation fuels are still an expensive niche product, and this will only change if demand is encouraged, which in turn requires fuel to become affordable for airlines.

This is only possible under a favorable policy framework. This includes regulations that put aviation biofuels on a level-playing field with the automotive sector, as well as user-friendly methodologies to account for the use of alternative fuels and globally harmonized sustainability criteria that allow the same fuel to be recognized as sustainable throughout the world. With the current development of a global market-based mechanism (MBM) under ICAO, a common global understanding of regulatory aspects for handling SAF is becoming even more important. Another element that could greatly help accelerating sustainable aviation fuel deployment is the use of innovative financing schemes.

Despite all challenges, a number of success stories can already be presented: long-term offtake agreements between airlines and SAF suppliers, projects of SAF supply to entire airports, making use of waste as sustainable feedstock to name a few. And the list is expected to lengthen in the near future.

I commend this SAF roadmap, which analyses the different aspects of the current and expected situation of sustainable aviation fuels and hopefully stimulates thought for further developments.

Michael Gill

Director, Aviation Environment

IATA

Executive Summary

This roadmap provides detailed information on a number of important topics concerning the commercialization and deployment of Sustainable Aviation Fuel (SAF). So far deployment has been limited to demonstration or sponsored commercial flights. While these flights have been excellent examples of both the performance and potential for SAF, until this can be incorporated into an airline's 'business as usual' plans, the achievement potential for CO_2 reductions from SAF will not be realized.

Following the current period of small series or demonstration flights, the next phase of sustainable fuel deployment will focus on supply to certain airports, either for single airlines which have concluded longer-term offtake agreements with SAF suppliers, such as United/Altair, British Airways/Solena and Cathay Pacific/Fulcrum, or even for all airlines operating on that airport, such as the plans for Amsterdam and Oslo airports. However, the total volume of engagements so far is small and more will have to be done to meet the SAF targets set by various countries and multi-stakeholder initiatives. A growing number of such initiatives have been created all over the world, gathering producers and users of SAF as well as government agencies. Where applicable, fostering SAF feedstock production to the benefit of rural economies is also an important goal.

Only drop-in fuels are considered in this roadmap, meaning a fuel that is fully compatible with current aircraft and infrastructure. The global nature of aviation has been taken into account with a detailed consideration of SAF accounting policies and sustainability legislation. With the current development of a Market Based Mechanism (MBM) under the International Civil Aviation Organization (ICAO), a common global understanding of regulatory aspects addressing SAF will become increasingly important. Furthermore, effective use of government policy mechanisms and innovative financing concepts will be necessary components of this process.

The concept of sustainable growth requires the aviation sector to meet today's needs without depleting the resources available to future generations. The industry is conscious of aviation's environmental impacts and its contribution to climate change.

In 2008 the aviation industry collectively agreed to the world's first set of sector-specific climate change targets. These targets are:

- 1.5% fuel efficiency improvement from 2009 until 2020
- Carbon neutral growth from 2020
- A 50% reduction in carbon emissions by 2050 relative to a 2005 baseline.

Three pathways are already approved for use of SAF in commercial aircraft, some at blends up to a maximum of 50%. These are:

Fischer Tropsch (FT) – this process converts solid biomass (including residual waste) into a synthetic gas and then processes the gas into a mixture of hydrocarbons including road and aviation fuels (often referred to as Biomass-to-Liquid - BtL). BtL fuel can be blended to a maximum of 50% with fossil kerosene.

Hydrotreated Esters and Fatty Acids (HEFA) – this process converts oils into fuel in a similar way that crude fossil oil is refined. The process is commercially available but concern over the sustainability of raw materials and high cost of waste oils has restricted uptake in aviation. Algal oils are in the early stages of development. HEFA fuel can be blended to a maximum of 50% with fossil kerosene.

Renewable Synthesized Iso-Paraffinic (SIP) – Aviation fuel which is produced from hydro-processed fermented sugars. The process converts sugar molecules to the hydrocarbon farnesane which can be blended to a maximum of 10% with fossil kerosene.

Sustainability harmonization assessment: Current legislation in several countries requires compliance with sustainability criteria developed for use in the road transport sector, and although not widely used today, any SAF reported within these systems would also have to comply with these criteria. Given the global nature of aviation it will be impractical for airlines to have to deal with varying standards from different jurisdictions, hence the harmonization objective.

The most advanced and widely implemented standards exist in the European Union under the Renewable Energy Directive (RED) and in the United States under the Renewable Fuel Standard 2 (RFS2). Section 4 provides considerable detail on the main similarities and differences between the schemes, including a strategy for developing harmonization proposals.

The preferred harmonization option is mutual recognition between the RED and the RFS2. This option is based on the mutual recognition of the sustainability requirements for biofuels in national legislation, as opposed to harmonization of voluntary schemes. An alternative approach to mutual recognition of the RED and RFS2 is to develop a 'Meta-standard' (or sustainability framework) for SAF. The Meta-standard would specify minimum key requirements, such as sustainability principles and/or criteria, that SAF producers would need to meet in order to be recognized by the aviation industry or governments internationally.

Accounting for SAF: Similar to sustainability legislation and compliance, how to account for SAF usage varies in different regions of the world. While accounting for fuel used my seem simple, calculating the attributable Green House Gas (GHG) benefit must be determined according to a number of variables. This is important given that incentives for SAF use are often contingent on achieving a certain level of GHG reduction.

Section 5 provides a detailed description of the different alternatives considered. The preferred alternative is a hybrid mass balance book and claim accounting system. We believe it is logical for the airline industry to use the existing *mass balance chain* of custody rules in operation for the road biofuel supply chain as much as possible until a defined 'control point'. From that control point onwards *a book and claim system* using *SAF certificates* will allow airlines to claim the use of SAF and the MBM may provide the appropriate platform to trade sustainability performance (i.e. emission allowances) with other airlines.

Effective policy: Policy instruments need to be applied to result in action. There is not one standardized perfect application of policy mechanisms. Different economies, geographies, and government priorities will likely dictate a different application of instruments. Section 6 details a number of different policy considerations. What is consistent is that jurisdictions must influence numerous areas to enable SAF production to advance. Some of these include:

1. Level playing field (or policy equality)
2. Research
3. De-risk public and private investment in production
4. Incentivize airlines to use SAF from an early stage
5. Support robust international sustainability criteria
6. Foster local opportunities

Financing models: A considerable challenge for developing SAF production facilities at scale is the significant capital involved, the long-term nature of such infrastructure, and the price uncertainty of the end product. The combination of these factors can make securing debt or equity financing expensive or challenging, and production risk mitigation (such as an airline off-take agreement) difficult. Section 7 presents some different financing models and demonstrations of the sensitivity many projects have to modest changes in the input assumptions. Further, the examples highlight how policy can be effectively applied to influence a projects financial viability.

Finally there are some excellent real examples to learn from. Given that less than a decade ago, the prospect of flying commercial aircraft on SAF seemed unrealistic due to the associated technical and safety challenges, it is impressive that in a short time a number of large projects, including some significant off-take agreements, have been signed between producers and airlines. Section 8 looks at some of these success stories in more detail.

Section 1—Introduction

1.1 Background and Aim of the Roadmap

Since ASTM approval in July 2011 more than 1700 commercial flights with passengers have occurred using SAF. Aviation's share of greenhouse gas emissions, while small in an absolute sense (approximately 2% of global emissions) is poised to grow. There is a strong rationale for aviation biofuels. Over 3 billion commercial passengers are expected to take a commercial air flight this year with passenger growth steady at around 5% per annum.

Today aviation is a service not just for the wealthy. It is accessible to the vast majority of the global population and serves a varied and valuable contribution to the global societal fabric from connecting friends and families, populating ideas and cultural sharing as well as enabling vital business through physical interaction and efficient cargo movement. For this reason it is essential that aviation continues to enjoy a license to grow and share these experiences and benefits with an even greater portion of the population. This can only occur if aviation can decouple growth and emissions. There are several mechanisms that can contribute to this but it is widely accepted that SAF will play a significant medium to longer term role in decoupling aviation growth and emissions. While technological options are available today, policy and financial barriers limit the widespread use of aviation biofuel.

It is extremely difficult to forecast the actual future use of SAF other than to suggest usage will increase from what is today a very low baseline. It is reasonable to assume usage will increase given the rhetoric of the aviation sector to work towards decoupling aviation growth and emissions. The forecast variance of future SAF use is a product of the numerous uncertain variables that influence these predictions. Predicting the technical potential for jet fuel production from alternative sources, constrained by environmental and other considerations derives a wide range of possibilities. What is ultimately relevant is the achievement of this potential. Achievement will be influenced by a number of factors including:

- Energy demand
- Finished product economics
- Societal choices with regard to usage of bioenergy

One aspect of societal choices will be the policy landscape and the level of influence this can have on potential achievement scenarios. This roadmap deliberately makes a focus of the requirement for a globally harmonized SAF sustainability framework and accounting platform as near-term important steps. The United Nations Committee for Aviation and Environment Protection (CAEP) Alternative Fuels Task Force (AFTF) is assessing different sets of assumptions that will impact on drivers of SAF potential out to 2050. This analysis, due for completion in 2016 will establish useful guide posts on what may be feasible. Some preliminary considerations are presented in Section 2.

This document will consider a number of important topics that require further work for SAF to be introduced as a 'business as usual' commodity.[1] Some of these topics include:

SAF accounting policy

It is important that the global policy on accounting standards be aligned and for SAF to have common metrics for valuing potential credits.

SAF sustainability harmonization concepts

It is increasingly important that the global policy on sustainability standards be aligned and for SAF to have common metrics. While it may not be practical to redesigning standards significantly in the quest for a global solution, it should be possible to harmonize legislation.

Policy and incentives

This section outlines some suggested steps that policy makers can consider in helping their air transport system grow with less carbon-intensive fuel, whilst in many cases also investing in green growth jobs and a new sustainable industry.

Economics and financing

A considerable challenge for developing SAF production facilities at scale is the significant capital involved. This can make securing debt or equity financing expensive, or worse a major business case impediment. This document presents some funding concepts. They are not likely to be definitive solutions, rather thought stimulation for deriving means to solve what is a complex problem.

The goal of this roadmap is to identify some of the key issues required to drive progress in the commercial deployment of SAF. Particular attention is directed to a detailed assessment of how the pathway to sustainability standard harmonization could be considered, as well as proposals for global SAF accounting standards.

Additionally the roadmap aims to demonstrate the requirement for effective policy and provides some possibilities for funding model structures. Finally, the roadmap provides some estimates in respect of the timeline potential for SAF commercial deployment. In all cases, it is critical that initiatives be closely coordinated with governmental stakeholders and assessed for compliance with applicable competition and antitrust laws.

1.2 Industry Commitments

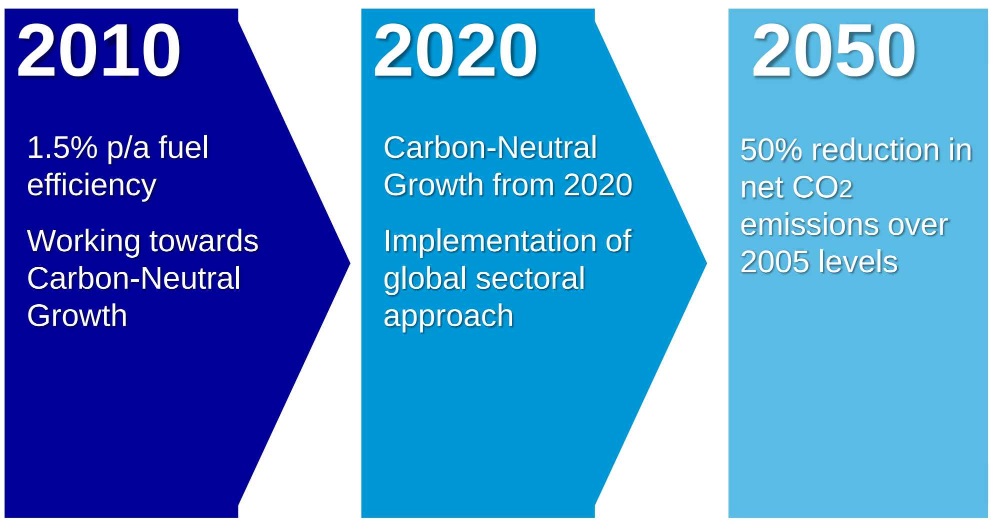
Sustainable growth calls for the aviation sector to meet today's needs without depleting the resources available to future generations. The industry is conscious of aviation's environmental impacts and its contribution to climate change.

[1] ATAG – Benefits Beyond Borders 2014

Considerable efforts are already in place to reduce or minimize the environmental impacts of aviation. IATA supports research, development, and the commercial deployment of SAF that meets necessary sustainability standards.

In 2009, the aviation industry collectively agreed to the world's first set of sector-specific climate change targets. These targets are:

- 1.5% fuel efficiency improvement from 2009 until 2020
- Carbon neutral growth from 2020
- A 50% reduction in carbon emissions by 2050 relative to a 2005 baseline.



The industry is delivering on the first target[2] with most fuel efficiency coming from investment in newer, more fuel efficient aircraft. It is accepted that to achieve the 2050 target, SAF will be required. While considerable progress has occurred the challenge remains to produce large quantities of sustainably produced alternative fuels at a commercially competitive cost to airlines.[3]

[2] http://www.iata.org/whatwedo/environment/Pages/index.aspx

[3] ICAO 'The Challenges for the Development and Deployment of Sustainable Alternative Fuel in Aviation' (May 2013)

Section 2—Timeline

2.1 Introduction

Significant progress in the development and deployment of SAF has been achieved over the last ten years. When the first feasibility studies for the use of biofuel as a sustainable alternative to petroleum-based jet fuel were conducted in the mid-2000s, few people would have envisioned that by 2014 over twenty airlines would have flown more than 1700 commercial passenger flights powered by SAF, and continuous SAF supply for airlines and airports would be imminent for 2015. Remarkable milestones on the way to operational deployment include the first test flight using a SAF blend by Virgin Atlantic in 2008, followed by a dense series of further test flights (see Figure 1), and the certification of HEFA fuels for commercial use in July 2011, which was the prerequisite for commencing SAF passenger flights all over the world. Three SAF production pathways are certified today, a number that is expected to rise to at least six by the end of 2016, as described in Section 2.3. The next step towards a broader regular uptake of SAFs is supply into the common fuel distribution system of selected airports, and in 2014 two airports, namely Karlstad (Sweden) and Oslo (Norway), inaugurated facilities that are planned to become fully operational in 2015. Additional larger airports are expected to follow.

While a wide variety of SAF production pathways have been developed (see Section 3) and solutions to most technical challenges to SAF implementation can be found[4], the political and economic boundary conditions still require further development to allow the large-scale production of SAF at affordable prices for airline customers. Nevertheless, promising signals are given by the first long-term offtake agreements between airlines and fuel suppliers, as described in Section 2.6, with delivery starting in 2015. Current announcements and targets set by industry, states, and multi-stakeholder SAF initiatives (see Section 2.8) give an estimate of the ramp-up of SAF volumes in the near-term future. In the long term, one must rely on scenarios based on considerations of technical feasibility and economic availability, which will yield a range of volume projections, as outlined in Section 2.9.

As far ahead as 2040 to 2050, new fuels and energy sources such as “solar jet fuel”, produced from CO_2 and water using solar energy, and aircraft using electric energy for propulsion will likely play an increasing role in the aviation industry’s commitment to reduce its global carbon footprint by 50% compared to 2005. However, considerable development efforts will have to be deployed before these technologies, which are today at lab scale, reach maturity. Drop-in fuels will therefore remain the only sustainable alternative to fossil jet fuels for at least two to three decades.

[4] IATA BioGuide http://www.iata.org/publications/Documents/guidance-biojet-management.pdf

2.2 Test Flights

The first flight using a SAF blend took off in February 2008, operated by Virgin Atlantic from London Heathrow to Amsterdam and powered with 20% biodiesel from coconut and babassu oil[5]. While this blend was not a drop-in fuel in the strict sense, all following SAF flights have used drop-in hydrocarbon fuels. Starting in the same year, a long series of test flights took place, involving numerous airlines, different aircraft and engine types, and blends of fuels originating from different feedstock types. More recently, fuels from new production pathways such as "Synthetic Iso-paraffin from Fermented Hydroprocessed Sugar (SIP)" were flight-tested, and more are planned. Figure 1 shows an overview of SAF test flights.

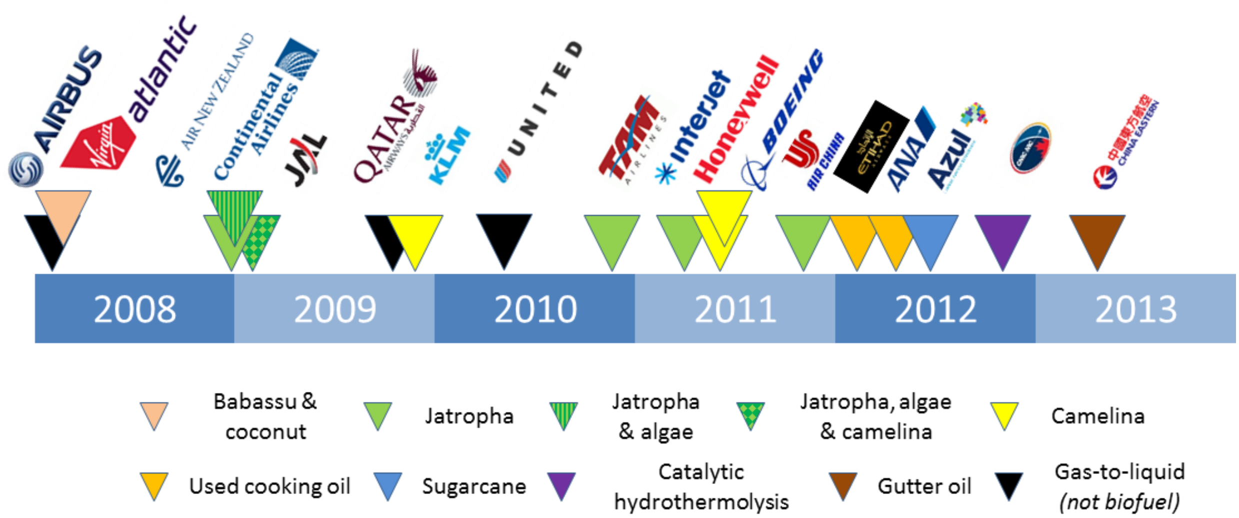


Figure 1. Alternative fuels flight tests between 2008 and 2013

2.3 Certification

In parallel, technical certification of alternative fuels took place, primarily led by ASTM International with strong support from the United States' Commercial Aviation Alternative Fuels Initiative (CAAFI) and the US Air Force. In 2009, ASTM approved fuels produced by the Fischer-Tropsch process as the first SAF suitable for use in commercial flights, up to a blend percentage of 50%. However, insufficient amounts of Fischer-Tropsch fuels were available for actually performing commercial flights.

This was followed in 2011 by the ASTM approval of HEFA fuels (hydrogenated esters and fatty acids, originating from vegetable oils and animal fats) in July 2011, which allowed, as a result of the improved availability of HEFA fuels, numerous SAF-powered commercial flights. In June 2014, the third production pathway for SAF was approved by ASTM, namely "Synthetic Iso-paraffin from Fermented Hydroprocessed Sugar (SIP)", (also known as Direct Sugar to Hydrocarbon [DSHC] fuel). All SAF certifications occur under

[5] http://www.sustainableaviation.co.uk/pages/news/virgin-atlantic-to-run-747-on-biofuel-in-february.html

the ASTM D7566 specification. Fuels that comply with D7566 are automatically recognized as meeting the ASTM D1655 specification for conventional jet fuel (i.e. can be used as jet fuel without restrictions).

Further pathways (see Figure 2) are currently undergoing the ASTM certification process, with specific task forces for each of them[6]. For the following ones research reports are currently under review:

- Alcohol-to-Jet (ATJ), which by the end of 2014 has finished its test phase and is expected to receive certification in 2015
- FT synthetic paraffinic kerosene with aromatics (SKA)
- Hydroprocessed depolymerized cellulosic jet

Test data are currently being compiled for the following:

- Alcohol to jet SKA
- Catalytic hydrothermolysis,
- Synthetic aromatic kerosene by catalytic conversion of sugars
- Synthetic (paraffinic) kerosene by catalytic conversion of sugars

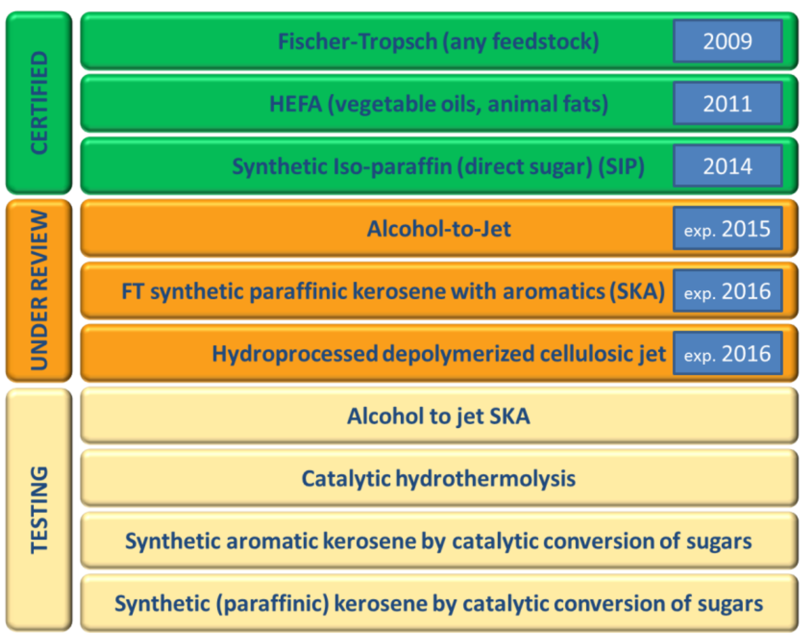


Figure 2. Past and future ASTM certifications of SAF production pathways

Following a proposal by Boeing, green diesel (also known as renewable diesel) at a low blending ratio (around 10%) is also being considered to produce aviation drop-in fuel.[7] A test flight with a 15% green diesel

[6] Reader is invited to refer to 2013 report or ICAO page on alternative fuels for further details.

blend was completed on 3 December 2014. The possibility to use a fuel produced for the much larger automotive market would offer cost competitive SAF option without the need for large investments in production plants. A significant ramp-up of green diesel blend uptake could be achieved within this decade.

It should be noted that the duration of the fuel certification process, which for the Fischer-Tropsch process took several years, is becoming progressively shorter, and is no longer viewed as an impediment to introducing additional fuel production pathways. This in turn encourages research and development of new and potentially more economically viable feed stocks and production processes.

2.4 Commercial Flights

The first commercial passenger flight using SAF took place on 22 June 2011, when the ASTM certification had been approved, but not yet officially published, thanks to a waiver from the Dutch Transport Authority. Between June 2011 and October 2014, 21 airlines have carried out over 1700 commercial flights with paying passengers. These are listed in Table 1.

Some airlines performed larger series of SAF flights on selected city pairs to gain experience with the operational and logistic challenges of regular alternative fuel use. The most noteworthy amongst them are:

- Lufthansa – one A321 was operated between Hamburg (HAM) and Frankfurt (FRA) for 6 months between July and December 2011, with about 6 flights per day. One engine was supplied with a 50% HEFA blend, while conventional Jet A-1 fuel was used in the other one; this allowed extensive comparative studies of the behavior of engines, aircraft fuel systems and infrastructure. These investigations were part of a technology project funded by the German government.
- KLM conducted a series of 200 flights between Amsterdam (AMS) and Paris (CDG) from September 2011, a series of 26 flights New York (JFK) – AMS (the first intercontinental flight series) in 2013, and a series of 20 flights AMS – Aruba (AUA) in 2014.

Other alternative fuel flights were conducted in conjunction with high profile public events, including:

- Four commercial flights operated by four airlines (Porter, Air Canada, Aeroméxico and GOL) powered by SAF brought ICAO Secretary General Raymond Benjamin from Montréal to the Rio+20 UN Conference on Sustainable Development on 18 June 2012.
- GOL conducted about 200 domestic SAF flights in Brazil during the 2014 FIFA World Cup.
- Finnair flew to the UN Climate Summit in New York from Helsinki on 23 September 2014 using SAF.
- Future opportunities may exist for noteworthy political or sporting events (e.g. the UN Climate Summit in Paris in December 2015 and the 2016 Olympics in Rio de Janeiro).

---

[7] Contrary to current biodiesel, which is an ester-type oxygenated compound, green diesel is a hydrocarbon fuel almost identical to conventional diesel, produced with the same process as HEFA fuel from vegetable oils and animal fats

Table 1. Commercial flights powered by SAF

Carrier	Aircraft	Flight path	Date	Feedstock	Supplier	Notes
KLM	B737	Amsterdam - Paris	22-Jun-11	Used cooking oil	SkyNRG	200 city pair flights from September 2011
Lufthansa	A321	Hamburg - Frankfurt	15-Jul-11	Mix of feedstocks	Neste Oil	1,200 flights over a six-month period
FINNAIR	A321	Amsterdam - Helsinki	18-Jul-11	Used cooking oil	SkyNRG	
interjet	A320	Mexico City - Tuxtla Gutiérrez	21-Jul-11	Jatropha	ASA	
AeroMexico	B777	Mexico City - Madrid	01-Aug-11	Jatropha	ASA	
IBERIA	A320	Madrid - Barcelona	03-Oct-11	Camelina	ASA	
Thomson Airways	B757	Birmingham - Arrecife	06-Oct-11	Used cooking oil	SkyNRG	Daily flights in early 2012 for six weeks
AIRFRANCE	A321	Toulouse - Paris	13-Oct-11	Used cooking oil	SkyNRG	Flight used 50% biofuel in each engine
UNITED	737-800	Houston - Chicago	07-Nov-11	Algae	Solazyme	40% biofuel domestic flight
Alaska Airlines	737s and Q400s	Seattle - Portland, Seattle - Washington	09-Nov-11	Used cooking oil	SkyNRG	75 scheduled domestic flights powered by 20% biofuel
THAI	777-200	Bangkok - Chiang Mai	22-Dec-11	Used cooking oil	SkyNRG	
Lufthansa	747	Frankfurt - Washington DC	12-Jan-12	Mix of foodstocks	Neste Oil	Reduced CO_2 emissions by 38 tonnes
LAN	A320	Santiago - Concepción, Chile	07-Mar-12	Used cooking oil	SkyNRG	Trial Flight
QANTAS Spirit of Australia	A330	Sydney - Adelaide, Australia	13-Apr-12	Used cooking oil	SkyNRG	Trial Flight
porter	Q400	Toronto City - Ottawa	17-Apr-12	Used cooking oil	Honeywell/SkyNRG	
Jetstar	A320	Melbourne - Hobart	19-Apr-12	Used cooking oil	SkyNRG	
porter	Q400	Montreal - Toronto	18-Jun-12	Camelina		
AIR CANADA	A319	Toronto - Mexico City	18-Jun-12	Used cooking oil	SkyNRG	
AeroMexico	777	Mexico City - São Paulo	18-Jun-12	Mix of feedstocks	ASA	
KLM	777	Amsterdam - Rio de Janeiro	19-Jun-12	Used cooking oil	SkyNRG	
KLM	777	New York, JFK - Amsterdam	08-Mar-13	Used cooking oil	SkyNRG	Flight KL642 operated 26 flights in 2013
LAN	A320	Bogota - Calí	21-Aug-13	Camelina		
KLM	A330	Amsterdam - Aruba	16-May-14	Used cooking oil	SkyNRG	20% blend as part of a 20-flight series
GOL	737	Multiple destinations in Brazil	June / July 2014	Inedible corn oil and used cooking oil	Honeywell UOP	200 flights on biofuel during the FIFA World Cup 2014
Lufthansa	A320	Frankfurt - Berlin	15-Sep-14	Farnesane sugar-based fuel	Amyris Total	10% biofuel in both engines
FINNAIR	A330	Helsinki - New York	23-Sep-14	Used cooking oil	SkyNRG	10% biofuel
SAS Scandinavian Airlines	737-800	Stockholm - Oslo	07-Oct-14	Used cooking oil	SkyNRG Nordic	10% blend
SAS Scandinavian Airlines	737-800	Trondheim - Oslo	11-Nov-14	Used cooking oil	SkyNRG Nordic	48% blend
norwegian	737-800	Bergen - Oslo	11-Nov-14	Used cooking oil	SkyNRG Nordic	50% blend

However, all commercial flights to date were operated with batches of fuel from dedicated production and delivered through a highly controlled supply chain and were thus not fully representative of day-to-day commercial alternative fuel operations. Close collaboration between numerous stakeholders is necessary to achieve further steps towards large-scale integrated SAF deployment and in particular supply into the distribution network of entire airports.

2.5 Multi-stakeholder Sustainable Aviation Fuel Initiatives

The realization of SAF flights, and even more the wide deployment of SAF for regular use, requires close cooperation between numerous stakeholder groups, including not only airlines and SAF suppliers, but also feedstock producers, airports, research establishments and governmental agencies (aviation authorities, agencies and ministries for transport, environment and agriculture). Different forms of joint initiatives for the deployment of SAF have been created in many parts of the world, and their number is continuously increasing. Their scope can range from a bilateral partnership for a specific project to associations gathering all of the above-mentioned stakeholders for continuous cooperation on a long-term basis.

ICAO has established the GFAAF database[8], which contains a comprehensive list of these initiatives all over the world.[9] Figures 3 and 4 show their distribution by type and region, including the number of newly created initiatives per year. A peak of activities can be seen around 2011 when commercial SAF flights were made possible after certification of HEFA fuels. Since then, more than 10 new initiatives have been created worldwide each year, and the trend is ongoing.

CAAFI in the US was the first organization to establish a structure inclusive of all stakeholders from industry and government involved in SAF deployment, and has completed pioneering work in many areas (e.g. in the certification of SAF pathways and establishing models for SAF commercialization). In a number of other countries, newly-established associations have mirrored elements of the CAAFI model, but adapted it to the specific situation of each country or region. Some of the most active multi-stakeholder associations are listed in Table 2 (see also Section 4.2).

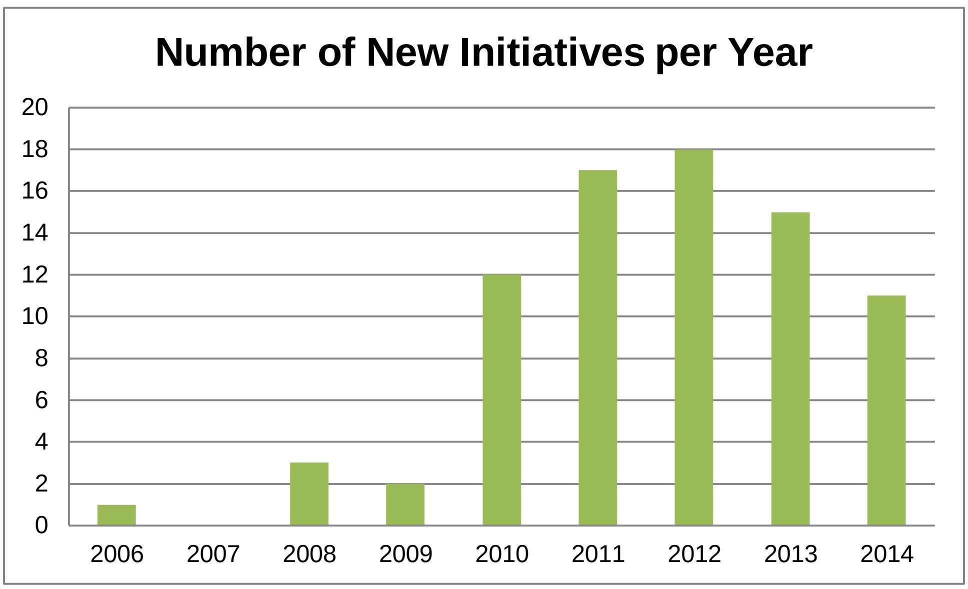
Table 2. Multi-stakeholder sustainable aviation fuel initiatives

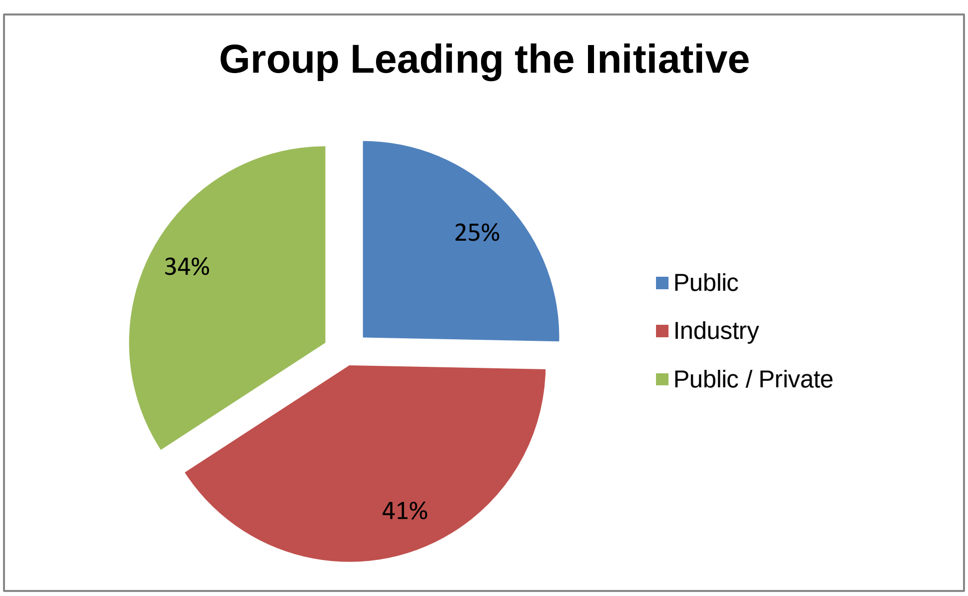
Initiative	Country/region	Website (*or if missing, relevant info*)
CAAFI	US	www.caafi.org/
MASBI	US Midwest	www.masbi.org
SAFN	US Northwest	http://climatesolutions.org/programs/saf/resources/safn
BioFuelNet	Canada	www.biofuelnet.ca/
Plan de Vuelo	Mexico	http://bioturbosina.asa.gob.mx/es_mx/BIOturbosina/Plan_de_Vuelo
ABRABA / PBB	Brazil	http://cdieselbr.com.br/
Biofuels Flightpath	EU	http://ec.europa.eu/energy/en/topics/renewable-energy/biofuels/biofuels-aviation
aireg	Germany	ww.aireg.de/
NISA	Nordic	www.cphcleantech.com/nisa
Bioqueroseno	Spain	www.bioqueroseno.es
Bioport Holland	Netherlands	*e.g.* http://www.greenaironline.com/news.php?viewStory=1904

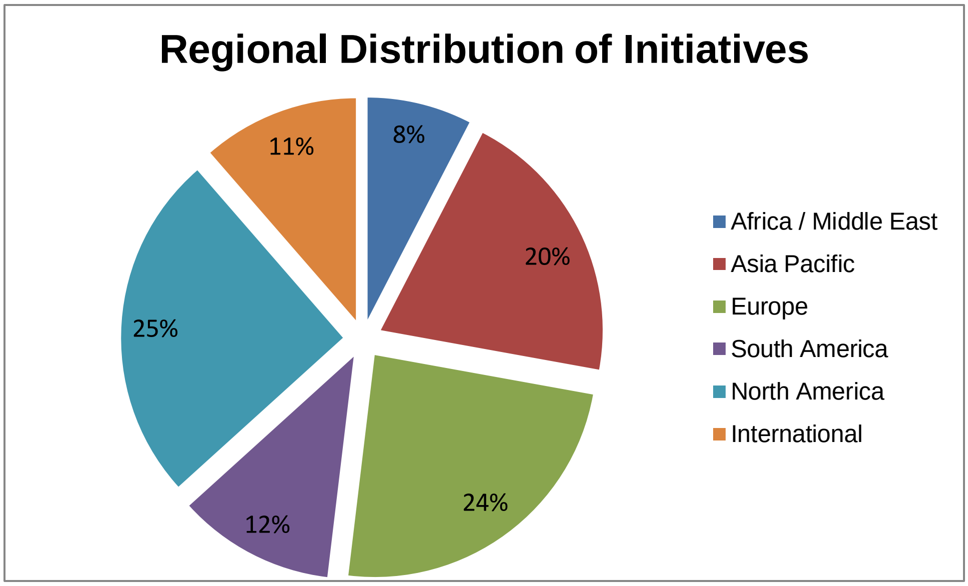
[8] ICAO Global Framework for Aviation Alternative Fuels, http://www.icao.int/environmental-protection/GFAAF/Pages/default.aspx

[9] IATA Report on Alternative fuels 2014 http://www.iata.org/publications/Pages/alternative-fuels.aspx

Initiative	Country/region	Website (*or if missing, relevant info*)
AISAF	Australia	aisaf.org.au
ABRETF	Indonesia	*e.g.* http://www.core-jetfuel.eu/Shared%20Documents/Sayuta_Senobua_Aviation_Biofuel_Program_Indonesia.pdf
INAF	Japan	*e.g.* http://www.greenaironline.com/news.php?viewStory=1958
SEASAFI	South East Asia	*e.g.* http://www.greenaironline.com/news.php?viewStory=1739
Fuel Choices Initiatives	Israel	www.fuelchoicesinitiative.com







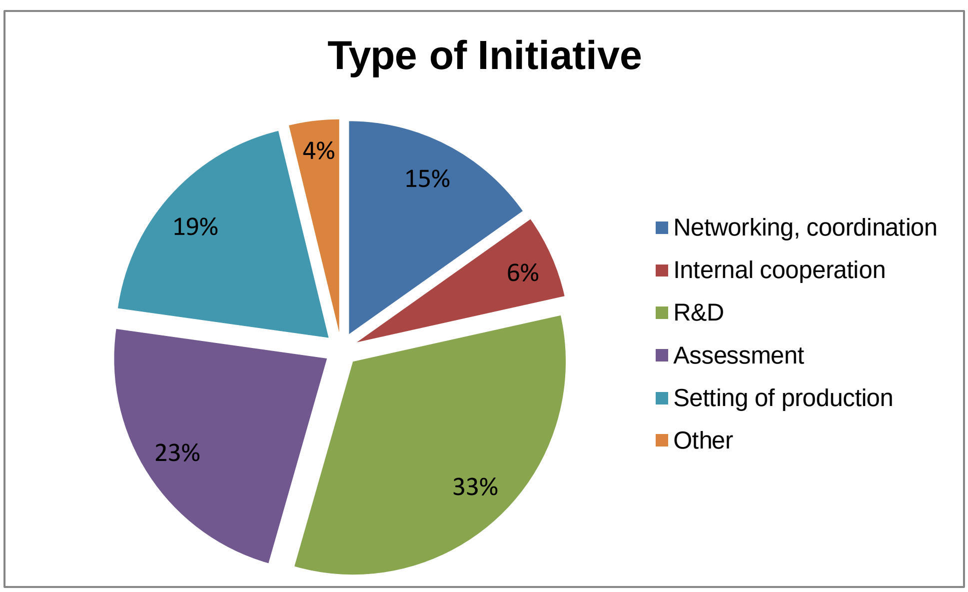
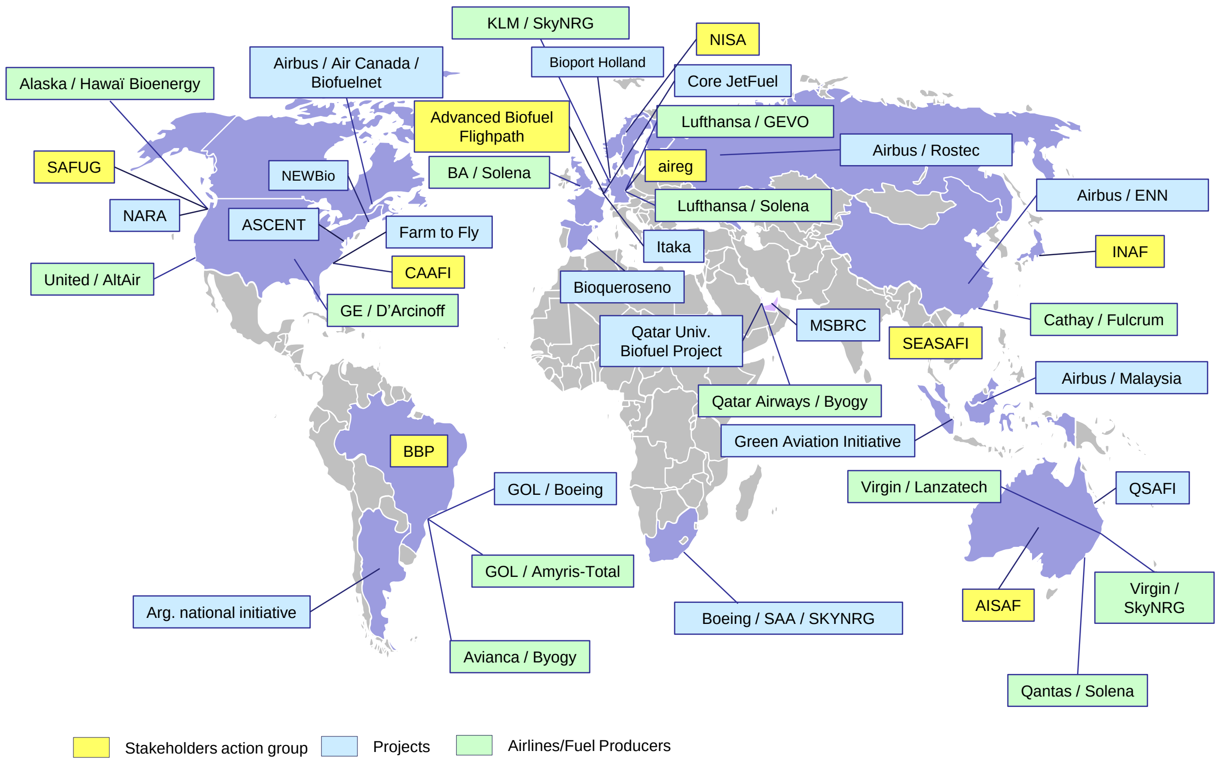


Figure 3. Source: ICAO

Interest in creating similar associations and SAF project groups has been expressed in various other countries. Two main trends can be distinguished:

- Countries where aviation plays an increasing key role, which are developing their aeronautical technology and industry (Japan, Israel, Singapore etc.).
- Countries with favorable conditions for biofuel feedstock production, often in tropical regions, interested in creating new opportunities for the local (often rural) economy (Indonesia, Malaysia, South Africa, India, etc.).



There are numerous partnerships working at various levels across the globe.

Figure 4. Mapping of worldwide initiatives (based on announcements recorded in GFAAF - not meant to be exhaustive – mainly initiatives since 2013)

2.6 Airline/fuel Supplier Collaboration

A significant challenge for SAF suppliers intending to supply the aviation market is the risk of demand continuity. At today's SAF prices and due to their low benefit margins, most airlines are hesitant to commit to larger SAF purchases. On the other hand, better certainty about continuous demand allows SAF suppliers to offer more competitive terms and potentially to invest into production facilities. There are increasing numbers of different types of agreements between airlines and SAF suppliers (see also Table 3):

- In December 2009, 15 airlines, mainly from the US, signed a MoU with alternative fuel suppliers AltAir and Rentech. This was followed by United Airlines concluding a purchase agreement in 2013 with AltAir for delivery of HEFA fuel over a period of three years beginning in 2015. A refinery in California has been retrofitted for the production of 90 kt/y of renewable diesel and jet fuel.
- A larger offtake agreement was announced in August 2014 between Cathay Pacific from Hong Kong and Fulcrum Bioenergy for delivery of 100 kt/y of SAF over 10 years, produced from municipal solid waste at a Fischer-Tropsch plant in Nevada. The business case for constructing this plant was assisted by a combination of an award from the US Department of Defense for military drop-in fuel bio-refineries

and a loan guarantee from the US Department of Agriculture, together with a strategic equity investment from Cathay Pacific.

- Southwest Airlines signed an agreement with Red Rock Biofuels, another beneficiary of the US military award, of around 10 kt/year of Fischer-Tropsch fuel from forest residues.
- British Airways is engaged with the fuel producer Solena in their project for building a waste-to-liquid plant. Solena has concluded a partnership and purchase agreement with British Airways with initial production expected in 2017 of 50 kt of jet fuel per year.

Other agreements have been concluded for joint technology development and test, the latest example being a cooperation project between Lufthansa and Gevo [10]on testing alcohol-to-jet fuel.

Table 3. Airline offtake agreements

Airline	Supplier	Volume [t/yr]	Product	Duration	Start delivery	Contract date
United	Altair	17 000	HEFA	3 years	2015	2013
Cathay	Fulcrum	100 000	FT (waste)	10 years	2017	2014
Southwest	Red Rock	10 000	FT (forest residues)	n/a	n/a	2014
British Airways	Solena	50 000	Municipal solid waste	10 years	2017	2012

2.7 Airport SAF Supply

Following test flights (from 2008) and commercial flights with closely monitored SAF supply on selected city pairs (from 2011), the next step of integrated deployment is SAF supply to the common fuel distribution system of pilot airports, with the possibility for all operators flying into these airports to be refueled with SAF.

Two such “bioports” have been inaugurated in 2014: the small airport of Karlstad in central Sweden and Oslo Airport. From each of the airports two biofuel-powered flights with different airlines took off in conjunction with the launch ceremony.

- At Karlstad a fuel tank was dedicated for SAF storage on 26 June 2014, which can be used by all operators. Regular supply is planned from early 2015. Inaugural flights were done by bmi regional and NextJet.
- Oslo Airport announced on 20 November 2014 that biojet fuel would be supplied through the airports hydrant system from 2015. SAS, Lufthansa Group, KLM, the airport operator Avinor and the Norwegian oil company Statoil concluded a supply contract of 2.5 million liters of SAF over 12 months. In the first phase, recycled cooking oil will be used as feedstock; at a later time forest residues are planned to be

[10] http://ir.gevo.com/phoenix.zhtml?c=238618&p=irol-newsArticle&ID=1920676

used. The first SAF-powered flights, operated by SAS and Norwegian took place on 11 November 2014 in conjunction with the Zero Emissions Conference.

Several other airports are planning the implementation of regular SAF supply through their common distribution network:

- Amsterdam Schiphol Airport, as part of the Bioport Holland initiative, is prepared to offer a continuous SAF supply from 2015 with the target of reaching 1% of total jet fuel within that year.
- Brisbane Airport is undertaking a study to facilitate the planning and development of infrastructure to deliver SAF to airlines.
- Helsinki Airport has been identified in a study by the Finnish Government to be well-positioned as a future bioport.

The airline-supplier agreements mentioned above are also relying on distribution facilities at specific airports:

- The British Airways/Solena agreement foresees a delivery of 50 kt/y at London City Airport; this is roughly the amount of fuel uplifted by BA at that airport.
- Altair will deliver its SAF to United Airlines at Los Angeles International Airport.
- Fulcrum will start delivering its SAF to Cathay Pacific at Los Angeles International Airport as well, and aims to develop distribution facilities at additional airports in the future.

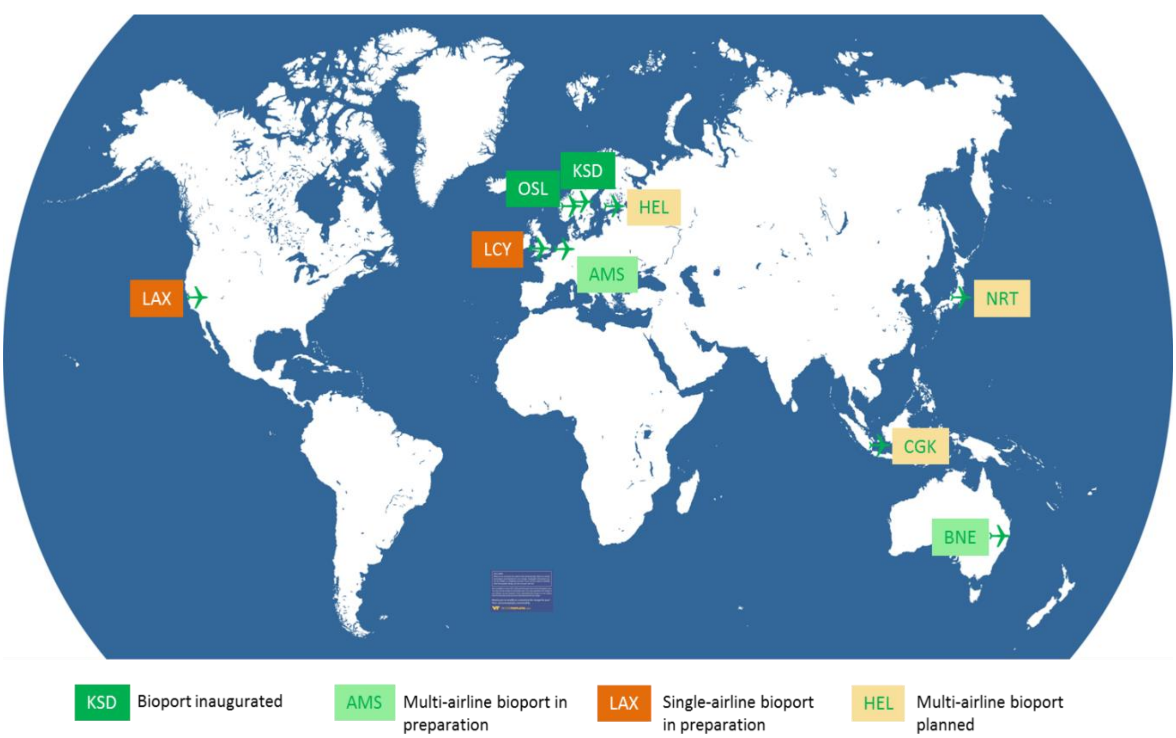


Figure 5. Current bioport projects

2.8 National and Industry Targets

Various governmental institutions, national or regional multi-stakeholder initiatives, and individual airlines have set targets for the implementation of SAF. While there are differences in terms of scope and ambition between the individual targets, there is a broad common view of the growth of SAF uptake over the next years, as can be seen in Table 4.

Table 4. Targets set by states and industry for SAF fuel implementation

Country/Region	Organization	Target	Timeframe	Remarks
Netherlands	Bioport Holland	1%	2015	
World	Boeing	1%	2016	
Indonesia	Government	2%	2016	
USA	FAA	5%	2018	
EU	EC (Biofuels Flightpath)	3-4% (2Mt)	2020	
Nordic countries	NISA	3-4%	2020	(follow EU)
Germany	Aireg	10%	2025	
Israel	FCI	20%	2025	
EU	EC (Transport White Paper)	40%	2050	
Australia	AISAF	50%	2050	

ICAO's Alternative Fuels Task Force (AFTF) is currently undertaking a projection of future SAF production and use. In the short term, this projection is based on existing announcements and targets by governmental and industry stakeholders, as presented above. In the long term, worldwide SAF availability will be driven mostly by technical and economic limitations regarding the availability of feedstock (biomass as well as other wastes and residues), combined with a continuous improvement of factors such as agricultural yield and chemical processing efficiency.

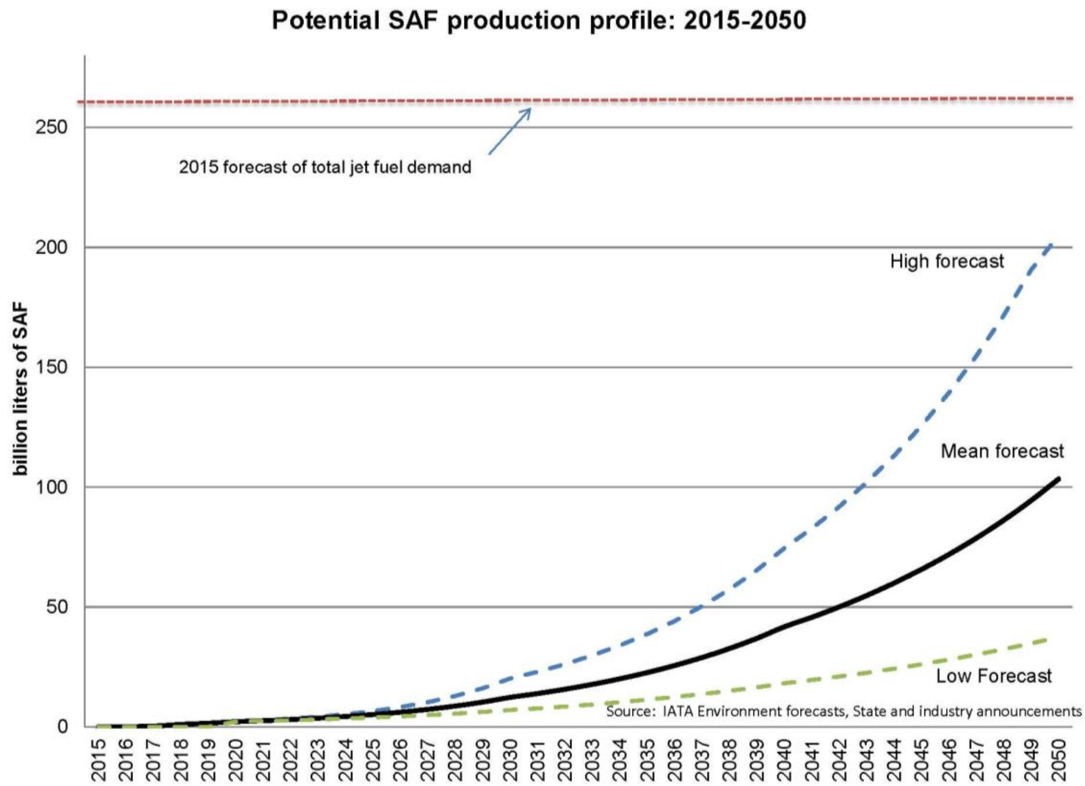


Figure 6. Sum of current airline intentions, engagements and forecasts for the use of SAF.[11] Note this chart is not intended to predict the assessment of the AFTF fuel production assessment task force.

2.9 Supply and Demand Evolution

It is difficult to make a reliable forecast of SAF production in the mid-to-long term, because its development strongly depends on political choices and opportunities to mobilize investments to overcome the commercialization challenges for this new product. The AFTF is currently working on a projection of SAF availability using the following method:

- In the short term (around 2020) existing commitments and targets by States and industry, including plans for production facilities, adjusted for commercialization probability, are used as inputs.
- In the long term (up to 2050) total biomass potential is being evaluated conditional upon a set of sustainability guiding principles. An assessment will then be made for what the achievement potential (technical and economic limitations and constraints) may be for converting this biomass into SAF.
- In the period between 2020 and 2050 different interpolations will be done based on a spectrum of possible social-economic world scenarios.

[11] IATA Survey January 2015 & IATA Environment modelling

IATA surveyed its member airlines about their intentions and engagements to use SAF in the near future. While the answers are not meant to anticipate the results of the AFTF study, they help ascribe probabilities to the achievement of state targets (see Figure 6). Obviously, the results represent a limited scope of airline projects, and the numbers would increase once further engagements are announced by airlines, but this is not likely to significantly affect the very short-term period until 2020.

While the specific survey results are confidential, some high level insights are a number of airlines have internal targets (some up to 10% of total fuel consumption) for using SAF by 2020. Further, a number of airlines indicated they are in discussion with potential suppliers. This implies there is material demand momentum occurring on ventures that are presently not public.

Not surprisingly, there was a common theme from airlines that the amount of future SAF used will be linked to the relationship between the SAF price and conventional jet fuel price. Many airlines indicated a strong desire for higher levels of SAF use, but acknowledged that actual use may be limited by commercial constraints.

The results of the IATA survey should be compared with the expected SAF supply capacity. One recent estimate for it is the E4Tech study for the UK Sustainable Aviation Sustainable Fuels Roadmap[12], which predicts a production capacity of around 6 Mt/year or 250 PJ/year worldwide by 2020.

Long-term projections of SAF use are more speculative. As an indication, one can consider projections of total biomass-based energy for transport and assume the share of SAF is similar to the today's share of aviation of roughly 12 to 14% of total transport fuels. IRENA[13] projects for 2030 a demand of primary bioenergy for transport of 31 EJ/year, equivalent to 16 EJ/year of final transport energy. This would mean a share of roughly 2 EJ/year or 50 Mt of sustainable jet fuel

2.10 Political and Economic Perspectives

Many of the aforementioned multi-stakeholder initiatives are well supported by national governments. These see a variety of reasons for engaging in SAF in general, and for aviation in particular:

- Production and use of sustainable, non-fossil energy allows reduction of greenhouse gas emissions contributing to states' obligations under the current Kyoto Protocol or a potential agreement from COP21 in Paris (December 2015) and/or to ICAO State Action Plans.
- Production of alternative fuels replacing crude oil allows reducing the dependence on oil imports, thus reducing the risk of strong fluctuations of oil prices, as have been observed in the recent past, and in the longer term a likely increase of average oil prices. An additional argument is the reduced risk of political pressure from oil-exporting countries.

---

[12] http://www.sustainableaviation.co.uk/wp-content/uploads/SA-SAF-Roadmap-FINAL-24-Nov.pdf

[13] http://www.irena.org/remap/IRENA_REmap_2030_Biomass_paper_2014.pdf

- For many, in particular developing, countries, growing feedstock for biofuels offers chances for new livelihoods for the rural population. A study by the South African government estimates that "*…a 4.5% biofuels penetration to the current fuel pool [of about 25 billion liters of transport fuel consumed in South Africa in 2013] … will contribute to energy security, create 55 000 jobs in rural farming, contribute to economic growth that will see ZAR $2 billion (USD $180 million) per annum added to the GDP.*"[14] It is worth noting that biofuel production is driven by highly industrialized companies with high quality and efficiency standards. Implementation of biofuel feedstock plantations often requires use of modern agricultural or forestry techniques; local farmers benefit from these modern techniques, which will help them to improve their food production, too, contrary to the "food-vs-fuel" cliché. The RSB considers this aspect in their Principle on food security and rural development, (Principle 5): which states "*In regions of poverty, biofuel operations shall contribute to the social and economic development of local, rural and indigenous people and communities.*" Similarly, it should be noted that careful analysis of the price rises for various food commodities observed in the last years (e.g. Mexican maize) shows that these were related to speculation in conjunction with the world economic crisis rather than to growing demand for biofuel production.
- Other benefits of biomass cultivation exist, such as decontamination of formerly contaminated soil; as a concrete example, this makes growing camelina an interesting option for some degraded land areas in Eastern European countries.

While these aspects are equally applicable to ground transport fuels, SAF deployment is often seen as an opportunity for governments and industry stakeholders to engage in an advanced green technology with high reputation, global visibility, high commitment of all stakeholders and a global network of expertise.

Obviously only a small share of feedstock for sustainable transport fuels will be used for aviation purposes. The current share of energy demand of aviation is about 10 to 15% of all transport energy. As a rule of thumb, it can be expected that, once SAF have been implemented at a large commercial scale, a similar share of all sustainable transport fuels will be used by aviation.

In the longer term a substantial part of the automotive sector is expected to be powered by alternative energy sources, such as batteries or fuel cells, whereas air transport will be dependent on liquid fuels for a much longer time. This would allow access to an increasing share of biomass and other alternative fuel feedstock for use in the aviation sector.

2.11 Long-term Developments

The projected availability of SAF considered above still appear to be insufficient to meet the long-term industry target of reducing the carbon footprint of global aviation by 50% from 2005 to 2050 (see Figure 7). However, in the very long term (several decades from today), more radically innovative sources of sustainable energy for aviation are expected. The most concrete promising technologies announced in the last few years are:

[14] Department of Public Enterprises, Republic of South Africa: Aviation Biofuels for South African Airways -Reference Manual, 2013

Solar jet fuel (or Sun-to-Liquid): This technology basically uses a reversal of the hydrocarbon combustion process; at extremely high temperatures (above 1500 °C) generated by concentrated sunlight, CO_2 and water vapor are converted into synthesis gas, which is the basis for production of hydrocarbons with the well-known Fischer-Tropsch process, which is also the basis for biomass-to-liquid fuel. A lab-scale amount of sun-to-liquid fuel was produced in April 2014 at the Zurich Institute of Technology (ETH) in the framework of the EU-funded SolarJet project. The technology is expected to achieve technical maturity around 2035. Large arrays of solar collectors capture the energy for this process (with a predicted efficiency in the order of 40 t fuel/ha*year), which is about twice the surface yield of algae fuel and an order of magnitude above today's energy crops. An important advantage is that otherwise unusable desert land can be used for this process.

Power-to-liquid: This technology relies on electrolytic production of hydrogen, which together with CO_2 from the atmosphere or from concentrated sources, generates synthesis gas that is converted into hydrocarbon fuels also using the Fischer-Tropsch process. With the expected increasing share of renewable electricity and predicted high efficiencies PtL is promising as a sustainable alternative fuel in the mid-to-long-term future (2030s). The PtL process has raised substantial public interest especially in Germany, where a demonstration rig was realized in 2014.[15]

Electrically powered aircraft: Thanks to the continuing progress of battery technology, the future use of electric power for propulsion of commercial aircraft now appears realistic. Electrically powered single-seat aircraft have existed since the 1970s, but recently large aeronautic manufacturers such as Boeing (FCD, first flight 2008), EADS (Cri-Cri, 2010) and Airbus (e-Fan, 2014) have built small electric aircraft to gain experience with this propulsion technology. At the 2012 Berlin Air Show (ILA) the Munich-based think tank Bauhaus Luftfahrt presented its Ce-Liner concept for a large single-aisle aircraft with electric propulsion. For a 190-seat aircraft the concept study predicts a range of 900 nm with the technology expected to be available in 2035, i.e. 79% of all routes relevant for this aircraft size category could be covered.[16] Hybrid (fuel/electric) propulsion is also envisaged for commercial aircraft, such as in the Boeing SUGAR Volt project[17]

[15] www.sunfire.de

[16] http://www.bauhaus-luftfahrt.net/archive/konzeptstudie-zur-elektromobilitaet-in-der-luftfahrt-201ece-liner201c

[17] http://www.boeing.com/aboutus/environment/environment_report_14/2.3_future_flight.html

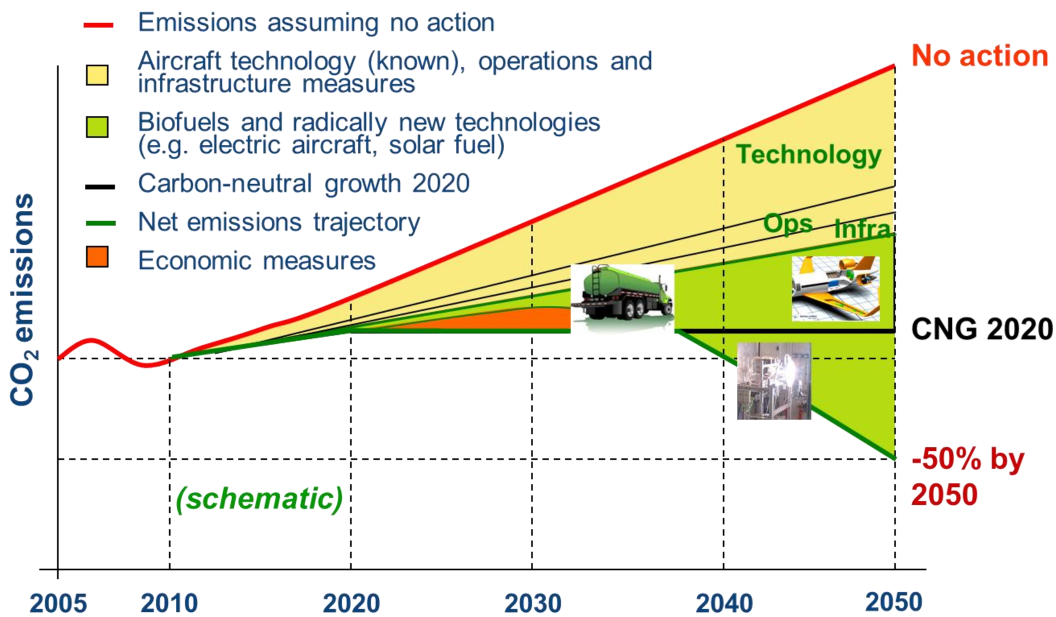


Figure 7. Contributions to the aviation industry's high-level emissions reduction goals (schematic)

These studies show that the means by which to close the remaining gap between SAF projections and the 2050 emissions reduction goal have become much more concrete than even a couple of years ago.

On the other hand, it is also obvious that jet fuel from biomass and similar feedstock from wastes and residues will remain the only available sustainable energy for aircraft propulsion for a long time. As discussed, this situation is significantly different from the ground transport sector. It will be important for policy makers to recognize and support this shift in demand to biomass and similar feedstock through holistic transport and energy policies.

Section 3–Technical and Economic Background

3.1 Technology Pathways and Cost Expectations

Aviation fuels require stringent fuel specifications. They also require stringent rules for handling to minimize the safety risk caused by fuel contamination. Consequently, drop-in SAF must essentially have the same performance properties as conventional jet fuels. A drop-in alternative fuel is one that is completely interchangeable and compatible (subject to certified percentage limits) with a particular conventional (typically petroleum derived) fuel.

There are currently three certified technology conversion pathways which can produce drop-in SAF: 1) Fischer-Tropsch (F-T), 2) Hydro-treated Vegetable Oils (HVO) or more generally called Hydro-processed Esters and Fatty Acids (HEFA), and 3) Renewable Synthesized Iso-Paraffinic (SIP) aviation fuel.

Fischer Tropsch (FT) – this process converts solid biomass (including residual waste) into a synthetic gas and then processes the gas into a mixture of hydrocarbons including road and aviation fuels (often referred to as Biomass-to-Liquid - BtL). BtL fuel can be blended to a maximum of 50% with fossil kerosene.

Hydrotreated Esters and Fatty Acids (HEFA) – this process converts oils into fuel in a similar way that crude fossil oil is refined. The process is commercially available but concern over the sustainability of raw materials and high cost of waste oils has restricted uptake for aviation. Algal oils are in the early stages of development. HEFA fuel can be blended to a maximum of 50% with fossil kerosene.

Renewable Synthesized Iso-Paraffinic (SIP) – is produced from hydro processed fermented sugars. The process converts sugar molecules to the hydrocarbon farnesane which can be blended to a maximum of 10% with fossil kerosene.

In addition to these three technologies, Pyrolysis is also a technically feasible pathway; however, like the certified pathways, it requires further work to reduce the unit cost of production. Other production pathways also yield liquid fuels and their economic potential continues to evolve. It is expected that up to 6 additional conversion pathways will be certified for use in commercial aircraft over the next 24 months through the ASTM process.

3.2 Fischer-Tropsch (FT)

FT synthesis is a catalytic chemical process used to produce a synthetic fuel by processing a gas obtained from the gasification of a feedstock. Within the FT synthesis, the conditioned synthesis gas is converted into liquid and solid hydrocarbons. The resulting products can be classified into naphtha, diesel or jet fuel, and waxes as well as combustible gases like propane and butane. The conversion efficiency, suggests about five to six million tonnes of biomass is required to produce one million tonnes of FT liquid fuel.

The FT production route is already certified to produce jet fuels from coal, biomass, and natural gas feedstock (when blended 50% with conventional jet fuel) and current developments show that FT fuels from biomass are technically feasible. Additionally, FT can be used to generate various final products, making it an interesting technology for the production of bio-based materials and potentially diversifying producer revenue.

3.3 HEFA

The HEFA technology is based on the hydro-processing of vegetable oils and animal fats. Approximately 1.2 tonnes of vegetable oil is required for 1 tonne of HEFA fuel. One of the main advantages of this technology pathway is the possibility to integrate this process into an oil refinery (with an additional step), avoiding the need to develop a dedicated production facility.

The HEFA production route is proven and already certified for blend ratios up to 50% and current investments in infrastructure suggest that the route has the scope to be economically viable in the near future.

Additionally, algal oil can be converted to biojet fuel via the HEFA technology, although algae biofuels are not yet produced commercially. Fundamental R&D challenges remain; however, it is expected that SAF from algae is technically possible using the HEFA process. The GHG profile associated with algae SAF production, while still in a research phase, has produced a wide spectrum of results.

3.4 Synthesized Iso-Paraffins from Hydroprocessed Fermented Sugars (SIP)

In 2014 the ASTM committee has included the use of renewable farnesane as a blending component in jet fuels for commercial aviation. The allowable blending percentage is 10% with the balance of 90% fossil kerosene.

3.5 Cost Expectations of Technology Pathways

The trading market for SAF remains opaque. There is not one widely referenced market price for SAF like there is for other commodities including crude oil. Intuitively, in an undeveloped market of both supply and demand the ‘experience curve’ will advance at different speeds.

A purpose produced single batch of neat SAF has typically cost between $2 and $7 USD per liter, compared to about $0.80 USD for conventional jet fuel. Over the long run critical scale will be achieved when the cost of biojet fuel equals the cost of fossil derived jet fuel, plus the cost of carbon, plus the social cost of sustainability. Production and feedstock improvements suggest further improvement potential exists to lower the unit cost of SAF production.

3.6 Availability and Economics of Feedstock Worldwide

The availability of different biomass feedstock varies greatly among the different regions of the world. Future production potentials depend on variables such as the development of the agricultural system (productivity level) and the governance of land use. Figure 8 lists a number of key biomass resources for advanced SAF production around the world.

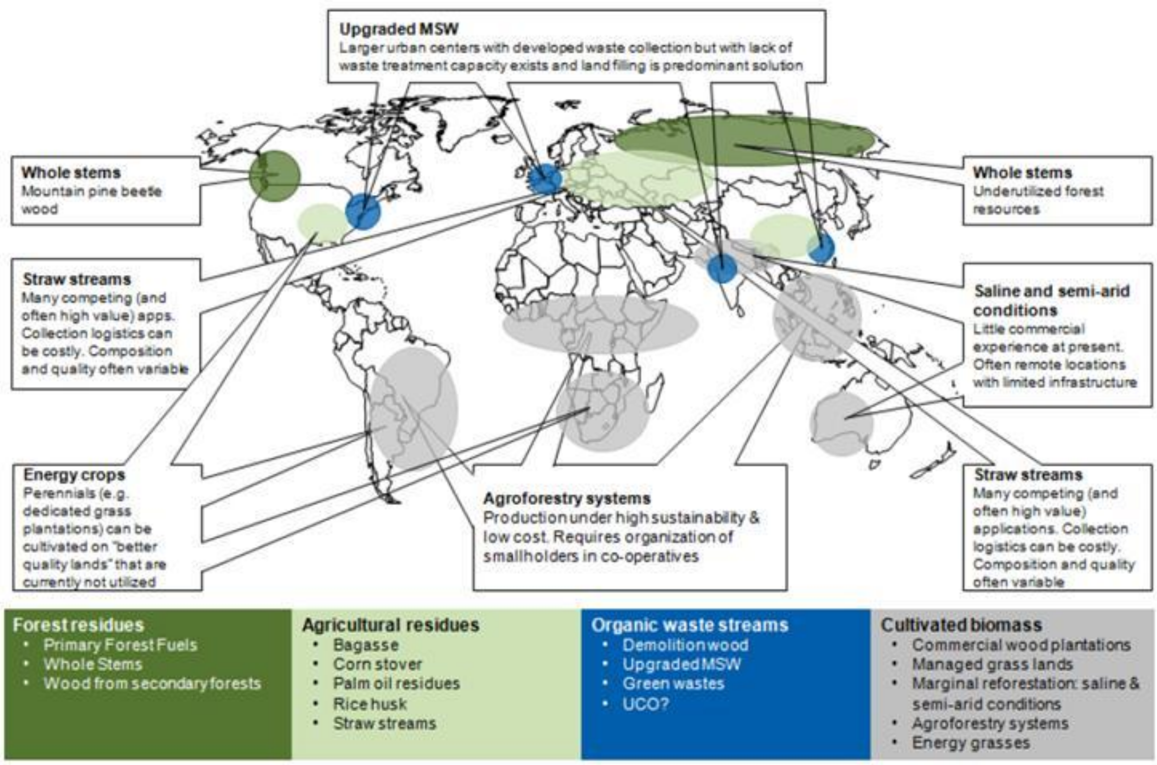


Figure 8. Key (potential) biomass resources and regions for the production of advanced SAF. Source; SKYNRG (2012)

According to the potential volumes that can be made available, the following biomass types appear to be the most relevant for the different technologies selected:

- Wood and forestry residues (FT)
- Agricultural residues, especially straw (FT)
- Municipal solid waste (FT)
- Jatropha oil (HEFA)
- Camelina oil (HEFA)
- Used cooking oil and animal fat (HEFA)
- Alcohols from sugars, like ethanol from sugarcane or from maize (ATJ/SIP)

- Direct Sugar to Hydro Carbon (DSHC)
- Algae (HVO/HEFA)

3.7 Wood and Forestry Residues

Forests cover approximately 3.95 billion hectares (or 30%) of the Earth's landmass. The German Biomass Research Centre (DBFZ) estimates the technical potential for wood based fuels to about 34 exajoules (EJ) in total by 2020. However, aviation generally applies strict sustainability standards precluding the use of primary forests. Further, even sustainable forest plantations derive a high value for manufacturing wood rather than converting to fuel. The technical potential is shown in Figure 9.

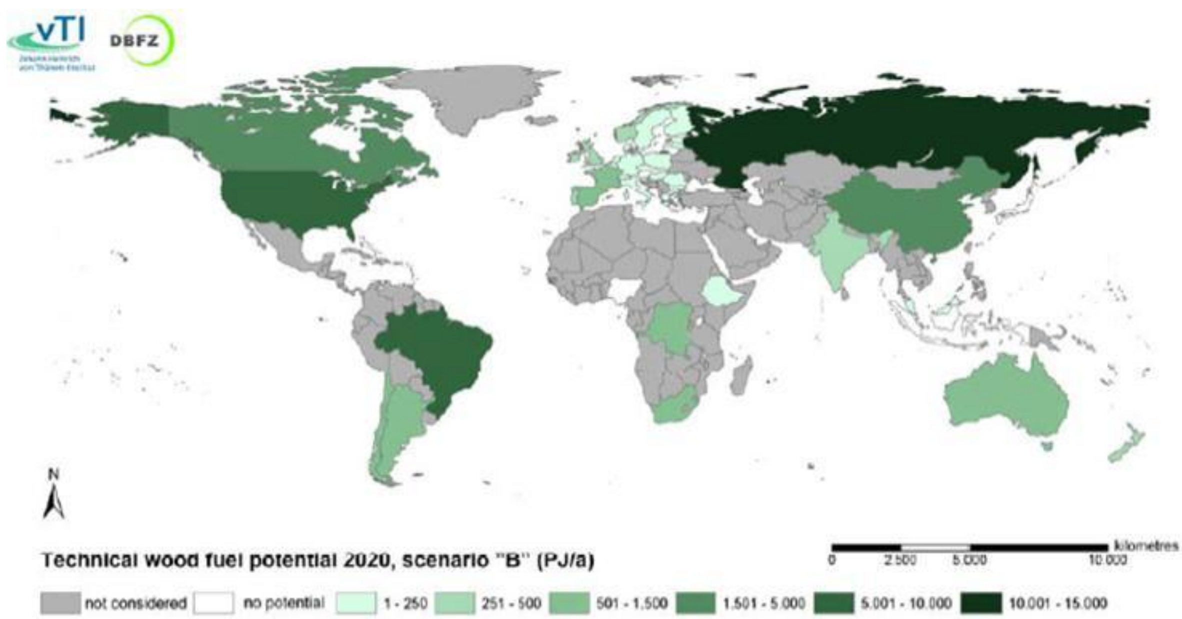


Figure 9. Technical wood fuel potentials in year 2020. Source: DBFZ (2011)

Agricultural Residues (straw)

According to the global straw potential research done by the German Biomass Research Centre, about 783 millions of tons (dry matter) of straw were available for the use of energy in 134 countries in 2011. Straw largely comes from the cultivation of maize, sugar cane, rice and wheat, with China having by far the largest theoretical potential, followed by India, the USA, and Brazil. Figure 10 shows the technical potential of straw for the years 2003-2007.

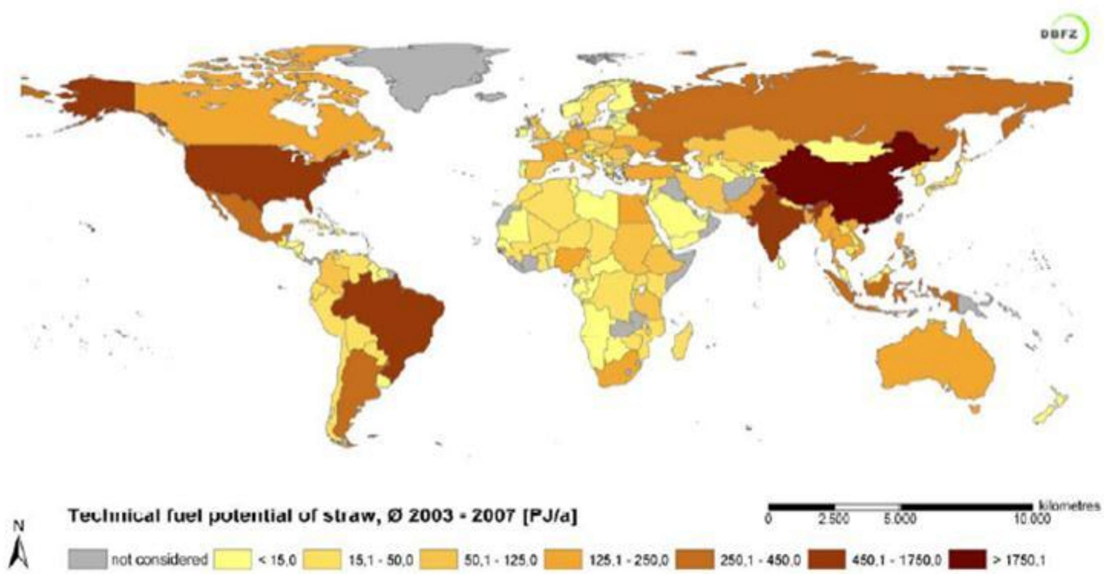


Figure 10. Technical fuel potential of straw during the period 2003-2007. Source: DBFZ (2011)

3.8 Agricultural Biomass

The availability of agricultural biomass for producing energy depends on the future availability of areas, which are not required for food production (the so-called non-food areas). Figure 11 shows the technical potential of agricultural biomass in year 2020 around the world. This is the theoretical potential based on a set of land exclusion variables (e.g. food production should be fulfilled), non-dependent of economic, policy or society constrains.

Brazil and the USA have the largest theoretical potentials. Both countries are already the largest ethanol producers in the world and are, therefore, relevant candidates for the production of ethanol for ATJ processes. These two countries are followed by Indonesia and Russia. Furthermore, the European Union, Canada, Argentina, Australia, Pakistan and South Africa also have large a potential for biomass crops.

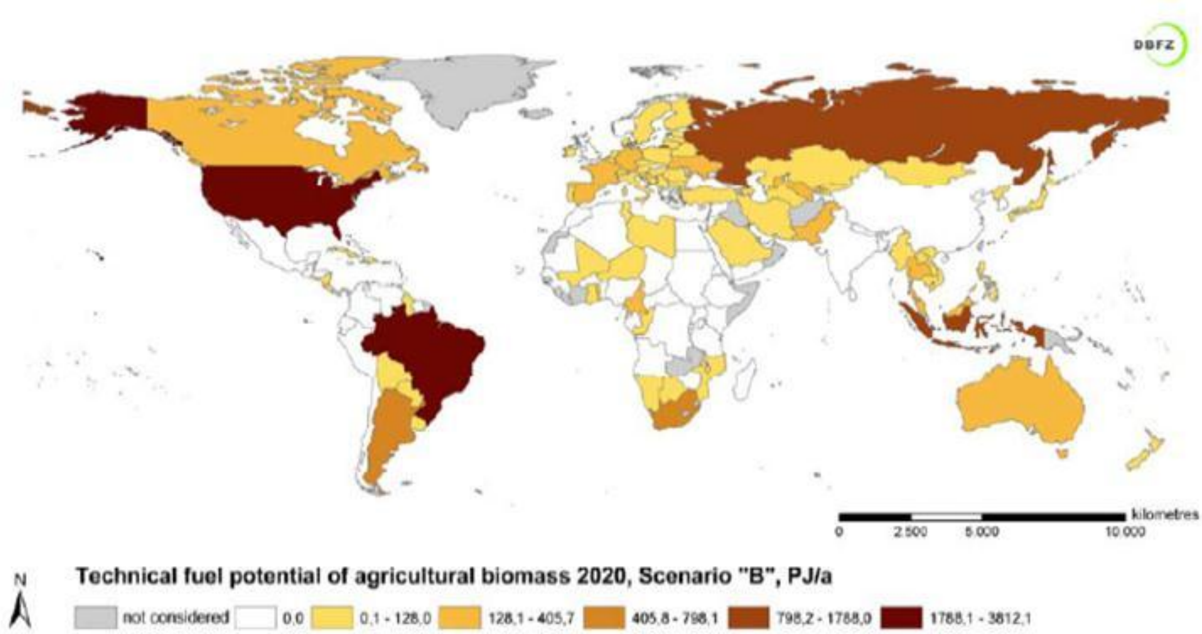


Figure 11. Technical fuel potential of agricultural biomass in year 2020. Source: DBFZ (2011)

3.9 Algae

Algae can grow in photo bioreactors or open raceways; they can also grow on non-arable land with various water sources. Algae have high growth rates, high photosynthetic efficiency and high value co-products. Algae can be genetically modified to produce specific by-products (lipids) as a result of their metabolic activity. However, the economics are uncertain as its production requires more energy and water than plant sources, waste and residues

3.10 Wastes and Residues

Waste and residues can also be used as feedstock for the production of SAF. The most viable residue for the production of SAF is used cooking oil (UCO) through the HEFA process. UCO is used in many businesses all around the world. The accessibility to UCO can be difficult given that a small number of entities control the supply. Presently the United States has the largest UCO market, largely due to having an effective logistics network in place, Municipal Solid Waste (MSW) can also be used for the production of biojet fuels via an FT process. The technology for doing so is advancing and some recent high profile airlines have signed large off-take agreements in commercial projects (Refer Section 8).

3.11 Cost Expectations of Feedstock

Feedstock is generally the largest cost item of SAF production. Its share in the total SAF cost may range from 45% to 90%. As a rule of thumb, the feedstock cost share is highest for HEFA, lowest for FT (waste residues) and somewhere in the middle for ATJ and SIP. In many cases the cost competitiveness of biojet fuels therefore depends on the price of feedstock.[18]

The cost of feedstock includes the price of raw material and its eventual pre-treatments. Transport costs from the feedstock supplier to the SAF plant must be added too. Table 5 shows a selection of the wide range of variables influencing feedstock, logistics and pre-processing costs:

Table 5. Variables influencing feedstock, logistics and pre-processing costs

Feedstock costs	Logistics and pre-processing costs
• Geographic origin	• Distance
• Feedstock type	• Accessibility
• Seasonality (droughts) and availability	• Mode of transportation
• Level of mechanization and inputs	• Technology level
• Scale	• Scale

Projects and strategies to increase feedstock yields and to optimize logistics in terms of availability and infrastructure are required to ensure the provision of feedstock at competitive prices.

3.12 SAF Efficiencies and Associated Lifecycle Emissions

SAF can be considered sustainable only if they have a substantially better GHG balance than their fossil alternative (jet fuel), do not harm the environment, or involve any negative socio-economic impacts. Not all biomass feedstock are fit to produce SAF (see Figure 12). The type and origin of the biomass feedstock largely determines the overall sustainability of the SAF, including the lifecycle of its GHG mainly through production and transport energy needs, use of fertilizers and land-use change (LUC) effects. Some types of biomass feedstock may actually cause more GHG emissions than conventional fossil jet fuel especially when considering indirect land use change impacts.

[18] SQ Consulting (2013)

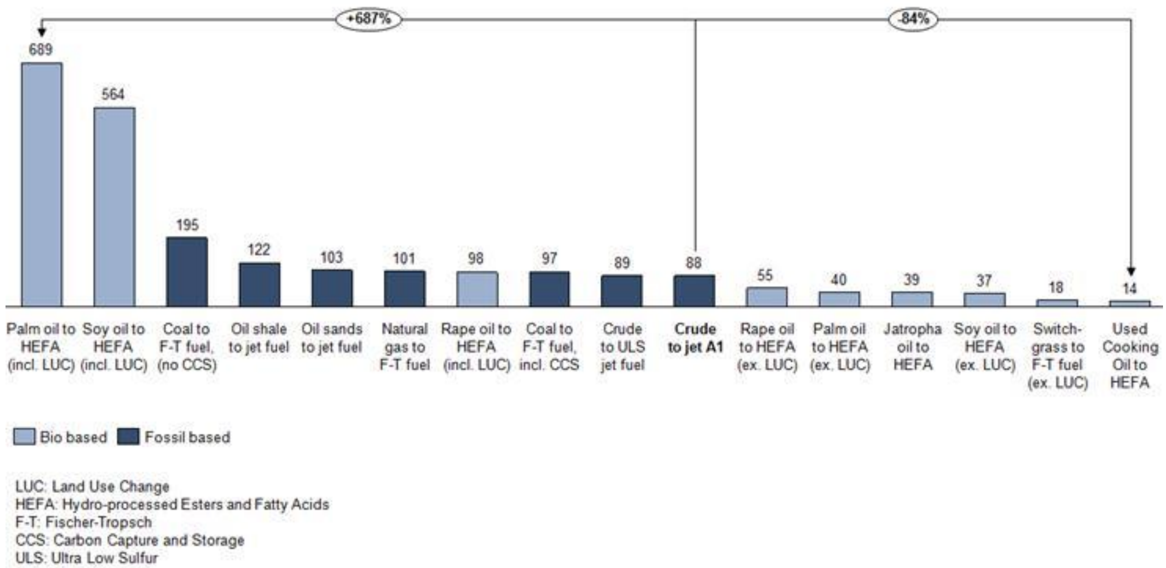


Figure 12. Well to Wing emissions different jet fuel production pathways (gCO_2/MJ), including renewable options. Source: White paper on SAF; Prof. Dr. André Faaij (Copernicus Institute, Utrecht University) & Maarten van Dijk (SkyNRG)

Table 6 presents a summary of the emissions reduction for a number of feedstock. SAF derived from wastes (such as animal fat and UCO), or based on wood and agricultural residues (such as straw), have significantly lower emissions than those based on conventional oil crops. SAF from algae can potentially be carbon neutral or even produce a reduction on GHG thanks to the absorption of CO_2 in co-products other than fuel. While these numbers are a useful guide, actual GHG reductions are ultimately dependent on the design of each specific project.

Table 6. Greenhouse gas emissions of SAF. Source: E4Tech (2009)

Technology pathway	Feedstock	Emissions (gCO_2/MJ fuel)	Savings CO_2 vs jet fuel (baseline)
	Jet fuel (average value)	87.5	
FT	Wood residues/straw	4.8	95%
HEFA	Conventional oil crops (palm oil, soy, rapeseed)	40-70	20%-54%
	Jatropha	30	66%
	Camelina	13.5	85%
	Animal fat	10	89%
	Algae (from open ponds)	-21 (best case) 1.5 (realistic case)	124% (best case) 98% (realistic case)

3.13 SAF Supply Chain

The SAF supply chain for the aviation sector has a number of similarities and differences compared to the SAF for road transport. Second generation biofuels for road transport and SAF may be produced in the same production plants. However, the biofuels market for the road transport sector is more developed and often subsidized. This means that production of SAF can be in direct competition with production of second generation biofuels for the road transport sector. Figure 13 illustrates schematically the SAF supply chain.

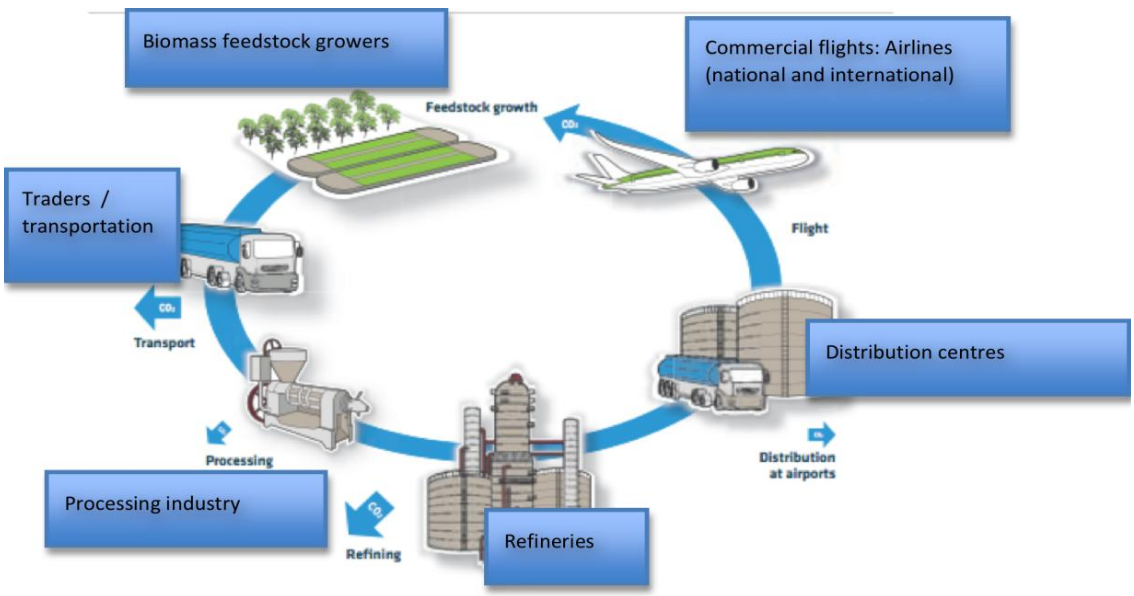


Figure 13. Supply chain cycle of SAF. Source: ATAG

The SAF value chain starts at the feedstock grower that produces the biomass. Eventually, various on-site pre-processing steps of the feedstock are involved prior to transport. For example, on-site pre-processes include the pressing of oil seeds or chipping of wood residues. The role of feedstock producers is to grow sustainable feedstock that meets the requirements of the buyers.

The biofuel producers buy the feedstock as input for the SAF conversion. Various intermediary stakeholders, who distribute or trade the feedstock from the grower to the SAF plant.

Refineries and/or oil supply companies buy the SAF from producers and refine it further if needed.

3.14 Biojet Fuel Price

SAF is an immature market. There does not presently exist a globally accepted SAF market price given the limited supply, and input cost variances which are influenced by geography, technology, and production process. This has resulted in many airlines treating their SAF procurement, hitherto, as confidential. Market economics suggest that as supply expands, the variance in global SAF price will narrow.

3.14.1 Evolution of Fossil Jet Fuel Price

Recently, fuel costs have accounted for around 30% of airlines operating costs, and sometimes more for low-cost carriers.[19] Crude oil prices have been historically high over the past 4 years, although declined sharply in late 2014 to around $50 USD per barrel for Brent.

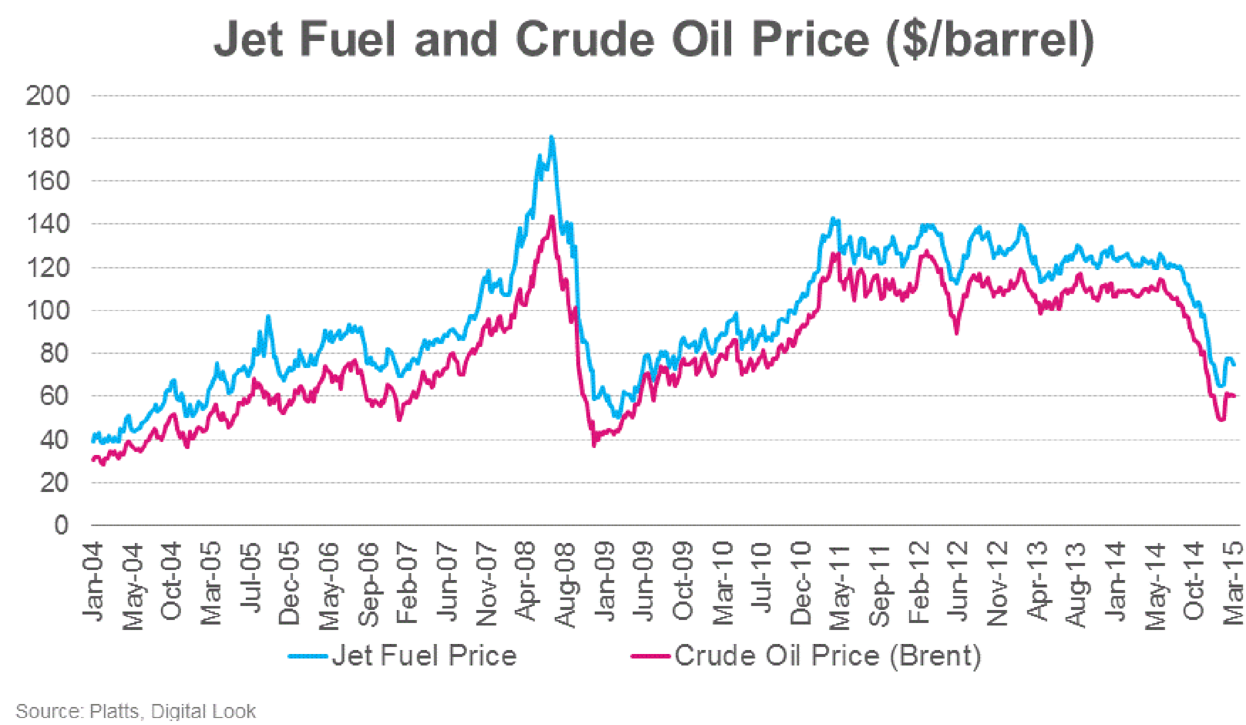


Figure 14. Evolution of jet fuel price since 2004.

3.14.2 Price Forecast

In the current situation of no developed market for SAF, with production only at intervals, and without any economic incentives, SAF are approximately 2 to 7 times more expensive than fossil jet fuel. SAF producers and airlines run their scenarios considering that incentives will disappear after some time, and that this will happen quicker when volumes increase due to any sort of obligation. Policy incentives can ultimately put pressure on national budgets, given the incentive is typically fixed, while the volume is variable. As volumes

[19] https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/fuel-fact-sheet.pdf

increase from successful policy, the government subsidy obligation also increases. This conundrum is important to address in early policy planning and communication about how a policy incentive will ‘fade out’ can be as important as the policy mechanism itself.

3.14.3 Links between the Prices of Biofuels and Food

A key characteristic of the production of bio-based materials for energy (including SAF) is its link to both the agricultural and energy markets, and its complex dynamics in price and demand. Energy markets and agricultural markets are connected. In fact, almost all commodities used in daily life are influenced by the oil price in some way, even if nothing more than through transport cost. Some economists refer to the price of oil as a global tax. It has been estimated that a $10 USD / barrel increase in the oil price takes approximately 0.1% off global GDP.[20]

3.15 Differences, Competition and Synergies with the Road Transport Biofuels Industry

3.15.1 Differences

There are a number of differences between the SAF industry and the biofuels for road transport. The most relevant differences are:

Maturity of the Sector

The market for biofuels for the road transport sector has been developed over a number of years. Current efforts are using the experience and inertia of an already functioning market to develop second generation technologies at a commercial level. Contrary to this situation, the market for SAF is still at an early stage, with no usage obligations and therefore commercialization developments are occurring at a slower pace.

International Scope

It is a characteristic that both biofuels and SAF and their feedstock can be produced anywhere independently of their place of consumption; both products can be transported and traded internationally. The road transport consumer however, typically buys fuel in one single jurisdiction, in contrast to the aviation consumer who buys fuel in multiple jurisdictions due to the international nature of flights. Different jurisdictions usually have (or potentially will have) different support mechanisms for SAF. There also exist differences between the accounting and sustainability requirements of different jurisdictions. In the short-term this may result in differences in the competitiveness of the industry, and in the availability and price of SAF, while in the longer term this highlights the importance of moving towards a globally harmonized compliance system.

[20] Goldman Sachs Equity Research 2011

Taxation

An additional important difference is the exemption from taxation for international (and some national) jet fuels, which removes the option of tax benefits for SAF, similar to those for automotive biofuels in various countries.

Stricter Safety Standards

The jet fuel supply chain has strict technical quality standards relative to road transportation fuels. Commercial aviation maintains an unblemished safety record regarding off-specification fuel, in part due to the thorough technical requirements defined in standards such as ASTM D1655. Comingling conventional jet fuel with SAF must satisfy equally strict criteria. ASTM D7566 outlines the requirements for SAF technical compliance. This specification applies only at the point of batch origination. Aviation turbine fuel manufactured, certified and released to all the requirement of ASTM D7566, thus meets the requirement of ASTM D1655 and shall be regarded as "Specification ASTM D1655 turbine fuel".[21]

3.15.2 Synergies and Competition

The production of SAF and second generation road transport biofuels can be linked. The same facilities are in many cases capable to produce both fuels simultaneously, from the same feedstock in different ratios depending on their market interest (see Figure 15).

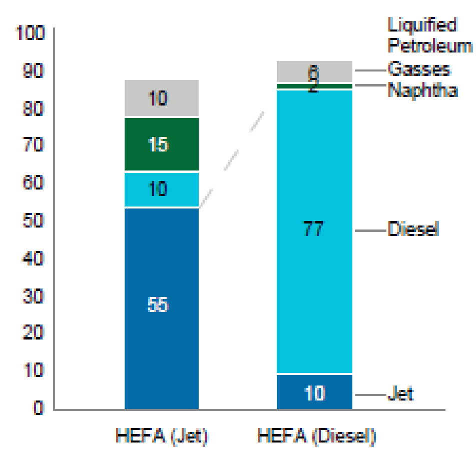


Figure 15. HEFA production possibilities (output as a % of input weight). Source: MASBI (2013)

If the price of ethanol is low enough, conventional ethanol plants could in the future add an ATJ process to produce SAF as well.

This capability for participating in both production chains represents the largest synergy between both industries, but it also introduces a factor of competition. Producers will primarily produce the product that

[21] IATA BioGuide (2nd Edition) www.iata.org

has the highest margin with the largest guaranteed market share. The market for road transport biofuels has already developed (mainly through mandates), whereas a similar market does not exist yet for the aviation sector. The biofuels market for road transport is strongly supported by different policy instruments around the world. In the case of the European Union, this market is already pursuing second generation biofuels. Since the production of SAF requires an extra refining step compared to second generation biofuels for road transport, the SAF cost will most likely be always higher than biofuels for road transport. This means that support incentives needed for bringing prices to competitive levels are larger for SAF compared to incentives needed for second generation road transport biofuels. This situation potentially affects the margins that biojet fuel producers may expect. At a minimum, a level policy playing field must exist, meaning producing SAF should receive the same incentive as producing biofuel for the road sector.

Some overlap exists between the aviation and road transport sector in technology use and development, especially when focusing on advanced biofuels. Both industries also deal with similar technological and commercial challenges:

- Both industries can be sensitive to the availability of feedstock and thus price and competition. Logistics, storage and pre-processing facilities largely overlap, especially upstream. Consequently, stakeholders coincide and participate in both supply chains;
- The road sector particularly, faces some public perception challenges, and, in some cases, negative sentiments on biofuels (e.g. due to competition in land use and impacts on food prices and other industries). Aviation can avoid these issues by focusing on second-generation biofuels from wastes and residues or appropriately certified sustainable feedstocks.

3.16 IATA's Role in the Commercialization and Deployment of SAF

IATA is a trade association with the objective to represent, serve and lead its member airlines. The primary role IATA can perform will be recommending and influencing policy, providing expert input to relevant working groups, and endeavoring to remove barriers toward the deployment of biojet fuel.

Some of the actions IATA undertakes to develop the commercial deployment of aviation biofuel are:

- Bringing together different stakeholders from industry and policymakers in the alternative fuel area and facilitating cooperation and partnerships between them
- Providing policy support at national, regional (e.g. EU) and international (UN) level to create the necessary framework for the commercialization of SAF
- Working towards removing obstacles to the realization of a cost-competitive, SAF market
- Promoting the use of SAF in compliance with robust sustainability criteria
- Raising public awareness for related industry efforts
- Playing a leading role in standard setting for drop-in SAF in the areas of technical certification and logistics, and providing related technical support
- Creating a platform for knowledge exchange, both amongst airlines and for external partners (e.g. airports)

Section 4—Sustainability Assessment and Proposals for Harmonization

4.1 Introduction

Current legislation in several countries demands compliance with sustainability criteria for biofuels used in road transport, most predominantly in the EU renewable energy directive (RED) and the US Renewable Fuel Standard (RFS2), to be eligible for incentives or to be counted towards targets set under these legislations. Although not widely used today, any SAF reported within these systems would also have to comply with these criteria. In contrast to the road sector, airlines operate flights to many different jurisdictions. Hence, as SAF usage becomes common globally it will be impractical for airlines to deal with varying standards from different jurisdictions. In an ideal situation, airlines would be able to purchase fuel from anywhere and use it on any flight with the knowledge it complies with the given sustainability standard.

Parts of Section 4 are extracted from the report by Ecofys "Assessment of sustainability standards for biojet fuel", the final report of a study sponsored by IATA (Ecofys, 2014a).

4.2 Overview of Legislation on Biofuels

4.2.1 Introduction

Countries considered are those which have already implemented sustainability requirements for biofuels. To date biofuel regulations have focused on biofuels for use in road transport, rather than for use in aviation. Nonetheless, a number of countries internationally have announced initiatives to stimulate the development of SAF.

The selection covers the key biofuel markets of the EU, USA, and Brazil, as well as Australia which has several planned initiatives for SAF. An overview of the relevant legislation and SAF initiatives in these countries is provided in Table 7.

4.2.1.1 Overview of Some National and Regional Initiatives

Table 7. Overview of legalization and SAF initiatives

Country	Rationale for selection	
	Relevant legislation	**Existing biojet fuel initiatives**
European Union	• Renewable Energy Directive (RED) • Fuel Quality Directive (FQD) • Emission Trading System (EU	• EU-wide: EU Advanced Biofuels Flight path Initiative, ITAKA, • Member State level: aireg, Biokerosene

Country	Rationale for selection	
	Relevant legislation	Existing biojet fuel initiatives
	ETS)	Agreement (Green deal)
United States	• Renewable Fuel Standard (RFS2) • Renewable ID Numbers (RINs) • Memorandum of Understanding with USA on biojet fuels	• Commercial Aviation Alternative Fuels Initiative (CAAFI) • Midwest Aviation Sustainable Biofuels Initiative (MASBI) • Sustainable Aviation Fuels Northwest (SAFN)
Brazil	• National Fuel Alcohol Program (ProÁlcool) • National Production and Use of Biodiesel (PNPB) • Memorandum of Understanding with USA on biojet fuels	• Sustainable Aviation Biofuels for Brazil (SAAB) • Brazilian Alliance for Aviation (ABRABA) • Brazilian Biojet Fuel Platform
Australia		• Australian Initiative for Sustainable Aviation Fuels (AISAF) • Flight path to sustainable aviation

4.2.2 European Union (EU)

The RED sets a 10% target for the use of renewable energy in transport by 2020 across the EU (and correspondingly at the Member State level). The target is measured against the use of fuel in road transport (denominator), but can be fulfilled by any renewable energy in any form of transport (numerator). This means that SAF could count towards the target, as well as renewable electricity used in rail or road transport. However, for SAF to be counted this requires implementation at the Member State level, and at present this has only been actioned by the Netherlands. Alongside the RED, the Fuel Quality Directive (FQD) sets a 6% target of GHG emission reduction from all energy used in road transport and non-road mobile machinery for 2020 compared with 2010. The FQD target does not apply to aviation fuel, but is expected to be a driver for increased road biofuels, alongside the RED.

Carbon emissions from flight operations from January 2012 are subject to the EU Emissions Trading Scheme (ETS). Initially all flights from, to and within the EEA (European Economic Area, i.e. EU plus Norway, Iceland and Liechtenstein) were intended to be included in the scheme. However, in November 2012 the enforcement of applying the EU ETS to flights to and from outside the EEA was put on hold for one year. The so-called “Stop the Clock” amendment was intended to give ICAO an opportunity to reach an internationally accepted solution to deal with carbon emissions from aviation. Following ICAO’s commitment in October 2013 to develop a global MBM (Market Based Mechanism) for the aviation sector, the exemption of flights to and from outside the EEA has been extended to 2016, meaning that until that time only intra-EEA flights continue to have to surrender allowances under the EU ETS.

The RED and the FQD have harmonized requirements regarding biofuel sustainability. Similarly, for biofuels to be zero emissions rated in the EU ETS they will have to demonstrate that they meet these same sustainability requirements. These relate to the protection of land with high biodiversity value and land with high carbon stock, including peatlands, as well as meeting minimum GHG savings.

There are several multi-stakeholder, government or EC-supported SAF initiatives in the EU (at both EU and Member State level); amongst the most relevant are:

- **EU Advanced Biofuels Flight Path Initiative:** In 2011, the EC, in coordination with Airbus, leading European airlines and key European biofuel producers, launched an industry-wide initiative to speed up the commercialization of SAF in Europe. The "European Advanced Biofuels Flight Path" initiative is a roadmap to achieve an annual production of two million tonnes of sustainably produced biofuel for aviation by 2020.[22]
- **Initiative Towards Sustainable Kerosene for Aviation (ITAKA):** ITAKA is a collaborative project between aircraft manufactures, airlines, fuel suppliers and others. It specifically aims to make a contribution to the fulfilment of some of the short-term (2015) EU Flight Path objectives. ITAKA will address challenges in two main areas: (1) development of commercial scale production and study implications of large-scale use, and (2) research on sustainability, economic competitiveness and technology readiness.[23]
- **Aviation Initiative Renewable Energy in Germany (aireg):** Aireg was founded in 2011, and comprises airlines, airports, research organizations, and companies in the aviation and feedstock industries. Aireg's target is for biofuels to make up 10% of the jet fuel consumed in Germany by 2025.[24]
- **Biokerosene Agreement (Green Deal) in the Netherlands:** In November 2013, the Dutch Ministries of Infrastructure and Environment and Economic Affairs, KLM, Schiphol Group, SkyNRG, Neste Oil and the Port of Rotterdam signed a declaration of intent to promote the large-scale deployment of SAF in the Netherlands.[25]
- **Bioqueroseno:** The "Spanish Initiative for the Production and Consumption of Biokerosene for Aviation" was formed in 2011 with the signing of an agreement between the Ministry of Industry, Energy, and Tourism; the Ministry of Public Works; the Ministry of Agriculture, Food, and Environmental Affairs; Services and Studies for Air Navigation and Aeronautical Safety (SENASA); and several companies related to the production of raw materials, refining technologies, aeronautical logistics and sustainability processes. This initiative is structured as a platform to exchange information, identifying needs as well as connecting the public and private sectors.[26]

---

[22] http://ec.europa.eu/energy/renewables/biofuels/flight_path_en.htm

[23] http://www.itaka-project.eu/default.aspx

[24] http://www.aireg.de/en/

[25] http://www.government.nl/news/2013/11/15/mansveld-biokerosene-agreement-chain-agreement-on-recycling-plastic-and-green-deals.html

[26] http://www.bioqueroseno.es/nav/en/default_en.aspx

- **NISA:** The Nordic Initiative for Sustainable Aviation comprises stakeholders from the public and private sectors of Norway, Finland, Sweden, Denmark and Iceland, covering airlines and their associations as well as authorities, airports and international manufactures (Airbus, Boeing). NISA was founded in November 2013 and is endorsed by IATA.[27]

4.2.3 United States (US)

The US Congress established the Renewable Fuel Standard (RFS) under the Energy Policy Act (EPAct) of 2005, to encourage the blending of renewable fuels into the nation's motor vehicle fuel supply. The RFS was the first renewable fuel volume mandate in the US and required 7.5 billion gallons (28.4 billion liters) of renewable fuel (either produced in the US or imported) to be blended into petrol[28] by 2012.[29] Progress against the RFS targets was rapid and by 2006 5.6 billion gallons (21.2 billion liters) of renewable fuel was blended, almost 25% more than was required in that year. This resulted in the US Environmental Protection Agency (EPA)[30] recalibrating the RFS targets in 2007. The RFS was strengthened by Congress under the Energy Independence and Security Act (EISA) of 2007. Under the EISA of 2007, the RFS program was expanded in several key ways, to:

- Include “on” and “off-road” petrol and diesel, in addition to “on” road petrol;
- Increase the volume of renewable fuel required to be blended into transportation fuel from 9 billion gallons in 2008 to 36 billion gallons by 2022;[31]
- Establish four new categories of renewable fuel, and set separate volume requirements for each
    - Cellulosic biofuel,[32]
    - Biomass-based diesel,
    - Advanced biofuel,
    - Total renewable fuel;
- Require EPA to apply minimum lifecycle GHG performance threshold standards for each category of renewable fuel with grandfathering provision for specific facilities;
- Impose restrictions on the types of feedstock that can be used to produce renewable fuel, and the types of land that can be used to grow and harvest feedstocks.

---

[27] http://www.cphcleantech.com/nisa

[28] Commonly termed “gasoline” in the US

[29] http://www.epa.gov/otaq/fuels/renewablefuels/

[30] The EPA is the Federal Agency tasked with developing and implementing the RFS.

[31] i.e. 34 billion liters in 2008 and 136 billion liters in 2022.

[32] Cellulosic biofuel volume target is set annually based on an evaluation of the volume of cellulosic biofuel that can be made in that year (reflecting the fact that cellulosic biofuel plant development in the US has been slower than originally planned under RSF1).

Following these changes, the RFS was re-labelled as the RFS2. The annual RFS2 targets are expressed as a volume percentage and prorated across the refiners, blenders and importers that are operating in the US ("Obligated Parties") to determine their target renewable fuel volume obligations (RVOs). The applicable percentages are set so that if each regulated party meets the percentages, and if EPA projections of gasoline and diesel use are accurate, then the amount of renewable fuel, cellulosic biofuel, biomass-based diesel, and advanced biofuel used will meet the volumes required on a nationwide basis.

The US uses tradable Renewable Identification Numbers (RINs) to facilitate compliance with the RFS. Although jet fuel is not mandated under the RFS2, producers or importers of SAF can still generate RINs provided the fuel meets the correct definition of renewable fuel.[33]

There are a number of SAF initiatives operating in the US.

- **Commercial Aviation Alternative Fuels Initiative (CAAFI):** CAAFI is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants and US government agencies. It aims to enhance energy security and environmental sustainability for aviation through SAF.[34]
- **Midwest Aviation Sustainable Biofuels Initiative (MASBI):** MASBI aims to define a roadmap for the development of sustainable advanced biofuels in the US Midwest. The MASBI Steering Group comprises United Airlines, Boeing, the Chicago Department for Aviation, Clean Energy Trust, and Honeywell UOP. In addition, over 30 other stakeholders are also participants.[35]
- **Sustainable Aviation Fuels Northwest (SAFN):** SAFN was launched in 2010 to explore the opportunities and challenges surrounding the production of SAF. The initiative was set up by Boeing, Alaska Airlines, three regional Northwest airports and Washington State University and is supported by over 40 organizations.[36]
- **US interagency biofuel partnership:** The US Department of Defense (DOD) is establishing interagency biofuel partnerships with the US Departments of Energy and Agriculture. The US Air Force has also set a goal for procuring half of its US-based jet fuel supply from bio-feedstocks by 2016, which will represent approximately 400 million gallons of aviation biofuel per year. The US Navy has a goal of procuring 336 million gallons annually by 2020.[37]

In addition to the above initiatives, the US and Brazil signed a Memorandum of Understanding to cooperate on the development of SAF in 2011.[38]

---

[33] http://fuelsprograms.supportportal.com/link/portal/23002/23005/Article/24606/While-there-is-no-renewable-fuel-obligation-under-the-RFS2-program-for-the-production-or-importation-of-conventional-jet-fuel-RINs-can-be-generated-for-renewable-jet-fuel-Is-that-right

[34] http://www.caafi.org/

[35] http://www.masbi.org/

[36] http://www.safnw.com/

[37] http://www.nrdc.org/energy/aviation-biofuel-sustainability-survey/files/aviation-biofuel-sustainability-survey-IB.pdf

[38] http://www.whitehouse.gov/sites/default/files/uploads/Partnership_Development_Aviation_Biofuels.pdf

4.2.4 Brazil

Brazil has a long history in production of biofuels, starting with the launch of the National Fuel Alcohol Program (ProÁlcool) in 1974, which made Brazil the most experienced country in processing bioethanol. Whereas the promotion of bioethanol was definitely successful, there were also downsides like geographical concentration of monocultures and dominance of big agro-companies leading to exclusion of family farms. In 2004, Brazil implemented the National Production and Use of Biodiesel (PNPB) with the aim of avoiding the same negative effects for biodiesel. However in June 2013, Stattman et al. (2013) concluded that the PNPB did not achieve his ambitious aim for social inclusion of family farms.

Brazil has effective policies for the promotion of biofuels in the ProÁlcool and PNPB, but in contrast to the USA and the EU, there is no overarching sustainability policy on biofuels. Instead there are several laws on environmental protection, agro-ecological zoning, and climate change which aim for broad environmental protection, but which do not set requirements for biofuels specifically.

To date, no laws have been implemented on GHG targets or chain of custody requirements. Besides agro-ecological zoning and the soy moratorium in the Amazon there are no further mandatory criteria for land use in Brazil.

Brazil has a number of initiatives that are aimed at stimulating SAF deployment in Brazil:

- **ABRAB:** Brazilian Alliance for Aviation Biofuels was created in 2010 as a forum to discuss the various aspects of developing SAF driven by the growing demand to meet the requirements for reducing greenhouse gas emissions in aviation as well as to provide support for Brazil's energy security. This initiative aims to make Brazil a major world player in SAF, similar to what is already being done in ground transportation. The goal is to promote public and private initiatives that streamline the development, certification, and commercial production of SAF.[39]
- **Sustainable Aviation Biofuels for Brazil (SABB):** Evolving from an initiative by Boeing, Embraer, FAPESP and UNICAMP in June 2013 several stakeholder workshops have been organized to develop a flightpath to SAF in Brazil including an action plan to replace conventional jet fuel.[40]
- **Brazilian Biojet Fuel Platform (PPB):** With Boeing, Embraer and several biofuel feedstock producers as members this platform works on implementing the flightpath developed by SABB.
- **UBRABIO:**

4.2.5 Australia

Australia has pledged to decrease its emissions by 5% in 2020 compared to the 2000 emission level. In order to achieve this aim, renewable energy targets have been set including stimulus measures for wind and solar. In 2011 a carbon tax was implemented to promote the shift from coal-based energy to renewable

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

[40] http://www.nipe.unicamp.br/sabb/

energy. The carbon tax was intended to lead towards an emissions trading system, which could then be harmonized with the existing system in New Zealand. However, a proposal to repeal the carbon tax, after heavy debate was successfully passed in July 2014.[41] The environmental policies of the current conservative government will make achieving Australia's 2020 GHG reduction target challenging and Australia under the current Abbott government earns the unique distinction as one of the only countries to be taking a backward step on environmental policies.

There are few policy measures for biofuels in Australia. At a national level a tax relief exists for biofuels, but mandatory targets for biofuels are missing. A sustainability standard is also non-existent at a national level, so there is no need to demonstrate compliance with sustainability criteria for domestically produced or imported biofuels. The only exemption is the state of New South Wales (NSW), where the Biofuels Act 2007 (amended in 2012) demands an ethanol mandate of 6% and a biodiesel mandate of 2% aimed to increase to 5%. However, in December 2011 the NSW government suspended the increase of the biodiesel mandate to 5% due to insufficient local biodiesel production. For biofuels to be counted towards the target in NSW, economic operators have to demonstrate compliance with the criteria of the Roundtable on Sustainable Biomaterials (RSB) voluntary scheme.

Despite the lack of a biofuels sustainability standard in national legislation, Australian industry has been proactive in striving towards SAF, which is shown by the following initiatives.

- **Flight path to sustainable aviation:** In 2011 the Commonwealth Scientific and Industrial Research Organization (CSIRO) drafted a roadmap for establishing SAF in Australia and New Zealand with support by airlines, manufacturers and engine producers. Key challenges and recommendations have been defined for the public and private sector.

The Australian Initiative for Sustainable Aviation Fuels (AISAF): Founded with the aim to create a platform for the promotion of SAF and to collaborate with the USA in line with the Memorandum of Understanding signed by the Australian Government in September 2011. Members include Qantas, having conducted the first flights with SAF in Australia, Virgin Australia, and other stakeholders from the aviation industry. In August 2014, due to the cessation of government funding, AISAF reverted to being an initiative of the Sustainability Program at the United States Studies Centre.

4.3 Comparison between the RED and RFS

4.3.1 Similarities between the Standards

A key similarity between the RED and the RFS2 is that SAF can be supplied under both standards and can be counted towards their respective targets. The RED target is measured against the use of fuel in road transport (denominator), but can be fulfilled by any renewable energy in any form of transport (numerator). This means that SAF could count towards the target. However, this requires implementation at the Member

[41] http://www.environment.gov.au/topics/cleaner-environment/clean-air/repealing-carbon-tax

State level, which has so far only been actioned by the Netherlands. Similarly, although jet fuel is not mandated under the RFS2, producers or importers can still generate RINs by supplying SAF.

The two standards cover broadly similar mandatory sustainability requirements, which must be met in order for biofuels to be counted. These requirements relate to restrictions on land conversion after December 2007 (RFS2) and January 2008 (RED), and also minimum GHG saving targets for biofuels.[42] Neither set of requirements cover wider environmental criteria, such as the protection of soil, water and air, or social and economic aspects. They do, however, both require wider environmental and social aspects to be reported by the authority on a periodic basis.

4.3.2 Differences between the Standards

There are a number of fundamental differences between the RED and RFS2. These primarily relate to the following aspects:

- Target setting
- GHG savings target and calculation methodology
- Chain of custody options
- Demonstrating compliance and auditing

Target setting

A key difference between the RED and RFS2 relates to how the targets are set up. The RED sets a renewable energy in transport target of 10% by energy in 2020, which is applicable at Member State level and across the EU as a whole. The RED does not set interim targets, or specify sub-targets for specific biofuel types (or other renewable energy types). As such, Member States have flexibility in how they meet the 2020 target. The RED also “double counts” biofuels produced from wastes and residues towards the 2020 target. To date this policy measure has resulted in the supply of significant volumes of UCOME[43] across the EU. The implication of double counting is that the 2020 target is likely to be met by supplying a lower volume of biofuel than would otherwise be required.

The RFS2 sets annual targets up to 2022 split by biofuel category (namely “advanced biofuel”, “biomass-based diesel”, “cellulosic biofuel” and “renewable fuel”). Unlike the RED, these targets are set on a volume basis. There is no differentiation between fuels supplied under the RFS2, except that different fuels are counted towards the RFS2 targets according to the degree that they displace petrol. These so called “equivalence values”, however, are not a function of the type of feedstock used to produce the renewable fuel or to the fuel production process.

[42] The land conversion restrictions apply to both agricultural and forestry products (e.g. wheat, roundwood) and agricultural and forestry residues (e.g. straw, thinnings).

[43] Used Cooking Oil Methyl Ester

GHG savings target and calculation methodology

A number of fundamental differences exist between the standards in relation to how the GHG saving targets are implemented. For a pathway to be accepted in the RFS2, the EPA calculates the typical GHG emissions associated with that pathway. The minimum GHG saving that has to be achieved for the pathway to be eligible depends on the fuel type; this ranges from 20% for renewable fuel, to 50% for biomass based diesel and advanced biofuel and up to 60% for cellulosic ethanol. In contrast in the RED, economic operators are responsible for reporting the GHG saving of their individual consignments of biofuels and ensuring that they meet the minimum GHG threshold. GHG savings can be calculated using actual values relating to the specific supply chain, or selected from a range of conservative ‘default values’ which are defined according to the feedstock and certain supply chain characteristics. Furthermore, the GHG saving targets in the RFS2 remain fixed to 2022. Under the RED the current GHG savings threshold is 35% for all biofuels, increasing to 50% from 1 January 2017 for existing installations and 60% from 1 January 2018 for installations that start producing biofuels after 1 January 2017. Additionally, the fossil fuel comparators for petrol and diesel in the RFS2 are around 10% higher than their equivalent in the RED, implying that, for example, a biofuel with a 50% GHG saving under the RFS2 would attain a lower percentage GHG saving under the RED.

The RED contains temporary grandfathering provisions for biofuels made from existing facilities. An expired provision enabled installations in operation on or before 23 January 2008 to be exempt from the 35% GHG savings requirement until 1 April 2013. Similarly, the 60% target applicable from 2018 does not apply to installations producing biofuel before January 2017. A key difference with the grandfathering provisions under the RFS2 is that the exemption for grandfathered facilities does not expire and is considered indefinite. These relate to renewable fuel facilities that commenced construction on or before 19 December 2007 and ethanol facilities that commenced construction after 19 December 2007, but before 31 December 2009 and fired with natural gas or biomass. In both cases the biofuels produced from these facilities are exempt from the 20% GHG savings requirement.

The options available in the standards for calculating GHG emissions differ. In the RFS2, the GHG emissions for fuel pathways are determined by the EPA through a formal review process.[44] Only those fuel pathways that meet the appropriate minimum GHG savings target are approved for use in the RFS2. As such, participants in the RFS2 do not have to undertake GHG calculations. The approach in the RED gives the option for participants to undertake their own GHG calculations if they do not want to use the relatively conservative “default values” for common biofuel pathways.

The standards take a different approach to land use change emissions. The GHG saving values quoted in the RFS2 take into account an overall estimate of both “domestic” (i.e. US) and “international” land use change emissions, whereas the RED currently requires participants to only take into account any actual *direct* land use change emissions associated with their specific supply chain. It should be noted that the EU has been discussing options to account for *indirect* land use change emissions as well, although no agreement has been reached.

[44] Defined as feedstock, fuel type and production process.

A further difference existing between the RFS2 and RED is the method for dealing with co-products. The RED allocates emissions to co-products on an *energy basis*, whereas the RFS2 uses the *system expansion* (also known as displacement) method.

Chain of custody options[45]

There is a fundamental difference in the approach that the standards take with regard to the chain of custody – the method by which sustainability information is traced through the supply chain from the production of the raw material to the fuel supplier who has to demonstrate compliance with the legislation.

The RFS2 places no restrictions on the mixing of biofuel produced in different facilities, with different feedstocks, or through different processes, provided that the origin is within the US. However, imported batches of biofuel need to be kept physically segregated from fossil batches until they are imported in to the US in order to comply with the RFS2 and receive RINs. Once the RINs have been generated then mixing of biofuel can occur.

The RED requires a mass balance system to be used, although stricter chain of custody options (like physical segregation) are also permitted. The book-and-claim system, however, is not permitted. Unlike the RFS2, the chain of custody requirements under the RED apply to all participants, there is no differentiation between imported and domestic biofuel.

Demonstrating compliance and auditing

Although the fundamental aims of the sustainability criteria in both the RED and RFS2 are largely the same, the options to demonstrate compliance with the sustainability requirements differ significantly. Under the RED, compliance is demonstrated through the use of voluntary schemes recognized by the EC or national systems implemented by Member States.[46] Voluntary schemes have become the preferred approach in most Member States and in some Member States (e.g. Germany and the Netherlands) the only options allowed in the national system are to adhere to one of the recognized voluntary schemes.[47] A number of options are available under the RFS2, the most relevant one being the "aggregate compliance approach". This provides a record keeping exemption for biofuel produced from planted crop or crop residue from existing US agricultural land, provided that the 2007 baseline amount of US agricultural land has not been exceeded. The approach is also open to countries outside of the US, and in March 2011 the EPA approved the use of this approach in Canada. Compliance options for feedstocks or biofuels originating outside the US and Canada primarily rely on record keeping and reporting to the EPA to demonstrate that the land from which the feedstock was obtained was cleared prior to 19 December 2007 and that the land was actively managed on that date. Voluntary schemes (termed "agricultural product certification programs") could

[45] For more information on chain of custody options see Ecofys, *Biojet Fuel Accounting Methods*, 2014.

[46] According to the legislation bilateral agreements between the EU and third countries are also foreseen, although none have been agreed to date.

[47] The term "voluntary schemes" defines sustainability standards for biofuels which have been developed by the private sector and can be used to demonstrate compliance with the RED or a national scheme. Even if the use of one of the voluntary schemes is mandatory, the term "voluntary" remains. Some schemes also go beyond mandatory requirements.

potentially be used to demonstrate compliance under the RFS2, although to date no schemes have been assessed by the EPA.

Finally, a difference exists in the auditing requirements between the standards. The RED only permits independent auditing, while under the RFS2 it is also possible for internal auditors to undertake auditing ("attest") engagements provided they meet certain minimum criteria.

4.4 Overview and Comparison of Relevant Voluntary Schemes

4.4.1 Voluntary Scheme Selection

There exists a large number of voluntary sustainability certification schemes.

Five voluntary schemes have been selected for a detailed assessment:

- Biomass Biofuel Sustainability Voluntary Scheme (2BSvs)
- Bonsucro EU
- International Sustainability & Carbon Certification (ISCC) EU
- Roundtable on Sustainable Biomaterials (RSB EU RED)
- Roundtable on Sustainable Palm Oil (RSPO-RED)

Some of these schemes have two different versions, an original one and one adapted to the specific requirements of RED; note that, where relevant, the "EU" or "RED" version of the scheme is shortlisted as this is the version recognized by the EC. In most cases the EU/RED version goes beyond the requirements of the standard version of the scheme, i.e. it covers the standard requirements *plus* the specific requirements of the RED.

The most interesting aspects in the assessment of voluntary schemes are the differences between the schemes and the comprehensiveness of the sustainability issues addressed. The **Biomass Biofuel Sustainability Voluntary Scheme (2BSvs)** and the **Roundtable on Sustainable Biomaterials (RSB EU RED)** are chosen as schemes with contrasting levels of ambition in terms of the sustainability issues covered. 2BSvs was developed to cover the mandatory criteria of the RED and so represents a scheme with a lower level of ambition, whereas RSB EU RED covers a comprehensive range of sustainability issues.

A further relevant aspect is whether the scheme covers feedstocks that are suitable for the production of SAF. Whereas many of the schemes cover multiple agricultural feedstocks, some are tailored towards specific feedstocks, like **Bonsucro EU** (targeting sugarcane) and the **Roundtable on Sustainable Palm Oil (RSPO-RED)**. These schemes are short listed for several reasons. Sugarcane is considered to be a promising future SAF feedstock, either via direct conversion into synthetic hydrocarbons (DSHC) or first into ethanol and then into alcohol to jet (ATJ). In addition, Bonsucro is the most dominant scheme in Brazil, which is also identified as a key market for SAF. Although palm oil feedstock which attracts a great deal of controversy, the RSPO has been chosen as it operates a "book-and-claim" chain of custody system, which may be an interesting option for the aviation industry. The book-and-claim system is further outlined in the report on accounting methods for SAF. Finally, the **International Sustainability and Carbon Certification (ISCC EU)** scheme completes the short-list, as it is the most widely used scheme by the (European) biofuels industry.

4.4.2 Review of Selected Voluntary Schemes

The comparison of the five 'short-listed' schemes focusses on the respective EU RED compliant versions. The basic information is accessed from the voluntary scheme websites. For all voluntary schemes the following aspects are considered: sustainability principles and criteria, guidelines for traceability and chain of custody systems, and audit requirements. The key features of each scheme can be found in a summary comparison in the following section.

4.5 Comparison of Key Aspects of Voluntary Schemes

The table below summarizes the key aspects of the five assessed voluntary schemes, which facilitates the identification of similarities and differences. Color codes are explained in detail for each voluntary scheme after the table.

Table 8. Comparison of voluntary schemes – key aspects

Aspect	2BSvs	Bonsucro EU	ISCC EU	RSB EU RED	RSPO-RED
Scope					
Feedstock coverage	All	Sugarcane	All	All	Palm Oil
Recognition of other EU schemes					
Mandatory Sustainability criteria					
Coverage of RED land criteria					
Soil, water and air protection					
Social					
Economic					
Chain of Custody (CoC) and Traceability					
Mass balance	Continuous	Continuous	Deficit - 3 months balancing period	Continuous	Continuous
Further CoC options	No	Physical shipment, Book-and-claim	Physical segregation	Identity of product preserved, Segregation of product	Segregated, Identity Preserved and Book-and-claim

Aspect	2BSvs	Bonsucro EU	ISCC EU	RSB EU RED	RSPO-RED
Unique ID number for consignment					
Coverage of tracked information through the supply chain	Low	Medium	High	High	High
Auditing					
Unit of certification	First gathering point and supply base	Mill and supply base	First gathering point and supply base	First gathering point and supply base	Mill and supply base
Certificate validity	5 years	3 years	1 year	3 months – 2 years depending on risk class	5 years

Similarities between the schemes

As all of the short-listed schemes are EC recognized, they naturally cover the RED land and GHG criteria. Furthermore, all five schemes have a global scope and cover the full supply chain from feedstock cultivation to biofuel production. Again, this is a result of the selection of voluntary schemes made for this report, as a global industry requires global operating schemes and prefers a one-stop-shop solution.

All five voluntary schemes permit group auditing, although at different points along the supply chain and with different requirements regarding the definition of a group and the sampling size for audit.

Main differences between the schemes

The main difference between the schemes is on the comprehensiveness of sustainability issues covered, as well as on requirements for traceability (as indicated in Table 8). These are explained in detail below:

1. **Recognition of other voluntary schemes:**
   - Bonsucro and RSPO-RED do not accept other EC recognized schemes.
   - 2BSvs only recognizes the EU versions of the German schemes REDcert EU and ISCC EU (partial recognition therefore marked yellow).
   - ISCC recognizes all EC recognized voluntary schemes, which means that 2BSvs certified rapeseed could be sold as ISCC certified rapeseed biodiesel in the end. The only condition is that the information tracked along the supply chain has to be in line with ISCC requirements, which are more comprehensive than 2BSvs. Nevertheless this 2BSvs / ISCC biodiesel will not necessarily fulfil all ISCC sustainability requirements, but it could be sold as such.
   - RSB recognizes all EC recognized voluntary schemes; however, the claim that can be made is differentiated. If a different scheme is used for the feedstock production stage, the claim made is “EU RED compliant”, rather than “RSB EU RED”. By doing so the RSB EU RED claim is protected.

2. **Environmental criteria:**

- **Soil, water and air protection:** 2BSvs does not include mandatory requirements for the protection of soil, air and water, but only recommends applying them. Bonsucro requires 80% of the non-RED environmental and social criteria to be met, while ISCC EU requires 60% of the “Minor Must” criteria to be met. Furthermore, ISCC EU does not require the auditing of soil, water and air protection if the specific EU Member State has implemented Cross Compliance.[48] This means both, ISCC EU and Bonsucro EU might not fully ensure all aspects of the protection of soil, water and air.

3. **Social criteria:**

- **Labour rights and working conditions:** 2BSvs focusses on the mandatory RED criteria and therefore includes no mandatory social criteria. The scheme instead recommends that the economic operator checks whether ratification of International Labour Organization (ILO) conventions in the country of feedstock origin have taken place. As mentioned above Bonsucro EU and ISCC EU have a threshold (80% and 60% respectively) beyond which RED or minor criteria which have to be met for compliance. ISCC EU does not require auditing of labour rights and working conditions if the country has ratified the relevant ILO conventions. Both ISCC and Bonsucro are again therefore less stringent than both RSB EU RED and RSPO-RED.

- **Land use rights:** Only 2BSvs does not demand the demonstration of compliance with land use rights. RSB has very ambitious social criteria also including rural and social development, food security and Free Prior Informed Consent in the stakeholder consultations about land rights.

4. **Chain of custody and traceability**

- **Mass balance:** ISCC permits a deficit in the mass balance which has to be balanced out within a 3 month period. All other four schemes require a continuous mass balance without any deficit, which means that at each moment in time the consignment is withdrawn from the mixture it has to have the same sustainability characteristics and quantities as the consignment added to the mixture.

- **Further chain of custody options:** Only 2BSvs limits the chain of custody options to mass balance. Most of the schemes also allow for more stringent chain of custody systems like physical segregation, which is still in line with the RED. Bonsucro and RSPO also provide the opportunity to use a book-and-claim system, but this is not permitted to be used in the RED scheme versions.

- **Traceability:** 2BSvs does not issue a unique ID number for each consignment like Bonsucro, ISCC or RSB, nor does it have a web-based tracking system in place like RSPO-RED, so actually tracing the consignment is challenging. 2BSvs certified rapeseed intended to be processed into ISCC EU biodiesel would have to have a unique identification number.

5. **Auditing and cost of compliance**

- **Certificate validity:** There is a broad range of certificate validity from 5 years (2BSvs and RSPO-RED) to 1 year (ISCC), down to just 3 months in case of high risk feedstock suppliers using RSB EU RED.

---

[48] Farmers in the EU receive subsidies for keeping land in Good Agricultural and Environmental Condition (GAEC), if the respective EU MS has implemented this Cross Compliance system. Sample checks are carried out to audit whether farmers met GAEC criteria.

4.6 Development of Proposals for Harmonization

4.6.1 Setting the Sustainability Ambition Level

The figure below summarizes the sustainability coverage of the national legislation and voluntary schemes that were assessed. It can be seen that they both include "common sustainability" requirements (highlighted in green). These relate to restrictions on land conversion (biodiversity protection and carbon stock protection), as well as minimum GHG savings requirements. The inclusion of criteria covering wider environmental impacts, or social and economic issues is currently not covered by national legislation (highlighted in red), and is only mandatory in some voluntary schemes.

RSB and RSPO set the highest level of sustainability ambition as they are the only schemes that include all of the sustainability criteria in a mandatory way, while 2BSvs only covers the common sustainability requirements. Bonsucro and ISCC include sustainability criteria beyond the common requirements; however, the schemes include exemptions for some/all of the criteria (highlighted in yellow).

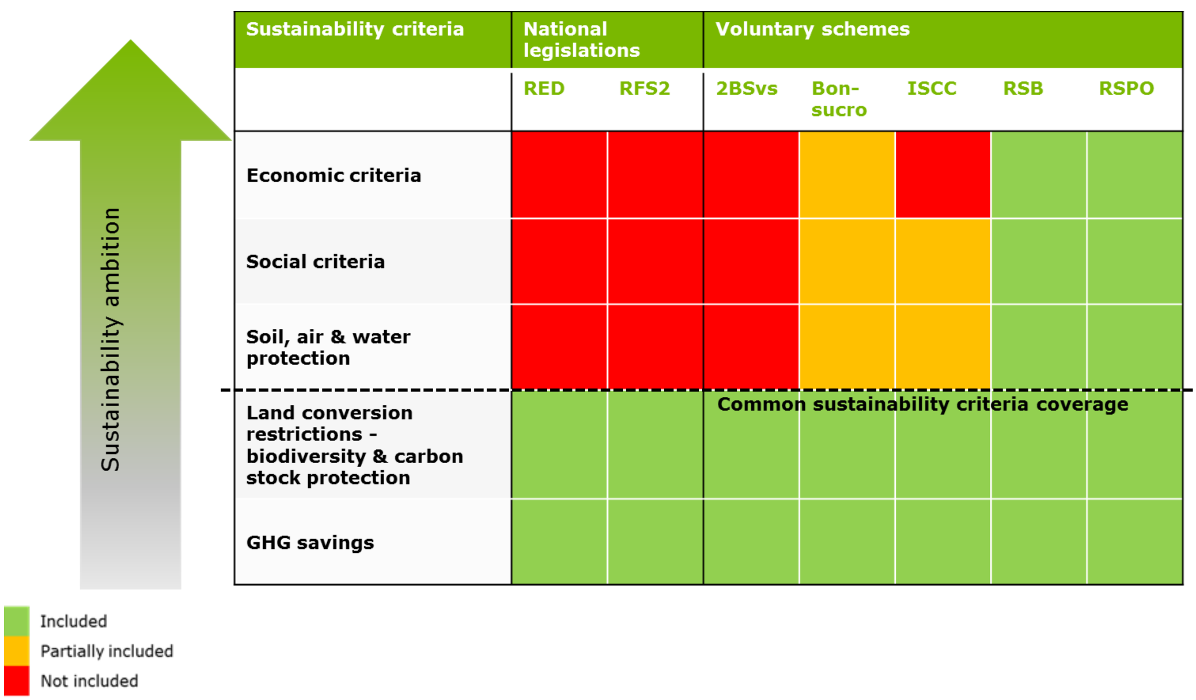


Figure 16. Overview comparing the sustainability requirements of the national legislation and voluntary schemes under review

An over-arching consideration for the aviation industry when developing harmonization proposals is to agree on the level of sustainability ambition that is desired. For example, should the sustainability criteria cover the minimum requirements currently set by national legislation and voluntary schemes, or is a higher level of ambition desired with the inclusion of wider environmental, social and economic criteria?

The **Sustainable Aviation Fuel Users Group** (SAFUG) "pledge" demonstrates a high level of sustainability ambition. Socio-economic impacts, including minimizing food competition, and the preservation of water quality are covered, in addition to GHG savings and the protection of highly biodiverse areas.[49]

4.7 Harmonization Options

4.7.1 Mutual Recognition between RED and RFS2 for Aviation

Mechanism

This option is based on the mutual recognition of the sustainability requirements for biofuels in national legislation, as opposed to harmonization of voluntary schemes. Mutual recognition of the RED and RFS2 is a desirable option as it would enable SAF to be freely traded between the EU and US, greatly increasing the opportunities for its deployment. Greater streamlining of the RED and RFS2 could also provide a strong basis for developing an internationally accepted approach to biofuels sustainability as they are the two major legislative sustainability standards in place today for biofuels.

As previously discussed, the RED and RFS2 share a common basis in that they both include requirements for GHG savings and restrictions on land conversion. Although there are some differences in the requirements, these are not considered to be a major barrier to mutual recognition. Furthermore, there are a number of practical steps that the EC and EPA (responsible for the RED and RFS2 respectively) could take to harmonize these aspects:

- **Land conversion restrictions:** Harmonization between the RED and RFS2 would need agreement on a common reference date (currently 1 January 2008 in the RED and 19 December 2007 in the RFS2). A practical solution could be to adopt the later date, which is the RED reference date. This has a low impact on sustainability because it only moves the RFS2 date forward by 2 weeks. Furthermore, there is no impact on compliance because farmers who currently comply in the US will still comply with the RED reference date.
- **Analysis of SAF pathway GHG emissions:** The GHG calculation methodologies in the RED and RFS2 share a common basis, although some differences exist (see bullet below). SAF should ideally realize significant GHG savings, although all improvements on a fossil fuel comparator should be recognized and not limited by thresholds.
- **Agree on common (fossil) jet fuel comparator:** The fossil fuel comparator is a fundamental parameter in the calculation of GHG savings. Currently the RED and RFS2 include a fossil fuel comparator for road transport fuel, but not for jet fuel. A necessary step would be to seek common agreement on an appropriate comparator so that GHG savings are calculated on a consistent basis.

[49] http://www.safug.org/safug-pledge/

On the other hand, there are major differences in the approach taken on chain of custody and auditing between the RED and RFS2. For, example the RFS2 permits a “mass balance” chain of custody system for domestic fuel, but requires imported biofuel to be fully segregated (“identity preserved”). The main difference from an auditing perspective is that the RED only permits independent auditing, while in the RFS2 internal auditors can also undertake auditing (“attest”) engagements. Mutual recognition of these aspects would therefore require greater effort. These aspects will require greater focus in discussions between the EC and EPA.

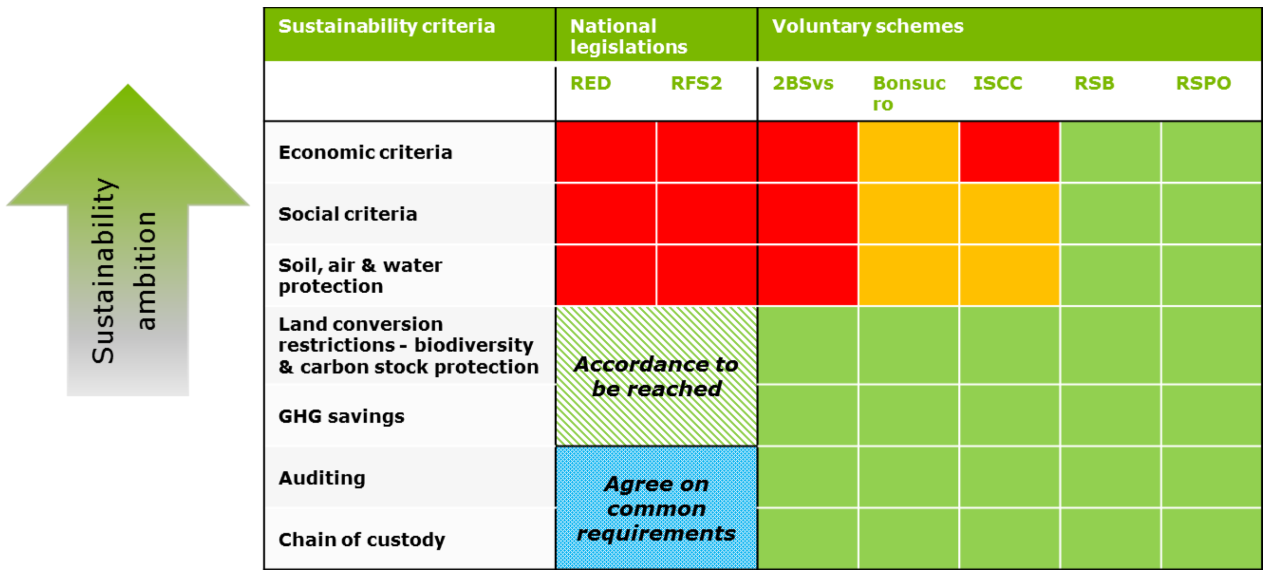


Figure 17. “Mutual recognition between RED and RFS2 for aviation” option

Target group to implement

The EC and EPA are key to the implementation of this option. The global MBM negotiations could serve as the motivation to start a dialogue on mutual recognition. Formal discussions could be conducted through the Open Skies process, which was initiated with the EU-US Air Transport Agreement in 2007 and amended in 2010. The Open Skies process strives for a transatlantic Open Aviation Area with a single air transport market between the EU and the US having no restrictions on air services.[50]

Table 9. Pros and Cons of mutual recognition between the RED and RFS2

Pros	Cons
Mutual recognition would greatly facilitate use of aviation biofuels globally	It may be difficult for aviation industry to influence the process
Mutual recognition would be a cost effective option for the aviation industry	It may take considerable time to reach consensus between EC and EPA on mutual recognition

[50] http://ec.europa.eu/transport/modes/air/international_aviation/country_index/united_states_en.htm

Pros	Cons
Mutual agreement may stimulate other countries/regions to adopt similar sustainability criteria	
Mutual recognition uses existing systems that are already in operation and work	

4.7.2 Meta-standard for SAF

Mechanism

An alternative approach to mutual recognition of the RED and RFS2 is to develop a 'Meta-standard' (or sustainability framework) for SAF. The Meta-standard would specify minimum key requirements, such as sustainability principles and/or criteria, that SAF producers would need to meet in order to be recognized by the aviation industry or governments internationally.

To enable all airlines to participate, a stepped approach to working towards higher sustainability standards could be included. For example, the Meta-standard could be differentiated according to different levels of ambition. For example:

A hypothetical Meta-standard option using voluntary schemes.

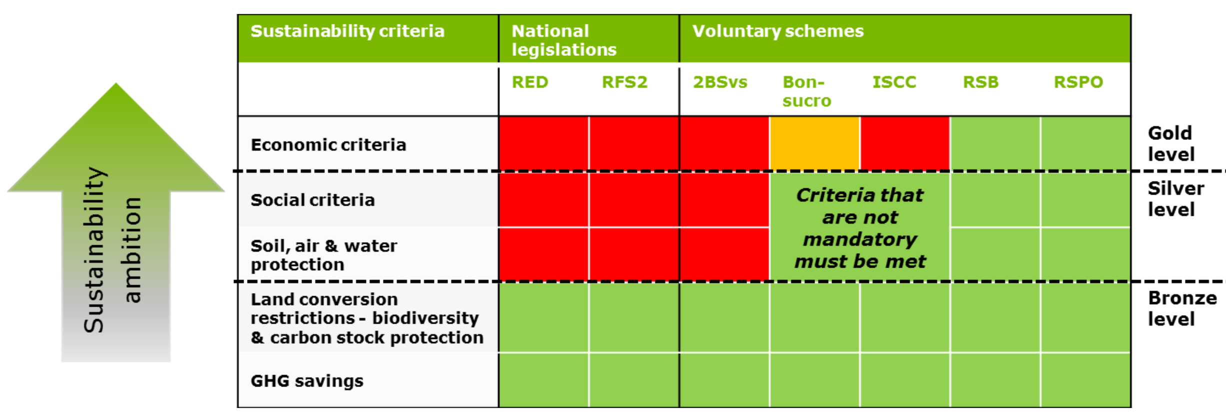


Figure 18. Hypothetical "Meta-standard" option met using voluntary schemes showing sustainability criteria requirements for Bronze, Silver and Gold level

Compliance against the Meta-standard could be demonstrated through the use of existing voluntary schemes. In this case a benchmark process would need to be established to determine which voluntary schemes could be used to demonstrate which level of compliance. In the example above Gold level would only be met by RSB and RSPO whereas the other voluntary schemes would meet the Silver level (ISCC, Bonsucro) or Bronze level (2BSvs).

Alternatively, compliance could be demonstrated through the use of an independent third party audit against the principles and criteria of the Meta-standard (Figure 19). The outcome of the audit would determine whether a feedstock producer could claim a Bronze, Silver or Gold level; or similarly, whether the minimum requirements of the Meta-standard were met at all.

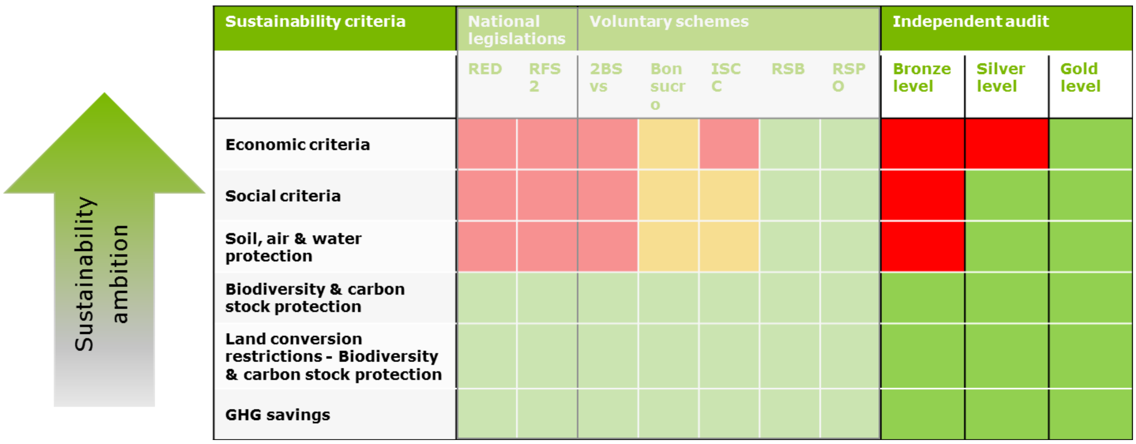


Figure 19. "Meta-standard" option met using independent audit showing sustainability criteria requirements for Bronze, Silver and Gold level

A third potential option is a hybrid type approach involving the use of a voluntary scheme together with independent auditing for criteria that the voluntary scheme does not cover. For example, a feedstock producer that is certified to a scheme that only meets the Bronze level could use an independent audit to raise the sustainability level to the Silver or Gold level.

A consideration when developing the Meta-standard would be to use ISEAL's Standard-Setting Code.[51] This internationally acknowledged standard defines the standard-setting process, including how a standard is developed, structured and governed. A specific element of the code includes the involvement of stakeholders and a public consultation throughout the standard setting process.

Target group to implement

Roles and responsibilities

- **IATA:** IATA could be a driver in the development of the Meta-standard in a multi-stakeholder process (in-line with ISEAL guidelines). Relevant stakeholders would include, inter alia, representatives from the aviation industry, biojet fuel supply chain, feedstock suppliers, NGOs and government bodies.
- **Independent party:** IATA would need support in the development of the Meta-standard, including benchmarking the voluntary schemes. Using an independent party offers greater credibility than if IATA undertook this activity themselves.
- **ICAO:** ICAO should recognize the Meta-standard and adopt it as an ICAO standard, with an agreed mandatory minimum level of sustainability criteria.

[51] http://www.isealalliance.org/our-work/defining-credibility/codes-of-good-practice/standard-setting-code

Table 10. Pros and Cons of a meta-standard for SAF

Pros	Cons
Meta-standard makes use of existing voluntary schemes or independent auditing	This option requires agreement on level of ambition and defining the Meta-standard
Meta-standard simplifies the claim that airlines use in the market and ensures that airlines use a consistent claim in market	This option requires development of benchmarking process
Meta-standard can be set up in way to allow for differentiated level of ambition	This option requires ongoing benchmarking (and possibly monitoring) of the voluntary schemes
SAFUG's sustainability pledge for criteria could contribute to defining the ambition levels	
The lowest Meta-standard level could help to define the minimum requirements in a global MBM	
Meta-standard can be used to raise awareness, as it could be consumer facing	

4.8 Policy options

The two preferred options of the Meta-Standard for SAF and mutual recognition between the RED and RFS2, are examined in more detail.

4.8.1 Meta-standard for Aviation Biofuels

A key first step in implementing a Meta-standard for the aviation industry is to establish a standard owner. One option is to establish a new, independent organization. A second would be to leverage the existing capabilities of either ICAO or IATA potentially minimizing costs and leveraging existing processes. It is suggested that a multi-stakeholder process is employed in the standard's development, in line with ISEAL guidelines. This will help to ensure that the Meta-standard has credibility and wide acceptance outside of the aviation industry. The main responsibility of the standard owner will be to design the Meta-standard, and organize the benchmarking process for assessing voluntary schemes' compliance with the Meta-standard. Integral to this is defining the sustainability ambition level(s) of the Meta-standard, and in particular whether a differentiated level of ambition is desired (e.g. bronze, silver, gold). A review of the principles and criteria of a selection of voluntary schemes would also provide a useful reference. Consideration of the SAFUG sustainability pledge should also be taken into account. These actions will reduce the effort and time required to set up the Meta-standard and help to ensure buy-in from the aviation industry and other interested stakeholders. The actual benchmarking process of the voluntary schemes against the defined levels of the Meta-standard has to be undertaken by an objective and independent third party commissioned by the standard owner. There are various models already in place for such benchmarking exercises which the aviation industry could draw lessons from, e.g. the RTFO Meta-standard benchmarking process, the EC process for assessing voluntary schemes, or the UK CPET (Central Point of Expertise for Timber) approach to recognizing voluntary schemes for forestry sustainability.

It is probable that the most challenging aspect of developing a Meta-standard will be reaching consensus on the ambition level(s). This process requires broad stakeholder involvement. The time required for this process depends on the level of urgency and how far apart the positions of the various stakeholders are.

There exists a proactive role for the aviation industry, represented by IATA, in defining a Meta-standard and to engage with policymakers to strive for the recognition of the Meta-standard by ICAO.

4.8.2 Mutual Recognition between RED and RFS2 for Aviation

Mutual recognition between the RED and RFS2 for aviation is a desirable option, but is likely to be more challenging to implement in comparison to the development of a Meta-standard. It is unlikely that discussions between the EC and EPA on mutual recognition will take place without a legislative driver. Therefore this harmonization option would need to be facilitated by ICAO.

The proposals for a global MBM at the ICAO level is an opportunity to initiate this process. A key first step therefore would be for IATA to introduce these concepts into some of the CAEP working groups for discussion and consideration.

IATA could further support harmonization discussions by engaging with companies that are active in both the EU and US markets in order to gain their insights, specifically relating to compliance with the standards. Furthermore, IATA could strive for a common fossil jet fuel comparator in the RED and RFS2, as such a comparator is not yet included in these standards. In a further step IATA could undertake a project to calculate the GHG emission for typical SAF pathways using the methodologies of both standards, or otherwise encourage its members to do so. If the GHG calculations result in meeting the GHG target in the RED and the RFS2 one of the major intentions of both pieces of legislation is already met. This will also be a great signal demonstrating that mutual recognitions might be feasible. However, it is understood that the AFTF will undertake a life cycle assessment for SAF which will be fed into the design of the global MBM and would therefore become the logical method for calculation GHG emissions.

The focus of discussions should therefore be on more complex issues like mutual recognition of different chain of custody approaches or the approach to auditing. The approach to auditing in particular is a discussion that is likely to arise in the context of designing a global MBM.

Section 5–Accounting for SAF

5.1 Introduction

Similar to sustainability legislation and compliance, how to account for SAF usage varies in different regions of the world. While accounting for fuel used my seem simple, calculating the attributable greenhouse gas (GHG) benefit must be determined according to a number of variables. This is important given incentives for SAF use are often contingent on achieving a certain level of GHG reduction.

Today, SAF are typically produced as a specific batch, in bespoke supply chains and delivered in dedicated consignments so reporting physical use is straightforward. However, the ultimate aim of the aviation industry is that the drop-in nature of SAF will allow the fuels to be fully integrated into the conventional jet fuel storage and distribution systems, and therefore be used by all aircraft refueling from those systems with no barriers. Ultimately, the most appropriate design choice for a SAF accounting system will be influenced by the final design of the global Market Based Mechanism (MBM) currently under development.

Parts of Section5 are extracted from the report by Ecofys "Accounting methods for biojet fuel", the final report of a study sponsored by IATA (Ecofys, 2014b).

5.2 Design of the Global Market-based Measure

The design of the global MBM for aviation GHG emissions which is currently being developed by the Global Market-based Measure Task Force (GMTF) of ICAO will have an impact on the approach for accounting of biofuels. ICAO will develop a proposal for the global MBM by 2016, with the aim of implementing it by 2020.

The design of the accounting system must be compatible with the requirements of the MBM, but at this point in time the detailed design of the global MBM is not fully defined or agreed. We can nevertheless indicate some important MBM design choices that will have an influence on the method for the accounting of SAF, so that the accounting system options discussed here offer sufficient flexibility to link to the final design of the global MBM. Some key MBM design choices that will impact the design of the accounting method are:

(1) Geographical scope

The geographical scope of the MBM is important. Flights to and from which countries are included and excluded from the reporting obligation is one of the design choices under consideration. It could be that flights to and from certain (small or developing) countries will be exempted from the measure.

(2) Sustainability requirements for SAF

The production of SAF causes upstream emissions, including emissions from feedstock production, transport, refining and other processes in the earlier parts of the supply chain before the fuel is loaded into the wing. It is anticipated it will be a requirement to capture these emission in the LCA methodology under the MBM.

(3) Linkage of MBM for aviation to other systems

The global MBM will create a market for emission allowances that can be traded between airlines. The aviation sector MBM could be linked to other emissions trading systems, such as the non-aviation sectors of the EU ETS or the Carbon Development Mechanism (CDM) to allow emission reduction credits from outside the aviation industry to be purchased and counted towards an airline's own emission reduction obligations within the MBM. Linking could be either one way or two way, i.e. it could also be agreed to permit other emissions trading systems to purchase allowances from the MBM.

In the following sections the key design choices for the accounting system are considered. Where possible these are linked to the global MBM design choices indicated above.

5.3 Chain of Custody Approach

Road transport biofuel supply chains generally operate using mass balanced based chain of custody approaches. Particularly within the EU, many of the existing voluntary sustainability schemes and detailed design rules are already defined for the chain of custody and are being implemented in practice. The aviation industry can look to these design rules and consider using features already in place and operating well in the market. This will be especially relevant for the biofuel production part of the supply chain that could have significant overlap – in terms of feedstocks and producers – with the current road transport biofuel industry.

A key difference between the road transport biofuel suppliers and the airline industry is that the airline industry is an end user of SAF. The end users – the airlines – will be required to record the SAF they use (red arrow in Figure 20) in order to calculate their emissions to be reported under the global MBM (blue arrow in Figure 20). This is unlike the road transport biofuel industry for which the end users – car or truck drivers, for example – are not required to report their emissions, and the obligations are placed instead on the fuel suppliers.

If the chain of custody method from the road biofuels sector is followed, this means that a *mass balance system* is operated until a control point, which should be defined to ensure that it guarantees that a certain amount of SAF has been entered into the aviation sector fuelling system. However, the mass balance system does not yet allocate the use of the SAF to a certain airline. To be able to do this, the verification of the SAF quantity at the control point should be coupled to a system that allows airlines to robustly claim the use of SAF.

A book and claim system that can be used by airlines from the control point onwards is a preferred option. At the control point SAF *'certificates'*[52] are generated by the fuel supplier in line with the amount of SAF that

[52] The term 'certificates' is a generic term, used to refer to a volume of biojet fuel that is proven tomeet specific sustainability criteria. The 'certificates' or 'tickets' can be transferred directly from fuel suppliers to airlines in a book and claim type system to demonstrate the transfer of a volume of biojet fuel. The term certificates here is not to be confused with a certificate from a voluntary sustainability scheme, such as RSB or ISCC, which might be used to demonstrate the sustainability of the biojet fuel.

is supplied. These certificates or tickets relate to a volume of SAF. They can then be sold directly from the fuel suppliers to the airlines, uncoupled from the actual delivery of the SAF to that specific airline. The assumption that underlies this certificate based trading is that whenever SAF reaches the control point, it will be used in the aviation sector somewhere, thus reducing the GHG emissions of the sector as a whole. The company (airline) that can claim the emission reductions is the company that has bought the SAF certificates.

The system could be set up so that airlines can trade SAF certificates amongst each other. An argument for having this tradable set up could be price differences for biojet fuel in different parts of the world. For instance, in countries where feedstock prices are lower, the SAF may also be less costly than in other parts of the world. An airline might therefore want to buy the certificates from other airlines to reduce their own emissions. While this market for SAF certificates could increase the flexibility of the accounting system for SAF, it requires further consideration. The market for GHG emissions in the global MBM, which is currently under development, should provide an appropriate platform to trade ‘environmentally friendly flying’ with other airlines. Creating a market for SAF volume certificates in parallel to a GHG emission market may unnecessarily increase the complexity.

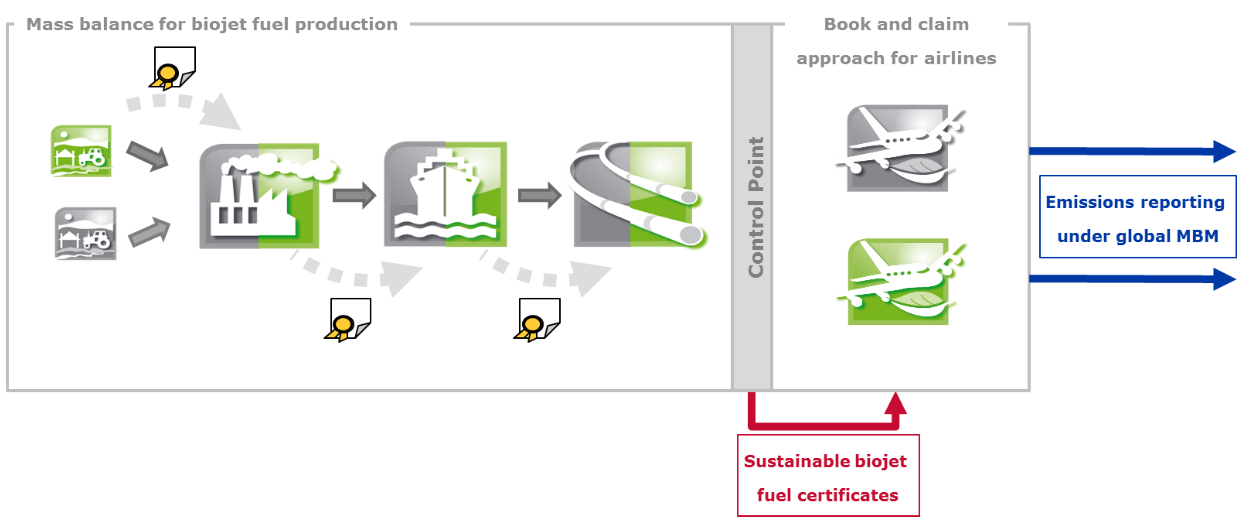


Figure 20. Hybrid mass balance / book and claim accounting system

5.4 Overview of Design Choices for the Accounting System

The following sub-sections consider the detailed design choices that will need to be defined for a robust SAF accounting system for airlines. All design choices described below build upon the assumption that a hybrid mass balance / book and claim system described in section 5.3 is used for SAF accounting. The key design choices for the accounting system that will be described in the section include:

- Choice of a robust control point;
- Airport or airline level reporting;

- Verification through a central registry or at the fuel inventory level;
- Limit on percentage of SAF reported;
- Treatment of upstream GHG emissions;
- Timeframe.

5.4.1 Control Point

A ‘control point’ needs to be defined that refers to a point in the chain where the total fuel going to the aviation sector can be identified. This is also the point in the chain that compliance with any sustainability criteria is demonstrated. It should be a well-defined point which is consistent across all supply chains, to ensure that all SAF fuel going into the aviation sector is captured within the system. It should also be an appropriate point in the supply chain to verify any sustainability or GHG claims made about the SAF.

Under the RED, the European Commission recommends that the requirement to demonstrate compliance with the sustainability criteria is placed at the fuel duty point (for road biofuel), as fuel volumes that cross this point are robustly monitored and recorded for tax purposes. This obligation usually sits with traditional fuel suppliers, although the fuel duty point varies slightly between Member States, so the party who owns the fuel when it crosses the duty point can sometimes be a fuel producer, a refiner, blender, or importer. This point, at which the reports on the biofuel use and its associated sustainability and GHG characteristics are verified, is referred to as the control point of the supply chain. Therefore, for airlines an appropriate point in the supply chain of SAF has to be defined for the purposes of consistent reporting on SAF use, and its associated sustainability and GHG characteristics.

As international jet fuel is not subject to fuel duty, there is no established equivalent to the fuel duty point in jet fuel supply chains.[53] Furthermore, airlines will have to report their emissions from activities in different countries, which mean that the point at which the claims are verified will have to be recognized internationally. The importance of the control point is to choose a point in the chain where the total fuel going to the aviation sector can be identified. Logically this could be the point of blending and certification, at which point the SAF has been blended with fossil fuel as a final ASTM D1655 certified fuel that fully meets the technical specifications and consequently it can be assumed that this fuel will be used in the commercial aviation sector.

Any requirements for the sustainability and GHG emissions of the SAF should be controlled at this blending and certification point. One important implication of this is that any GHG emissions resulting from actions later in the supply chain after the control point would need to be included by using a standard factor as it would no longer be possible to use actual GHG emissions (as that future part of the supply chain is not yet known). This is also done in the RED GHG methodology where a standard factor is applied for the final distribution and retail of biofuel.

[53] In some cases tax is paid for fuel used in domestic flights (e.g. in Australia and some states in the US), but generally no tax is paid on international aviation fuel.

5.4.2 Airport or Airline Level Reporting

The proposed global MBM (or another emission reporting purpose) may have a "*geographical constraint*", which rules emissions from flights from or to certain countries in or out of the scope of reporting. An example is the current design of the EU ETS, in which only intra-European flights are included in the scope of the reporting. A future global MBM might include all international (commercial) flights or it might exempt flights in certain countries from the scope of the reporting because of their limited contribution to emissions from the aviation sector as a whole.

Airlines naturally operate across different airports and across different countries, so if there is any geographical constraint on the reporting, airlines will find that some of their operations are in and some are out. Therefore, the geographical scope of the reporting purpose has an effect on the level at which the recording of SAF consumption must be done to ensure that all airlines are accounting for SAF consumption consistently within the global MBM.

Accounting could be done on an *airline level*, which would mean keeping track of the SAF use for an airline as a whole, or at an *airport level*, which would mean airlines should keep track of the SAF use from each airport that they fly from (Figure 21)[54]. Note that there is a difference between how an airline needs to *record (account)* their SAF use and how they *report* it under a global MBM. In some cases, fuel is delivered to more than one airport from a single fueling system or pipeline. For example, Geneva Airport (Switzerland) and Lyon Airport (France) share a pipeline. In this case, it may not be possible to distinguish the (SAF) fuel use at an individual airport. For these cases, a further option of *fuel system level* accounting might be a more appropriate option, should airline level reporting not be favored.

It is assumed that airlines reporting under a global MBM system would be subject to some kind of independent verification. The independent verifier that provides the verification of the claimed emission reductions resulting from the SAF use will need to check the claim either at the airline, airport, or fuelling system level, depending on the design choice made.

It would be beneficial to the implementation of the accounting system to have the fuel purchasing and invoicing structure of the airline claiming the SAF use as the leading argument for accounting at an airport or fuel system level, to avoid unnecessary changes to airline fuel purchasing structures and bookkeeping practices. Note, again, that it may be appropriate for the proposed global MBM to only require *reporting* at an overall airline level, even if fuel use records are *accounted* for at an airport level. Figure 21 shows the options and implications for the level of SAF accounting.

[54] This also implies that any independent verification of an airline report would be done at an airport fuel system level

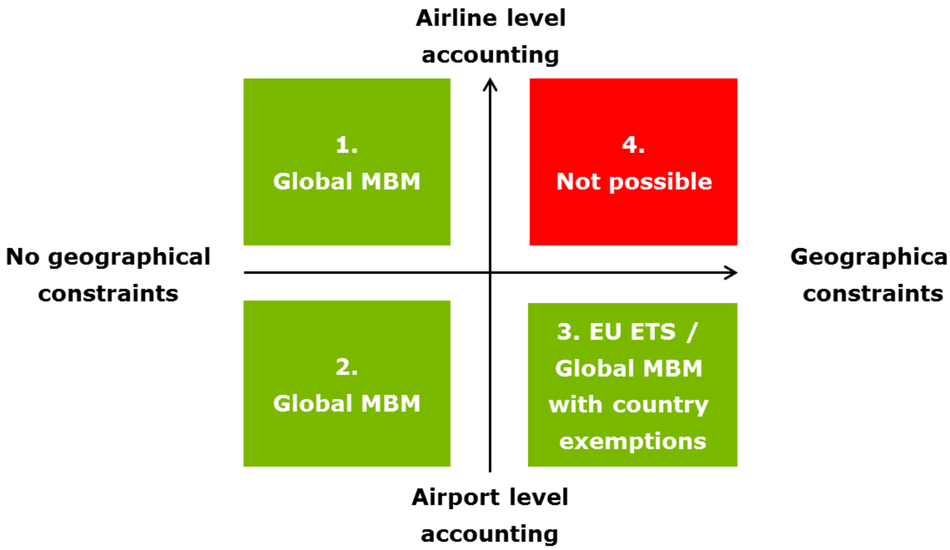


Figure 21. Accounting system design

1. **No geographical constraint, airline level accounting –** If the system has no geographical constraints and the reporting obligation is put on airlines, then it is not necessary to know at which airport the SAF was purchased, as long as it was purchased by the airline claiming the SAF use. In a system with no geographical constraints the accounting can be done on an airline level, thus based on fuel purchasing records of a company as a whole.
2. **No geographical constraint, airport level accounting –** If there are no geographical constraints it is not necessary to know at which airport the SAF was bought. However, for other reasons such as the rigor of the verification, accounting and reporting could be done at an airport level. The accounting should in this case include a check that the amount of SAF use claimed from an individual airport does not exceed what could have been used by the airline from that specific airport.
3. **Geographical constraint, airport flight route level accounting –** If a system has a geographical constraint, it is necessary to check whether the claimed SAF use by an airline does not exceed what could have realistically been used by that airline on routes that are within the scope of the global MBM from individual airports. This check will have to be done at the airport flight route or fuelling system flight route level, by matching the fuel use of an airline for the specific routes from an airport that are in the scope of the reporting purpose with the biojet fuel bought from those same airports, and checking the feasibility of the emission reduction claim.
4. **Geographical constraint, airline level accounting (not possible) –** Accounting for SAF use on an airline level in a geographically constrained system is not possible, as it will not offer the possibility to check against the operational data of that airline to ensure that all airlines are only recording the SAF use that is within the geographical scope of the system.

The EU ETS currently requires airport (aerodrome) level reporting. Similarly, the RED requires mass balance records to be kept at a site level throughout the supply chain, where site is defined as “a geographic location with precise boundaries within which products can be mixed." This would be the equivalent to an airport level, although it could be argued that a pipeline or a fuelling system still meets this definition.

Note that there is a direct link between the level that SAF is accounted and how verification of that fuel would have to work. If accounting is at an airline level – and therefore at a global level – a global SAF registry would be required to ensure that the same fuel is not claimed by different airlines operating from different airports. This would give maximum flexibility to airlines. However, if SAF is accounted at the more local, airport level.

The global MBM that is under development at ICAO could potentially exempt smaller and/or less developed countries, and could therefore have a geographical constraint. The information from which airport or fuel system fuel was uplifted and for which routes (indeed for individual flights) is already recorded by many airlines, and could therefore be integrated into a SAF *accounting* system. It would be beneficial for SAF deployment that reporting under a proposed global MBM is required at an airline level and that an accounting system is designed at an airline level. This is likely to be the most logistically efficient option for airlines and gives maximum flexibility in SAF reporting.

5.4.3 Central Registry or Verification at the Fuel System Level

It is suggested to establish a system in which SAF certificates are created by a fuel supplier when a final batch of SAF that meets the technical specifications is created, i.e. blended. These certificates can then be sold directly to airlines that want to green their operations, separately from the physical delivery of the biojet fuel. A verification system must be designed to ensure that: (1) the SAF (or parts of it) are only sold to a single airline, and that only this airline can claim the emission benefits from using the SAF; (2) no more SAF certificates are sold than SAF was delivered to the fuel system; and (3) only SAF that meets the sustainability criteria as demanded by the aviation industry can generate sustainable SAF certificates.

Two alternatives exist to control the creation and trade in SAF certificates:

1. Verification through a central registry

The central registry option would require ICAO, or another appropriate and independent international aviation body, to establish an international centralized database system in which fuel suppliers can input batches of SAF when these are "created" at the control point (=blending point). The database system then creates a number of SAF certificates for the owner of the fuel at the blending point, which can be transferred to airlines that want to buy SAF. Once the fuel company transfers its certificates to an airline, its stock of SAF certificates in the database is depleted by the amount that it has transferred. The advantage of using a central registry is that it is robust from the perspective of preventing double claiming, and provides a centralized overview of all SAF consumption worldwide. It could therefore be used alongside airline level accounting, giving maximum flexibility for airlines.

2. Verification at the airport fuel system level.

Another option would be to do independent verification at the airport fuel system level. In this case the fuel supplier at the airport can generate SAF certificates without having to notify a central database of the production of SAF. When a certain volume of SAF enters the fuel system at the airport fuel system level the certificates for that volume are created and can be sold to airlines. The fuel system operator at the airport will need to undergo a regular verification to check whether the accounting rules have been applied in the correct way and that fuel suppliers have not sold more certificates to airlines than they are entitled to. In addition, airline data would need to be verified to ensure that they are not recording more SAF than they have been transferred, in line with their fuel purchase records. An advantage of this system is that it is easier to set up in the early phases of biojet fuel market development where only a few airports will generate certificates by putting SAF in their systems. It could also be performed in line with existing fuel quality checks that are performed by fuel suppliers and with verification of fuel and GHG data at airlines. A disadvantage is that the system is less robust from the perspective of identifying fuel that is transferred to more than one airline. Simply verifying at the airline level would not identify SAF that was also transferred to another airline at the same airport, so some verification has to be performed at the fuel supplier level. Any inconsistencies identified at a fuel supplier level could cause implications for a number of airlines, which could be challenging to resolve. This option also provides less of a centralized overview about SAF consumption worldwide than an international central registry.

5.4.4 Limit on Percentage of Biojet Fuel Reported

SAF fuel from HEFA or F-T can currently be used up to a 50% blend with fossil jet fuel in civil aviation, to be ASTM D1655 certified. SAF is generally sold to airlines today in a blended form. In the future it might be possible to buy only the SAF component of the blend, and it is also expected that the use of up to 100% SAF might become permitted under ASTM.

When SAF is handled through the existing fueling infrastructure, the physical SAF component that actually is put into the aircraft will be different from the contractual or administrative biojet fuel blend percentage that was bought. A design choice has to be made if there is maximum limit to the amount of SAF that airlines can claim to have used, and if so, how high this limit should be.

It must be noted that this design choice does not exist in the road transport biofuel sector, as in the road sector the end user (or vehicle owner) does not have any reporting obligation of its emission or its fuel consumption. Therefore, in the road transport sector, it is not relevant to determine how much biofuel was used by the various end users, although car manufacturers do specify technical limits to the amount of bio component that can be used in their engines.

For the SAF accounting system, three design options exist:

1. **No limit on the % SAF –** Airlines are able to *claim* up to 100% SAF, although they are (at this moment) technically not allowed to use 100% SAF in the aircraft. Fuel suppliers would still be responsible for ensuring that the physical fuel used meets the current technical specifications. This option will require a change to the current fuel purchasing practices so that an airline is able to purchase only the bio-part of a certain batch of SAF blend. No changes to this approach would be needed in the future if the fuel quality standards are amended to allow pure SAF to be used in the aircraft.
    - This is the most flexible approach, allowing airlines to fully green their operations and not be limited to a maximum 50% use of SAF. Furthermore, not putting a limit on the maximum amount of biojet fuel claimed does not create a potential barrier for the introduction of 100% SAF use in the future.

- From a public perception perspective there could be reasons to limit the maximum SAF claimed to the technical limit of 50% to avoid a risk of "green washing".

2. **Limit on the % SAF in line with the fuel quality specifications –** Airlines are able to claim up to 50% blend of SAF used, in line with the current ASTM specifications.
   - This option offers reduced flexibility compared to no limit, allowing airlines to replace at most half of their fossil fuel consumption with SAF consumption.
   - The advantage is that this approach will be most compatible with the current fuel handling practices where the blending of the SAF component is done before the fuel is purchased by the airline. From a public perception perspective and from a physical fuel specifications perspective, airlines do not risk claiming more SAF than could have been used.
3. **Typical use limit –** Airlines can report up to a typical use limit of SAF from a certain airport (e.g. 5%). This option is closely linked to the physical consumption of SAF.
   - This option allows communication that is closest to the physical use of SAF.
   - However, the option allows the lowest level of flexibility in the claims made and approaches reporting of the physical fuel use, which is not desired by airlines. A typical use limit would also have to be chosen. There is little basis for this number as the typical use will vary greatly from situation to situation and is expected to evolve rapidly over the coming years. The number chose therefore risks being arbitrary.

The most practical solution could be to set the reporting limit of SAF based on the technical specifications or there should be no limit imposed. A 50% limit on the SAF claimed in line with the ASTM fuel quality specifications is in line with current fuel handling practices, reduces the risks of negative public perception and will likely provide sufficient mitigation potential for airlines for the foreseeable future. On the other hand, no accounting barriers are identified for allowing reporting of up to 100% SAF use. Treatment of Upstream GHG Emissions

The upstream emissions of SAF are the GHG emissions that occur from the cultivation and collection of biomass feedstock (e.g. fertilizer use, diesel use, emissions associated with direct land-use change etc.), from processing of the biomass and production of biofuel, and the transport and distribution of the biofuel. The approach to reporting of upstream GHG emissions from biojet fuel in the reporting obligation will have an effect on the level of detail of the data that an airline purchasing biojet fuel needs to collect. Different methods in dealing with upstream emissions are applied in the EU ETS, and the RFS and RED systems that could also be applied to the SAF accounting and GHG reporting system.

1. **Include upstream emissions through detailed GHG balance of biofuel –** All supply chain stakeholders will need to record and pass on detailed information on energy use and inputs throughout all steps of the supply chain. This allows all supply routes to deliver highly detailed information to the airlines on the GHG performance of their products.
   - Applied as an optional route in the EU RED, allowing the fuel suppliers to claim a better GHG performance than indicated by the conservative default values in the RED legislation.

- The advantage of this option is that it incentivizes SAF and supply chains with better GHG savings and allows airlines to accurately report on the actual emission reductions achieved with the use of specific batches of SAF.
- This method is however highly detailed and this method could be costly to the fuel provider, both to collect the data and do the calculations, and to robustly verify the calculations. This cost could make the end price of the SAF higher.

2. **Include upstream emissions through default emission factors –** Based on the different production routes and feedstocks, default GHG emission factors for SAF can be developed. The default values can always be used or they can be used whenever no detailed GHG balance of the SAF is available.
3. **Exclusion of upstream emissions –** If the SAF meets the sustainability criteria for SAF as required by the reporting scheme, the use of SAF is reported as having no GHG emissions ("zero-rating").

Note that under a global MBM a distinction could be made between the GHG emissions from SAF reported by airlines and the number of allowances or tradable units that airlines can claim due to that SAF use. For example, in the EU ETS biofuels are allowed to be counted as zero emissions for the purposes of GHG allowances, as long as they first demonstrate that they meet the minimum GHG threshold under the RED. This approach ensures that biofuels achieve at least a minimum GHG saving without the added complexity of reporting and the number of allowances being based on the actual calculated GHG emissions. Airlines recognize that not counting the upstream emissions of biofuels under the EU ETS gives an extra incentive to drive forward the use of biofuels in the short term. The current low price of allowances, however, results in the EU ETS alone providing a relatively low driver for biofuel currently.

An efficient solution would be for fuel suppliers and airlines to track information on at least the origin, the feedstock, and the conversion process of all SAF used to enable basic GHG calculations or default values to be used. It is plausible to develop an approach based on conservative default values as a basis for airline GHG accounting, with the opportunity to substitute these with actual GHG calculations, to incentivize SAF producers to produce SAF with higher GHG savings.

5.4.5 Timeframe

There are several distinct elements of the accounting system for which defining rules on an appropriate timeframe is relevant.

Timeframe of the mass balance system (before the control point)

The core principle of a mass balance system is that over time the sum of the outputs from a point in the supply chain has to have the same characteristics as the sum of the inputs for that point in the supply chain. Within the mass balance part of the system, it is helpful to define consistent rules on, for example: the timeframe over which the mass balance input and output records need to be balanced; whether or not any deficit in the amount of SAF is allowed during that time period; and whether 'banking' or 'borrowing' are allowed between periods. In other words, to what extent does the physical stock of SAF need to relate to the administrative stock of SAF over time.

The European Commission guidance for the RED allows either a continuous of fixed period of time. The Commission Communication states: "*The balance in the system can be continuous in time, in which case a 'deficit', i.e. that at any point in time more sustainable material has been withdrawn than has been added, is required not to occur. Alternatively the balance could be achieved over an appropriate period of time and regularly verified. In both cases it is necessary for appropriate arrangements to be in place to ensure that the balance is respected.*"[55]

In practice voluntary schemes recognized by the EC operate a variety of approaches, although the most widely used schemes opt for requiring that the balance is maintained as a minimum every 3 months to ensure that deficits are not allowed to build up over a whole year.

Continuous monitoring of a mass balance can be burdensome, and can be difficult for certain parts of the supply chain, especially farmers who find it hard to keep detailed up-to-the-minute records during harvest periods. However, a continuous mass balance ensures that SAF can only be sold administratively once it is received, avoids any risk of over selling of SAF or of the associated sustainability information.

A discrete timeframe for the mass balance allows more flexibility. Within this, longer periods of time allow even more flexibility, but they can make it more difficult for verifiers to reconcile different mass balance systems in the supply chain; for example, if different supply chain parties are operating over different time frames. In practice many businesses will have the capacity to operate monthly mass balances, in line with their financial accounting.

Timeframe for the validity of the biojet fuel certificate (after the control point)

A SAF certificate is generated when a batch of ASTM certified SAF blend is produced. The physical batch may be stored for a period of time, before being used, but the assumption is that eventually the batch will be used in aviation and will therefore lead to a GHG emission reduction compared to using fossil fuel. It will need to be decided whether there should be a maximum timeframe within which a fuel supplier needs to transfer their SAF certificates to airlines.

If the SAF blend is physically stored for a very long time, but the SAF certificate is already transferred to an airline, a discrepancy could come to exist between the moment when the emission reduction is claimed and the moment when the SAF is actually used. Similarly, a sustainable SAF certificate might be created when a batch of SAF is produced and used and only purchased by an airline a number of years after it was created. In this case the emission reduction could be claimed years after the SAF was uplifted into a plane. Both of these situations could result in a strange situation from a public perception perspective. However, they should not cause an issue for the robustness of the accounting system, as long as the control point is set at a point at which it is certain that the fuel passing this point will be used in commercial aviation and as long as the verification of the system is robust.

The main reason to set a maximum validity of SAF certificates would be to identify when the SAF was produced. This might be useful if, for example, there were policy changes in the global MBM that affected

[55] COM 2010/C 160/01 Communication on voluntary schemes and default values in the EU biofuels and bioliquids sustainability scheme, section 2.2.3: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2010:160:FULL&from=EN

the future treatment of SAF, which required the system to be able to identify SAF that was produced and supplied at different points in time. However, these changes could equally be applied to when the certificates are *redeemed*, rather than when they are *generated*. If a maximum validity for such certificates is set, there is a potential risk of causing fluctuations in the price associated with those certificates as their expiry date approaches.

Timeframe for the airline to 'redeem' the biojet fuel certificate for emissions reporting

For the book and claim part of the system, once a batch of SAF reaches the control point, a SAF certificate would be generated. These certificates will be transferred to airlines when they purchase SAF. It will need to be decided whether there should be a time limit for airlines to redeem those certificates for their emissions reporting. This will also be impacted by the previous decision, as to whether SAF certificates should have a 'vintage'.

Unlike for fuel suppliers who may store the SAF after it has been produced, it is assumed that once an airline has been transferred SAF certificates they would want to use them towards their emissions reporting in the current reporting period.

The relevant timeframe for airlines to monitor, report and verify their SAF consumption and emissions should be in line with what is required by any reporting obligations. Rules on any potential trading of *emissions* certificates are expected to be defined under the proposed global MBM.

For the proposed global MBM the reporting and verification period may potentially be annual. Data on SAF use will need to be monitored on an ongoing basis and ideally be integrated into the existing fuel purchasing and monitoring systems. If the global MBM sets a limit on the maximum SAF that can be claimed and/or on the geographical scope of which SAF can be claimed, then this data will need to be monitored on an ongoing basis and regularly checked by the internal systems at the airline. These checks will see if the reported SAF consumption matches the activities of the airline. Formal independent verification of the data is likely to only be required on an annual basis, in line with annual reporting.

5.5 Policy Options

This section has considered various different accounting choices for a SAF accounting system. For some of the accounting system design features the final choice will depend on the design of the global MBM, while for other features the design of the MBM is not likely to have a significant impact.

Table 11. Overview of SAF accounting system design choices

Topic	Design options	Preferred solution
Chain of custody approach	• Book and claim • Mass balance	(Hybrid system) • Mass balance from the start of the supply chain to the control point • Book and claim, using SAF certificates, from the control point to the airline

Topic	Design options	Preferred solution
Control point	• Defined point in the biojet fuel supply chain	• Blending and certification point
Airport or airline level reporting	• Airport level reporting • Airline / fuel system level reporting	• Airline / fuel system level reporting
Central registry or verification at the fuel system level	• Central registry • Verification at the fuel system level	• No recommendation, further discussion on the costs and benefits of both options is needed
Limit on the percentage of biojet fuel reported	• No limit • Limit on the % SAF in line with the fuel quality specifications • Typical use limit	• No limit, if public perception concerns can be overcome, otherwise limit based on fuel quality specifications
Treatment of upstream GHG emissions	• Include upstream emissions through detailed GHG balance of biofuel • Include upstream emissions through default emission factors • Exclusion of upstream emissions	• Mandatory inclusion of upstream emissions through default emission factors (with option for more detailed GHG calculations for those airlines who wish to)
Timeframe for different levels of the accounting system • Mass balance system • Validity of the SAF certificate • Validity of the emission reduction claim	• Any timeframe is possible for all levels of the accounting system	• Mass balance – apply flexible rules that are as much as possible in line with the current supply chain operation and current voluntary schemes • Validity of the SAF certificate for the fuel supplier - from an accounting perspective there is no need for a maximum timeframe, from a public perception perspective there might be a reason to set a maximum timeframe for the validity • Validity of the emission reduction claim for the airline - timeframe in line with the global MBM accounting period

During the next steps of the design of the accounting methodology, there will be a number of key stakeholders who should be involved and engaged. Important government stakeholders who would have a key role in steering and agreeing on the accounting approach include:

- ICAO Committee on Aviation Environmental Protection (CAEP) would play a crucial role, especially in relation to the relationships to the global MBM;

- European Commission[56] and key Member States with a special interest in aviation such as the Netherlands. The European Commission especially has experience in developing the monitoring, reporting and verification guidelines for the EU ETS. The Commission already publishes detailed guidance relating to aviation. Key points within this guidance will need to be further elaborated as experience is gained from the inclusion of aviation in the scheme and especially now that only the intra-European flights are included within the scope. The European Commission also has experience in setting up and running the central registry system for the EU ETS, from which key lessons could be learned;
- US Environmental Protection Agency, with experience on the development of the RFS2;
- Standardization bodies may also have a role to play in international standard setting. In particular ASTM should be consulted in relation to its existing chain of custody rules.

Other key stakeholders from industry would include airlines; airports and airport fuel system operators and pipeline operators; and fossil and SAF suppliers, especially those actively developing and trialing the use of SAF.

It will also be important to engage sustainability certification schemes and take on board any practical lessons from operating chain of custody systems, especially RSB, RSPO, Bonsucro and RTRS on the development and operation of book and claim systems.

[56] Currently DG CLIMA leads on the EU ETS, DG MOVE on aviation and DG ENER on biofuels, including biojet fuels for aviation. However, a new Commission is being formed at the time of writing. The DGs, their responsibilities and the Commissioners responsible may change under this new Commission that is currently being put in place.

Section 6—Economics and Effective Policy

6.1 Introduction

Despite considerable progress in the development of SAF over the past decade, it is in general, not price competitive with conventional fossil kerosene.[57] Policy support is required to accelerate commercialization and address the challenges of energy security and aviation's requirement for a drop-in fuel.

6.1.1 Policy Instruments Incentivizing Deployment of SAF

There are various policy instruments available to overcome investment barriers for the deployment of SAF. In some instances a 'combination' of policy instruments might be required to achieve optimal outcomes.

Effective cost-benefit modelling is required in order for decision-makers to select an optimal mix of policy instruments, while taking into account a wide range of considerations. Further, they need to identify the different stakeholders associated with each investment barrier, and closely understand competing interests, and how the policy can address the barrier constraint.

Policy instruments that incentivize SAF production and use can be grouped into the following categories:

1. Economic instruments
2. Command and control instruments
3. Co-regulation instruments
4. Voluntary and collaborative instruments

Each of these categories of policy instruments can be applied to various stages of the value chain. In most cases, policy instruments form a 'policy package' designed to promote SAF production and consumption in a region or a country.

There are also supporting instruments such as communication and diffusion. They basically include information campaigns and marketing actions to increase public awareness of stakeholders to show the necessity of reducing carbon emissions through the use of SAF. In terms of economic effectiveness, these supporting instruments are less powerful to start or maintain a SAF market, but they are good for supporting the four categories of instruments described above for influencing public behavior and accelerating the deployment of SAF.

[57] ICAO: The Challenges for the Development and Deployment of Sustainable Alternative Fuels in Aviation (May 2013)

6.2 Economic Instruments

Economic instruments are also referred to as price-based instruments or market-based instruments. Economic instruments use market, price, and other economic variables to provide incentives for the production and use of SAF. These instruments seek to address the market failure of externalities by incorporating the external cost of production or consumption activities. This can be done through direct incentives, subsidies, taxes or charges on processes or products, or by creating rights trading mechanisms (such as SAF certificate trading or emissions-trading mechanisms).

Economic instruments can be implemented in a systematic manner, across an economy, region or across multiple economic sectors.

While it is acknowledged that in the long term, SAF must achieve price parity with conventional fuels, in the immediate term support mechanisms are required to stimulate market demand. This support is essential to enable scale–up and optimization and reduce production costs.

The application of economic instruments is beneficial for starting a market; however, they may become expensive to sustain when the market engages and beneficiaries are reluctant to lose the economic advantages of receiving incentives or benefiting from tax exemptions or discounts. Hence, it is important to not just design and introduce market support mechanisms, but also articulate how these support mechanisms ‘fade out’ or define a time period for expiration.

Economic instruments can be applied to different stages of the SAF supply chain. A number of examples of economic instruments for incentivizing the production and use of SAF are listed below:

Production of biomass:

- Direct incentives: Premiums for energy crops, incentives for sustainable energy crops, support to use waste land;
- Pricing: Regulation of prices for feedstock together with guaranteeing investors and producers a minimum income;
- Funding: R&D for applicability of energy crops and crop yields, demonstration of new crops.

Production of SAF:

- Direct investment and subsides for SAF production facilities;
- Financing schemes (public loan guarantees) or low-interest rate loans for de-risking the construction of SAF production facilities;
- Tax exemptions or tax incentives to SAF producers for reducing the price of SAF production (proportional to the amount of SAF produced);
- Funding of R&D for more efficient production and new technologies;

Distribution and supply of SAF:

- Financing schemes (public loan guarantees) for de-risking the construction of logistics and distribution infrastructure.
- Trading of SAF certificates (for example RINs in the USA or Biotickets in the Netherlands).

Final users market:

- Funding for R&D;
- A potential market based mechanism for global aviation.

6.3 Command and Control Instruments

Command and control instruments are defined as the regulation establishing what is permitted and what is not permitted in a specific industry or activity. This establishes the obligations to be complied with, and the sanctions that result from non-compliance. Command and control instruments include direct regulation for the industry development via legislation.

By way of example, the command element would set a standard, a production obligation or consumption mandate and the 'control' will monitor and enforce the standard.

Command and control instruments can be applied to different stages of the biofuel supply chain. Some examples of how this approach could be applied include:

Production of biomass:

- Making available or putting quotas on set-aside lands for the production of energy crops and non-food crops destined to the production of SAF.

Production of SAF:

- Emissions mandates through fuel quality standards. Authorization quotas for SAF producers;
- Regulations restraining or increasing the import of SAF or the feedstock to produce them.

Distribution and supply of SAF:

- SAF obligations for a minimum amount of SAF sold;
- Blending mandates for a certain share of SAF. Blending mandates can be related to national SAF production obligations and are measured over a period of time (usually a calendar year). Mandates could be flexible, for example with the possibility of waving them under specific circumstances, or making them tradable among obliged parties.

6.4 Co-regulation Instruments

Co-regulation refers to the recognition of industry voluntary initiatives or programs as part of the public regulation. Co-regulation is especially valid when there is a need to regulate economic activities performed across the geographic borders of different countries.

Strengths in public regulation include democratic legitimacy, applicability to all firms within a jurisdiction, and enforceability through national supervisory agencies. Weaknesses include challenges to development, no applicability outside the national jurisdiction and potential high implementation costs for private sector parties. Therefore, the recognition of industry initiatives as part of the public regulatory framework combines the strengths of industry initiatives and public regulation.

Examples of co-regulation instruments for the promotion of SAF are:

- Governmental recognition of industry agreements setting own “targets” for the production or consumption of SAF.
- Governmental recognition of rules for compliance of such obligations or targets. These rules may include trading mechanisms for SAF certificates at national or international level, and can link different sectors (aviation and road transport for example).
- Negotiated support and/or penalties for the compliance of recognized obligations and recognized agreements

The use of voluntary certification systems to prove a mass balance system and sustainability criteria of biofuels targets under the European Renewable Energy Directive (RED) is an example of international co-regulation.

6.5 Voluntary Initiatives and Collaborative Instruments

When sufficiently articulated and extended among industry players, voluntary and collaborative instruments can become effective private policy instruments.

The adoption of standards, codes of conduct and self-regulation by the industry, is a form of voluntary instrument. A wide adoption of voluntary initiatives by the industry could achieve positive results over time and face fewer impediments to becoming established internationally. Under this scenario there is an incentive to strive for better performance, while under a command-and-control approach, facilities are unlikely to make constant improvement unless regulations are modified and made stricter year after year. With that said, the effectiveness of voluntary instruments must be in all cases considered in relation to regulations.

Voluntary instruments may also happen between the private and public sectors with public –private partnerships (PPP). The US based Commercial Aviation Alternative Fuels Initiative (CAAFI) is an effective working example. Voluntary instruments are likely to be most effective when used in synergy with, or complementary to, other public policy instruments.

A number of examples of voluntary initiatives and collaborative instruments for incentivizing the production and use of SAF are listed below:

Production of biomass and production of SAF:

- Networking, partnerships and contracting between feedstock suppliers and the SAF sector;
- Harmonization and adoption of standards;
- Certification and labelling.

Distribution and supply of SAF:

- Voluntary agreements with manufacturers or suppliers;

Final users market:

- Voluntary private procurement.
- Adoption of own targets with respect to usage of SAF and emissions reduction.

6.6 Inventory of Existing Biofuel Policy Instruments around the World

Approximately sixty countries around the world have implemented policy instruments within their jurisdictions for promoting the deployment of biofuels; however, in almost every instance this is for the road transport sector. There are a number of reasons that can explain this:

- The road sector was ahead of aviation in terms of biofuel development hence also benefitted from the early policy formulation;
- Road sector fuel generally has larger direct taxes applied to it relative to aviation;
- Less strict technical standards generally apply to road biofuel, relative to SAF.

While the policy pendulum hitherto favors the road sector, there are some valid reasons why this should be levelled, if not shifted to favor aviation. Some of these include:

- SAF is typically more expensive to produce due to more stringent technical requirements, relative to road sector biofuel. If policy favors the road sector, a rational biofuel producer will produce the product capable of generating the best return on investment
- The road sector has alternatives to a liquid fuel, such as electricity. This option is not available for aviation and is not likely to be a realistic alternative over the medium term; hence, effective policy will target the optimal allocations of goods suggesting liquid fuels should be biased towards aviation. Over the long run this will maximize carbon reduction potential.

The main motivations for promoting the production and consumption of SAF are:

1. Decarbonizing sector activities (aligning with industry goals such as carbon neutral growth by 2020);
2. Mitigating dependence on fossil fuel availability and price (fuel security);
3. Promotion of local agriculture, new industry and the creation of jobs in both rural and urban areas.

6.7 Policy Actions

The following policy instruments need to be applied to result in action. There is not one standardized perfect application of policy mechanisms. Different economies, geographies and government priorities will dictate a different application of instruments. What is consistent is that jurisdictions must influence 6 key areas to enable SAF production and deployment to advance.

1. Level playing field (or policy equality)
2. Research
3. De-risk public and private investment in production
4. Incentivize airlines to use SAF from an early stage
5. Support robust international sustainability criteria
6. Foster local opportunities

Section 7—Financing Models

7.1 Background

A considerable challenge for developing SAF production facilities at scale is the significant capital involved, the long-term nature of such infrastructure, and the price uncertainty of the end product. The combination of these factors makes securing debt or equity financing expensive or challenging, and production risk mitigation (such as an airline off-take agreement) difficult. This can mean that production financing does not occur naturally like a traditional infrastructure project such as building a toll road, or a new factory or even a traditional refinery. The below funding concepts are presented as considerations. They are not expected to be definitive solutions, rather thought stimulation for deriving means to solve what is a complex problem.

7.1.1 Investment in Fossil Fuel

Annual investment in upstream oil and gas is forecast by the International Energy Agency to be more than $850 billion annually by 2035.

The gradual depletion of the most accessible reserves is forcing companies to move to develop more challenging fields, putting pressure on upstream costs. This is one factor underpinning an oil price that is forecast by the IEA to reach $135/barrel in real terms by 2035.

Meeting long-term oil demand growth depends increasingly on the Middle East, once the current rise in non-OPEC supply starts to slow in the 2020s. Higher average oil prices support the business case for long-term supply-side infrastructure investment in renewable energy. The challenge for the equity and debt markets is to evaluate the future shape of the policy landscape, overlaid with information on economies of scale, the technology learning curve and fossil oil prices to determine how much of the forecast $850 billion oil and gas investment should be directed towards SAF production.[58]

7.2 Fossil Jet Fuel and Price Forecast

The starting point for deriving future deployment of SAF is the assessment of long-term realizable potentials for each type of renewable and for each world region. The assessment is based on a review of the existing literature and on the refinement of available data. It includes the following steps:

1. The *theoretical* potentials for each region are derived. General physical parameters are taken into account to determine the theoretical upper limit of what can be produced from a particular energy, based on current scientific knowledge.

[58] International Energy Agency

2. The *technical* potential can be derived from an observation of such boundary conditions as the efficiency of conversion technologies and the available land area to install wind turbines. For most resources, technical potential is a changing factor. With increased research and development, conversion technologies might be improved and the technical potential increased.

Long-term *realizable* potential is the fraction of the overall technical potential that can be actually realized in the long term. To estimate it, overall constraints like technical feasibility, social acceptance, planning requirements and industrial growth need to be considered.

7.2.1 Population Assumptions

Population growth continues to place stress on natural resources. In 2014, the Economist forecast the global population to reach 9 billion by 2050, up from 7 billion in 2013.[59] Population growth is contingent on average fertility rates in respective countries. Many variables influence this; however, while the acceleration of growth is slowing, aggregate growth is not forecast to stop in the foreseeable future. This implies a growing demand for energy and highlights the need for sustainable supply options.

7.3 Potential SAF Funding Concepts

Traditionally, airline fuel procurement teams will agree to purchase defined quantities of fossil kerosene under agreed terms of conditions for price and logistics. While geographical variances exist, the market for fossil kerosene is reasonably transparent with globally accessable price information for both kerosene and the underlying commodity of oil. Furthermore, fossil kerosene is typically supplied by large multinational companies. Their financial health or security is unlikely to be materially influenced by a single airline off-take agreement.

In the new and evolving market of producing both biofuel for the road sector and SAF for the aviation sector, single off-take agreements can be influential to the project economics or a prospective production facility, in part due to the more favorable risk profile an off-take provides. There are numerous different concepts for how an airline might engage with a SAF supplier. There is no single correct model and it is expected many examples will be trialed in the early years of SAF commercialization and deployment. The important objective for an airline to engage with a prospective SAF suppliers is for the airline to receive a reliable defined quanity of SAF at an acceptable price or price range, while the guaranteed airline demand (under the defined conditions) reduces production risk and hence improves financing terms for the SAF producer. Some potential models are explored later in the chapter under airline demand. These include:

- Standard off-take
- Intermediary off-take

[59] http://www.economist.com/news/international/21619986-un-study-sparks-fears-population-explosion-alarm-misplaced-dont-panic

- Floating purchase agreement
- Infrastructure funding model
- Hybrid model

7.3.1 Background

A considerable challenge for developing biojet fuel production facilities at scale is the significant capital involved, coupled with price uncertainty of the end product. The combination of these factors makes securing debt or equity financing difficult and/or expensive, and production risk mitigation (such as an airline off-take) problematic. The below funding concepts are designed as considerations. They are not likely to be definitive solutions, rather thought stimulation for deriving means to solve what is a complex problem.

7.3.2 Cost Benefit Analysis – Overview

SAF projects should be financially viable in order to guarantee their long-term continuation. This is the case if the present value of the revenues is higher than the costs. However, the comparison and summing up of costs and revenues is difficult for two reasons.

First, costs and revenues occur at different points in time. For example, high costs may initially occur for the establishment of the feedstock, e.g. development, planting and maintenance. In contrast, revenues are earned only when the feedstock can be used and converted into a fuel for sale. Additionally, constructing a facility to produce SAF requires large upfront capital and can take many months, or even some years to achieve production potential.

Second, money is likely to have a different value in the future. This is due to inflation, and due to the fact that funds could earn interests if deposited at a bank instead of being invested in the project. In order to enable a comparison of future cash flows within a SAF project, the Net Present Value (NPV) is calculated. The NPV is defined as the sum of the present values of all future costs and revenues, i.e. all projected expenses of the proposed biofuel project, as well as all expected revenues. To calculate the NPV, all future costs and revenues have to be transformed to their present values using a discount rate. These present values may then be summed up to result in an overall positive, negative or neutral result. The NPV is often the most important tool in the assessment of the financial viability of projects.

The largest influence on the NPV of a project will generally be:

1. The amount of up front capital required (i.e. to construct the project)
2. The discount rate
3. The timing of future revenues

The standard formula for calculating the Net Present Value (NPV) of a project is:

$$NPV = \sum_{t=0}^{n} \frac{(\text{Benefits-Costs})_t}{(1+r)^t}$$

where:

r = discount rate

t = year

n = analytic horizon (in years)

NPV = Net Present Value [national currency]

B = benefits in year i [national currency]

C = costs in year i [national currency]

r = discount rate [%]

n = lifetime of project [years]

In a first step for every single year of a project life cycle the annual costs and benefits have to be identified.

In a second step, they are converted into their present value. For each year of the project lifetime the costs and revenues are discounted. The summing up of the discounted costs and benefits (NPV) results in a positive or negative Present Value. If the NPV is positive, then the project should be pursued (i.e. it is costing one money not to do the project). In a situation where a firm has multiple positive NPV projects to choose from, the higher internal rate of return (IRR) should be selected. This is the rate of return on the funds employed. Many corporation and funds management businesses stipulate a required IRR on their invested capital.

Project discount rate

Projects are usually financed with credits. Therefore, the discount rate should be the cost of finance for the project. Further, the influence of inflation has to be taken into account. The following formula can be used to calculate the discount rate:

r = ((1+i) / (1+p)) – 1 * 100%

r = real discount rate (long term cost of project debt)
i = nominal interest rate (long term project lending rate)
p = annual inflation rate

For example, if the long-term project lending rate for a SAF project is 16 % and the average inflation of the last years was 3% this would result in a real discount rate of around 12.6 %.

Project lifetime

The lifetime taken into account for the cost benefit analysis should be adapted to the project duration. For example, if a biojet plant is to be established, the lifetime of this plant should be considered. If bioenergy cultivation is to be established, the time until the project ends is the minimum life time. It is possible to assess projects with different forecast useful life based on estimating either the salvage values or depreciated value at the end of the period.

7.3.3 Potential Biojet Fuel Cost-benefit Analysis Examples

The five examples presented below are hypothetical, but demonstrate the sensitivity of many projects to small changes in the input assumptions. Further, they highlight how policy can be effectively applied to influence a projects financial viability. While a 'real life' project will have numerous line items within construction, operating costs and revenues, for the sake of simplicity these are aggregated.

Example 1:

Example 1 is a base case scenario. This is an example where purchasing land, equipment and constructing a SAF refining plant cost $260 million. Both operating costs and revenues ramp up, then remain consistent from year 3. In a real world scenario these are not likely to be linear but this does not impact the example. A discount rate of 9% is conservative. This example delivers a forecast NPV of -$83.28 million or an internal rate of return on the funds employed of 3.82%. A rational firm would not undertake this project.

EXAMPLE: 1	*Simplified cost-benefit example - base case project CBA*										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Improvements						-25					17.5
Equipment	-10					-10					5
Total	-260	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggregate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-260	10	10	20	20	-15	20	20	20	20	230
Discount rate	9%										
NPV	**-$83.28**										
IRR	**3.82%**										

Example 2

Example 2 replicates Example 1, except in this case a project grant of $100 million is received. This could be a government grant. A grant is often contingent on satisfying certain criteria; however, in this case it is assumed this criterion is met and the funds are received unconditional.

While the aggregate of the grant is only 2.5 years of projected revenue, the advantage of receiving these funds at project inception is significant, particular with high discount rates.

This change to the project delivers a $16.72 million positive NPV at an IRR of 10.43%. A rational firm would undertake this project.

EXAMPLE: 2	*Simplified cost-benefit example - project grant*										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Project grant	100										0
Improvements						-25					17.5
Equipment	-10					-10					5
Total	-160	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggregate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-160	10	10	20	20	-15	20	20	20	20	230
Discount rate	9%										
NPV	**$16.72**										
IRR	**10.43%**										

Example 3:

Example 3 replicates Example 1 except in this case the firm acquires an interest free loan for 10 years of $150 million. This could be provided from a government program and when the project is more mature this debt could easily be refinanced and repaid. Further, conceptually the idea of an interest free loan could be substituted with non-dilutive equity.

This changes the project NPV from -$83.3 million to -$3.3 million, or essentially a 'line-ball' project. Further, the IRR of 9.5% may be feasible for some investors.

EXAMPLE: 3	*Simplified cost-benefit example - interest free loan*										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Interest free loan	150										-150
Improvements						-25					17.5
Equipment	-10					-10					5
Total	-110	0	0	0	0	-35	0	0	0	0	60
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Annual aggregate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-110	10	10	20	20	-15	20	20	20	20	80
Discount rate	9%										
NPV	**$3.36**										
IRR	**9.51%**										

Example 4:

Example 4 replicates Example 1; however, in this case the SAF supplier receives a 10% subsidy. While in this case the subsidy is not sufficient to generate a positive project NPV it demonstrates the annual subsidy improves the forecast IRR from 3.82% in example 1 to 5.23% in example 4.

EXAMPLE: 4	Simplified cost-benefit example - revenue subsidy										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Improvements						-25					17.5
Equipment	-10					-10					5
Total	-260	0	0	0	0	-35	0	0	0	0	210
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Subsidy		1.5	2.5	4	4	4	4	4	4	4	4
Annual aggregate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-260	11.5	12.5	24	24	-11	24	24	24	24	234
Discount rate	9%										
NPV	**-$61.16**										
IRR	**5.23%**										

Example 5:

Example 5 incorporates some of the policy features of the other examples. It includes a revenue subsidy of 10% of revenues, a project grant of $50 million and an interest free loan of $100 million repayable in 10 years.

This example clearly demonstrates how combining some policy mechanisms can make an otherwise unattractive project successful. Example 5 generates a forecast NPV of $46.59 million at an IRR of 15.1%. Even at a discount rate of 9% this project is comfortably acceptable. This shows how when connected stakeholders, such as the project owner and operator, the government, end product demand such as an airline and debt financiers, work collaboratively, policy mechanisms can combine to build a strong business case.

EXAMPLE: 5	Simplified cost-benefit example - project grant										
Project analysis (Million USD)											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Capital costs											
Project construction	-250										187.5
Project grant	50										0
Interest free loan	100										-100
Improvements						-25					17.5
Equipment	-10					-10					5
Total	-110	0	0	0	0	-35	0	0	0	0	110
Operating costs											
Aggregate annual costs		-5	-15	-20	-20	-20	-20	-20	-20	-20	-20
Revenues											
Subsidy		1.5	2.5	4	4	4	4	4	4	4	4
Annual aggregate revenues		15	25	40	40	40	40	40	40	40	40
Net Cash Flow	-110	11.5	12.5	24	24	-11	24	24	24	24	134
Discount rate	9%										
NPV	**$46.59**										
IRR	**15.1%**										

It is, and should be assumed, that subsidies either reduce or 'fade out' over time. If this is articulated by policy makers it does not need to impact project feasibility. It is assumed that both the technology learning curve and project economies of scale will reduce the unit cost of production over time, thus reducing the reliance on subsidies. Interest free loans or project grants simply tackle the high discount rate conundrum at the start of a capital intense project in an embryonic industry.

7.4 Airline Demand

Demand commitment from an airline can play a material and valuable role in project risk mitigation. This has the effect of reducing the discount rate of which the project NPV (and ultimately project decision) is highly sensitive to. There are a number of methods for an airline to commit to SAF from a prospective supplier.

7.4.1 Standard Off-take

An off-take is traditionally an agreement entered between a producer and a buyer to buy/sell a certain amount of the future production. It is generally negotiated long before the construction of a facility to guarantee a market for the facility's future production and improve chances of getting financing for the installation concerned. While these agreements are common in the natural resource sector, the magnitude of jet fuel as an input cost in aviation is unique in making the aviation sector hyper sensitive to price variations. It is natural for airlines to preference conditional off-take agreements, which is often not sufficient for a prospective producer to secure financing. An offtake agreement can assist procuring debt finance or reducing the cost of financing as this off-take guarantees revenue for a portion of total output.

7.4.2 Intermediary Offtake

This model is based on the airline using intermediaries to stand between the end user (airline) and the producer, hence transferring risk away from the airline. The intermediary uses organizations skilled in different types of risk pricing. This may need to occur so the airline can procure SAF within acceptable aviation business risk parameters. It is conceptually similar to how airlines use financial markets to reduce expense line volatility through currency and oil markets. It is likely this intermediary will be a large investment bank.

7.4.3 Floating Purchase Agreement

An entity (could be an airline, but not exclusive to airlines) will purchase a ‘right’ in the form of an option or derivative. This will entitle the owner to a quantity of SAF per annum, over a fixed time period (10-20 years) at an indexed price linked to a proxy, excluding oil. The price will have a ceiling and a floor to allow some risk sharing clauses between the producer and consumer. There will be an upfront cost to this derivative which accumulates a pool of capital for a producer. This enables the scope to add equity and debt funding, to build the plant. The market for the rights to the fuel (the option or derivative) is managed by a market maker.

7.4.4 Infrastructure Funding Model

The airline works with an infrastructure owner to achieve a positive production plant NPV by using the infrastructure asset balance sheet for low cost debt funding. Privatized airports are excellent examples where there is a commercial relationship between the airport and the airline. Under a regulated airport profit model, such as the building block method, the airport will welcome expanding its balance sheet, while the airline (in conjunction with the SAF supplier) has operational ownership of the produced fuel. In this model the airline may have some equity ownership in the production plant, along with the airport. It is essential for the interests of the airport and airline to be aligned. The Bioport concept could deploy this model.

Section 8—Success Stories and the Opportunity

8.1 Overview

Less than a decade ago, the prospect of flying commercial aircraft on SAF seemed unrealistic, given the technical and safety challenges.

Since then, the prospect of using SAF in commercial aircraft has become a reality. Currently three SAF production pathways have been approved by the standards agency ASTM and over 1700 commercial flights have taken place. While these flights have been an impressive demonstration of the technology and environmental potential of these fuels, commercially introducing this as a 'business as usual' operation has remained elusive. There is however, some material progress occurring and 2015 should see the first SAF being used in regular business operations.

A non-exhaustive selection of larger SAF deployment projects is described below.

8.2 United / AltAir

In June 2013 United Airlines and AltAir Fuels executed a landmark agreement in the commercialization of SAF. United have agreed to purchase 15 million gallons (45,000 tonnes) of lower-carbon SAF over a three year period with the option to purchase more. Significantly the airline is purchasing the SAF at a price competitive with traditional, petroleum based jet fuel, and intends to use the SAF on flights operating out of its Los Angeles hub (LAX).

AltAir fuels have displayed commercial innovation by using idle refining equipment and retooling it to produce SAF. The facility will convert non-edible natural oils and agricultural wastes into approximately 30 million gallons (90,000 tonnes) of low carbon advanced biofuels and chemicals per year.

8.3 British Airways / Solena

Solena Fuels, in partnership with British Airways has committed to building the world's first facility to convert landfill waste into jet fuel. British Airways has made a long-term commitment to purchase all 50,000 tonnes per annum of the jet fuel produced at market competitive rates. The SAF produced each year will be enough to power all the British Airways flights from London City Airport twice over with carbon savings equivalent to taking 150,000 cars off the road. The facility is due to be completed in 2017 and will generate significant gross domestic product for the British economy in both construction and operation.

This is an excellent example of generating a local solution. Some key features include negative cost feedstock (the City of London is paying Solena for taking the waste and thus avoiding landfill), a significant off-take agreement and additional equity investment from British Airways, and support from Barclays Bank for capital expenditure financing.

8.4 SkyNRG – Green Lane Program

The JFK Green Lane program was initiated in March 2013 and has successfully executed 26 weekly flights undertaken by KLM between JFK and Schiphol using a 777-200 aircraft. The SAF that was used for the flights had to meet very strict sustainability criteria and SkyNRG has installed an independent sustainability board consisting of leading NGOs and scientists advising on all feedstock and technology decisions. The program has demonstrated the feasibility of flying regular flights on SAF. It also showed that it is possible to organize and coordinate a complex supply chain, demonstrating cooperation between numerous public and private parties.

In total it is forecast the program realized approximately 232 Mt of CO_2 savings.

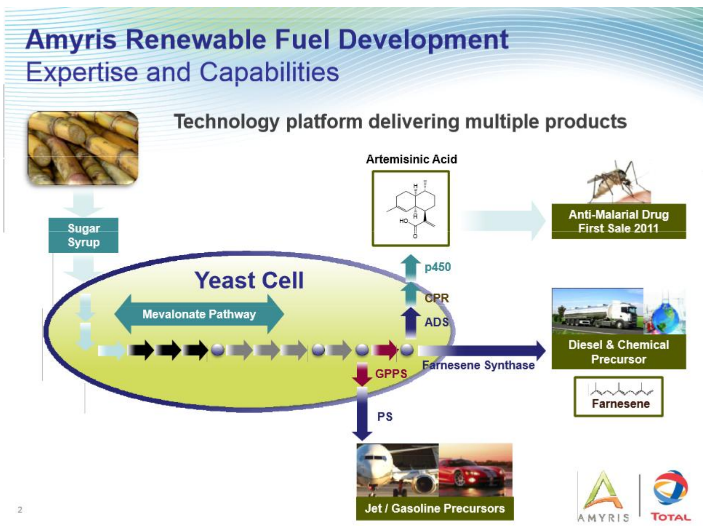
In support of this, the Dutch Ministry of Economic Affairs, Schiphol Group, SkyNRG, Neste Oil and the Port of Rotterdam signed in 2013 a declaration of intent aimed at large-scale use of SAF and the creation of a Bioport for jet fuels in the Netherlands.

8.5 Total / Amyris

Amyris and Total have formed a joint venture to produce and market renewable diesel and jet fuel from Amyris's renewable farnesane. Total is Amyris's largest investor, holding approximately 18% of its outstanding common stock, and is taking the most proactive stance of the traditional oil industry.

The joint-venture is a first step towards the commercialization of SAF. It is expected the process will be scaled up further over the next few years, driving the unit cost of production lower. Total is extremely experienced in traditional fossil fuel supply, operating in more than 130 countries and is aiming to become a key supplier in SAF.

Total aims to be active in the development phase and maintain control all along the supply chain. This will allow the company to supply fuels from the field to the plane.



8.6 Cathay / Fulcrum

Cathay Pacific has become the first airline investor in US based sustainable biofuel developer Fulcrum. Cathay Pacific has also negotiated a long-term supply agreement with Fulcrum for an initial 375 million US gallons of SAF over 10 years (representing on an annual basis approximately 2% of the airline's current fuel consumption) that meets all the airline's technical requirements and specifications. Fulcrum plans to commence construction of its first commercial plant later this year and to build large scale, waste-to-renewable jet fuel plants at multiple locations, including locations strategic to the Cathay Pacific network, primarily in North America.

Section 9—Conclusions

This roadmap considers drop-in SAF that is functionally equivalent to petroleum kerosene and is fully compliant with existing infrastructure. While the 'business as usual' usage of SAF is still small, a huge amount has been achieved since the first test flight occurred in 2008. Entrepreneurial activity to develop and commercialize drop-in SAF has not slowed, however despite these efforts, the aviation industry, which is highly sensitive to competitive distortion is yet to commit to significant volumes of SAF despite environmental willingness.

With the prospect of a global MBM for aviation, the pathway towards a global standard of sustainability and how to account for CO_2 emissions reductions must be addressed. This roadmap endeavors to present a pathway towards achieving this outcome. It is likely to be an iterative process; however, the information represents useful starting positions.

For the assessment of sustainability standards the two preferred options are a Meta-standard for SAF and mutual recognition between the RED and RFS2. An important feature of a Meta-standard will be to establish a standard owner. Integral to an effective Meta-standard will be defining the sustainability ambition level(s) and, in particular, whether a differentiated level of ambition can be achieved. Defining the base or lowest acceptable level of sustainability will require broad stakeholder engagement.

A second alternative is mutual recognition between the RED and RFS2 for aviation. This is potentially a more challenging option than implementing a Meta-standard. The proposals for a global MBM at the ICAO level appear to be an ideal opportunity to explore the potential of both of these options.

Accounting methods will also play an important role in globalizing SAF use. It is recognized that a number of key stakeholders including the ICAO Committee on Aviation and Environment, European Commission, US Environmental Protection Agency and standardization bodies will play a key role in steering and agreeing on an accounting approach.

This roadmap supports a hybrid system between a book and claim and mass balance as the chain of custody approach. To ensure sustainable product properties, mass balance should apply throughout the production process to the commercialization point while book and claim, using SAF certificates, from the commercialization point to the airline is preferred.

It is irrefutable that policy settings will play a major role in SAF deployment over the medium term. At a minimum the policy landscape must be 'leveled' or made equivalent between SAF and biofuel for the road sector. There is no single perfect policy, nor method for application. Different policy options should be used together and government sponsored task forces aggregating the required diversity of skill sets to make effective decisions is recommended.

The short-term uptake of SAF, while not precise is less challenging to predict given the various public off-take agreements and commercial deployment activities. By 2020 it is extremely plausible that SAF use per annum will be over 2 billion liters. While this headline number is impressive, as a percentage of the 270 billion liter per annum demand, it is modest. True GHG reduction success will be linked to aviation's ability to genuinely commercialize SAF. A wide range of ingredients for success are presented in this roadmap. There should be no illusion to the challenge of evolving an energy supply mix that has enjoyed the benefit of over 100 years for learning, maturity and development. For this reason, all stakeholders need to play an active role in materializing the aviation sectors environmental goals of carbon neutral growth from 2020 and halving CO_2 emissions by 2050, relative to 2005.

In 2014, Aviation celebrated 100 years of commercial passenger transport. It was an ideal opportunity to reflect on the tremendous achievements of the industry, transporting over 65 billion passengers, supporting 58 million jobs and creating $2.4 trillion in global GDP per annum but also to consider the shape of the future. In the future, the license to continue to provide these significant economic benefits and provide these social opportunities to even more of the global population, will be increasingly contingent on providing these sustainably.

The opportunities and potential is significant, but not guaranteed. SAF can and must play a positive and impactful role on the future of aviation.

Appendix: Key Features of Selected Voluntary Sustainability Schemes

1. 2BSvs

The Biomass Biofuel Sustainability voluntary scheme (2BSvs) was developed by a consortium of French companies[60] involved in agricultural production and the biofuel supply chain, coordinated by certification company Bureau Veritas. The scheme was specifically developed to enable economic operators to meet the requirements of the RED. 2BSvs was formally recognized by the EC as a voluntary scheme in the first batch of schemes on 19 July 2011.

Table 12. Overview of the 2BSvs voluntary scheme

Information	
Basic information on scheme	
Feedstock coverage	Multiple agricultural feedstocks
Geographical coverage	Global
Supply chain coverage	Full supply chain (feedstock production to biofuel production)
Accredited certification bodies[61]	Bureau Veritas Certification France, Certis, Control Union Inspections France, Intertek Certification France, OCACIA, SQS, SGS
No. of companies using the scheme or certified area	Not available
Recognition of other voluntary schemes[62]	• STD01 (Verification of Biomass Production): REDcert EU (13/09/13), ISCC EU (01/12/11), RTRS (13/09/13) • STD02 (Requirements for Mass Balance): REDcert EU (13/09/13), ISCC EU (01/12/11)

[60] AGPB (represents cereal producers in France); AGPM (represents maize producers in France); CGB (represents 14 unions of sugar beet producers in France); COOP de France (represents cooperatives of French farmers); Fédération des Négoces Agricole (represents private wholesalers/traders of agricultural crops); ONIDOL (Inter-professional association of oilseed producers and related industries including biodiesel in France); SNPAA (represents French industrial producers of alcohol from agricultural origin)

[61] http://en.2bsvs.org/verification-bodies.html

[62] http://en.2bsvs.org/fileadmin/user_upload/documents-pdf-EN/2BSvs-INS-01-PRO-02-v130913_EN.pdf

Information	
Sustainability criteria	
Environmental	**Scheme requirement** • RED land criteria: Preservation of High biodiversity land (but *not* highly biodiverse grasslands[63]), High carbon stock land, Peatlands **Scheme recommendation** • Soil, Water, Air protection • Good agricultural and environmental condition (GAEC) standards – in relation to cross-compliance
Social	**Scheme recommendation** • For countries that are a significant source of raw material for biofuels it is recommended that economic operators report whether the country of origin has ratified and implemented the ILO conventions No 29, 87, 98, 100, 105, 111, 138 and 182
Economic	• Not covered
GHG criteria and calculation methodologies	
GHG savings	• 35% for all biofuels (increasing in line with the RED)[64]
What options are available for calculating GHG emissions?	• RED default values • Actual values (RED methodology)
Units	• gCO_2eq/t product
Chain of Custody and Traceability	
COC options available	• Mass balance (RED) only
Mass balance (RED) characteristics: • continuous • deficit and balancing-up period	• Continuous (deficit is not permitted)
Prevention of double counting/claiming	• Use of internal registry
What information is tracked through the supply chain (RED)?	• Type of feedstock, harvest year, country of origin, sustainability characteristics (including GHG)

[63] At the time of writing the EC has not yet agreed a definition of highly biodiverse grasslands (a Decision is expected in 2014). Until this time voluntary schemes can either a) achieve "full" EC recognition by prohibiting conversion of all grasslands, b) achieve "partial" EC recognition on highly biodiverse grasslands if the scheme does not include such a provision.

[64] 2BSvs already includes the future GHG thresholds. Other voluntary schemes, like ISCC, currently do not and will need to be updated at a future time in order to continue to be recognized by the EC.

Information	
Auditing	
Unit of certification	• First gathering point (with collection sites) and supply base
Is Group certification permitted?	• Raw material production: Square root of total number of biomass producers in group supplying first gathering entity is audited annually • First gathering entity: Central office and square root of Collection sites (3% permitted if lower risk) are audited annually
Certificate validity	• 5 years
Burden of complying with scheme	
Relative cost of achieving compliance with scheme compared to other schemes	**Low –** 2BSvs has minimum mandatory requirements focussing on compliance with the RED without additional criteria. In addition the tracked information per consignment is limited.

2. Bonsucro EU[65]

Bonsucro (formerly known as the Better Sugar Cane Initiative or BSI) is a global multi-stakeholder not-for-profit initiative dedicated to reducing the environmental and social impacts of sugarcane production. Bonsucro members include over 100 companies connected with the sugarcane supply chain, including farmers, industry, intermediaries, end-users and civil society. Bonsucro aims for 20% sugarcane market penetration by 2017.

The scheme has been in development since 2005/06. Bonsucro launched its Production Standard in 2010 and certification started in 2011. A key feature of the scheme is that it is designed to measure the impact of sugarcane production by means of *metric* indicators. Bonsucro has amended its certification system to include the RED requirements and developed the “Bonsucro EU” Certification Scheme for those members who wish to market their product for the EU biofuels market. Bonsucro EU was formally recognized by the EC as a voluntary scheme on 19 July 2011.

Table 13. Overview of the Bonsucro EU voluntary scheme

Aspect	Information
Basic information on scheme	
Feedstock coverage	Sugarcane
Geographical coverage	Global
Supply chain coverage	Full supply chain (feedstock production to biofuel production)

[65] http://bonsucro.com/site/wp-content/uploads/2013/02/ENG_WEB_A-Guide-to-Bonsucro_1.pdf

Aspect	Information
Accredited certification bodies	Cert-ID, Control Union, IG Cert, LRQA Brasil, OIA, SCS Global Services, SGS (currently under review), TÜV Rheinland, WQS[66]
No. of companies using the scheme or certified area	37 mills certified (mainly Brazil, but also Australia), covering 850k ha certified sugarcane area, 2.6m m^3 of certified ethanol[67]
Recognition of other voluntary schemes	Bonsucro does not recognise other voluntary schemes
Sustainability criteria	
Environmental	• RED land criteria: Preservation of High biodiversity land (but *not* highly biodiverse grasslands), High carbon stock land, Peatlands • Soil, Water, Air protection, Biodiversity and ecosystem services • Note: 80% of the non-RED environmental and social criteria need to be met to achieve compliance – except for "core" environmental criteria
Social	• Labour rights and working conditions, Land use rights • Note: 80% of the non-RED environmental and social criteria need to be met to achieve compliance – except for "core" social criteria
Economic	• Continuously improve key areas of the business • Note: 80% of the non-RED environmental and social criteria need to be met to achieve compliance
GHG criteria and calculation methodologies	
GHG savings	• 35% for all biofuels (increasing in line with the RED)
What options are available for calculating GHG emissions?	• RED default values with guidance on the calculation of land-use emissions
Units	• gCO_2eq/MJ fuel
Chain of Custody and Traceability	
COC options available	• Mass balance (incorporating RED requirements), Physical shipment, Credit Trading System (CTS) (i.e. book-and-claim)
Mass balance (RED) characteristics: • continuous • deficit and balancing-up period	• Continuous (deficit is not permitted) with 1 month balancing period
Prevention of double counting/claiming	• Each consignment has an unique ID number generated by an accounting system

[66] http://bonsucro.com/site/certification-process/licensed_certification_bodies/

[67] http://bonsucro.com/site/in-numbers/

Aspect	Information
What information is tracked through the supply chain (RED)?	• Consignment # identifies the harvest year and unit of operation (farm/site), Description of raw material and quantity, Sugar/Alcohol % content, Statement that production was awarded Bonsucro EU certificate and that production complies with land use criteria, GHG emission, Country of origin, Proportion of processing residues (molasses) used in production
Auditing	
Unit of certification	• Mill and supply base
Is Group auditing permitted?	• Raw material production: Sampling based on volume of sugarcane supplied to the mill • Supply chain: Multi-site certification permitted in the supply chain after the mill
Certificate validity	• 3 years
Burden of complying with scheme	
Relative cost of achieving compliance with scheme compared to other schemes	**Medium –** Economic operators have to demonstrate that environmental criteria beyond RED and social criteria are fulfilled.

3. ISCC EU

The International Sustainability & Carbon Certification System (ISCC) is a multi-stakeholder initiative initially developed by consultancy company Meo Carbon Solutions and supported by the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Agency for Renewable Resources (FNR). The German Ministry of Environment (BMU) was also involved in the development process. ISCC was initiated in 2006 in a multi-stakeholder process. ISCC EU was formally recognized by the EC as a voluntary scheme on 19 July 2011.

ISCC also operate the "ISCC DE" version of the scheme, which was recognized by the German government before the EC recognized the EU version. The two versions of the scheme operate in parallel because of the legal recognition status in Germany and in the EU. Key differences relate to, for example, the percentage of farms that need to be audited (higher in ISCC EU), although the ISCC DE version also now includes specific requirements for the traceability of waste and residues which were mandated by the German government. In general ISCC DE is only used in the German market, although it is also recognized as a voluntary scheme in Austria. Other EU Member States would be free to recognise ISCC DE, but most simply recognise the EC recognized version of the scheme.

Table 14. Overview of the ISCC EU voluntary scheme

Aspect	Information
Basic information on scheme	
Feedstock coverage	Multiple agricultural feedstocks
Geographical coverage	Global
Supply chain coverage	Full supply chain (feedstock production to biofuel production)
Accredited certification bodies	Abcert AG, agroVet GmbH, ASG Cert GmbH, Baltic Control Ltd, Bureau Veritas Certification Germany GmbH, Cert ID Ltda, European Inspection and Certification Company (EuroCert) S.A, DEKRA Certification GmbH, DNV Certification AB, DQS-UL CFS GmbH, Global-Creative-Energy GmbH, GUT Certifizierungsgesellschaft mbH, ICIM S.p.A., INTERTEK Certification GmbH, KIWA NV, PCU Deutschland GmbH, RINA Services S.p.A., SC@PE.International Ltd, SCHUTTER CERTIFICATION B.V., SCS Global Services, SGS Germany GmbH, TÜV NORD CERT GmbH, TÜV SÜD Czech s.r.o., TÜV Rheinland Cert GmbH, TÜV SÜD Industrie Service GmbH, TÜV Thüringen e. V.[68]
No. of companies using the scheme or certified area	4,797 certificates have been issued of which 2,363 certificates are still valid.[69] This includes both ISCC EU and ISCC DE.
Recognition of other voluntary schemes	• ISCC accepts all EC recognized voluntary schemes. • BUT: information tracked through the supply according to ISCC.
Sustainability criteria	
Environmental	• RED land criteria: Preservation of High biodiversity land, High carbon stock land, Peatlands (Note: Any conversion of grassland is currently prohibited within the ISCC system subject to EC Decision on highly biodiverse grasslands) • Soil, water and air protection (not audited in EU if Member State has implemented cross-compliance, 60% of "Minor Must" criteria must be met) • Good agricultural and environmental condition (GAEC) standards – in relation to cross-compliance in Europe (not subject to audit by ISCC auditors)
Social	• Labour rights and working conditions, Land Use Rights (not audited in EU if Member State has implemented cross-compliance, assumed to be met if country has ratified applicable ILO conventions, 60% of "Minor Must" criteria must be met)

[68] http://www.iscc-system.org/en/certification-process/certification-bodies/recognized-cbs/

[69] http://www.iscc-system.org/en/certificate-holders/all-certificates/

Aspect	Information
Economic	• Not covered
GHG criteria and calculation methodologies	
GHG savings	• 35% for all biofuels (increasing in line with the RED)
What options are available for calculating GHG emissions?	• RED default values • Actual values (RED methodology)
Units	• gCO_2eq/MJ fuel (final producer only) • gCO_2eq/kg product pre-allocation (supply chain) • gCO_2eq/kg product post-allocation (supply chain – only if RED default allocation factors used in conversion)
Chain of Custody and Traceability	
COC options available	• Mass balance (RED), Physical segregation with two options: 1. Physical segregation of all consignments, 2. Physical segregation of sustainable and non-sustainable consignments
Mass balance (RED) characteristics: • continuous • deficit and balancing-up period	• Deficit with balancing period of 3 months
Prevention of double counting/claiming	• Economic operators have to keep records of all incoming sustainable products including a unique batch identification number • Receiver of consignment has to check the ISCC database to see whether the supplier has a certificate of conformity for the sustainable product valid for the period of delivery
What information is tracked through the supply chain (RED)?	• Unique identification number for each consignment • Unique registration number of the certificate and name of suppliers certification system • Type of incoming sustainable products • Date of entry of sustainable products • Amount or percentage of sustainable products in tons • Information on values used in GHG calculation (default, disaggregated or actual values) • GHG emissions of incoming sustainable product • Means of transportation and distance from supplier to company in km
Auditing	
Unit of certification	• First gathering point and supply base
Is Group auditing permitted?	• Raw material production: Group auditing is possible for homogenous groups of agricultural product. The members of the group have to be located in the same region, climatic

Aspect	Information
	conditions have to be similar, similar production systems apply and the risk assessment has shown a similar risk exposure. The size of the (random) sample is determined by the group risk factor multiplied by the square root of the number of group members – with a minimum size of one. Risk factors: Regular = x1, Medium = x1.5 and High = x2.
Certificate validity	• 1 year
Burden of complying with scheme	
Relative cost of achieving compliance with scheme compared to other schemes	**Medium –** ISCC also demands compliance with environmental criteria beyond RED and social criteria. Furthermore economic operators have to provide a comprehensive set of data for each consignment.

4. RSB EU RED

The Roundtable on Sustainable Biomaterials (RSB), formerly the Roundtable on Sustainable Biofuels, is a multi-stakeholder initiative which was initiated by the Ecole polytechnique fédérale de Lausanne (EPFL). Since January 2013 the RSB has been an autonomous organization based in Geneva. The RSB is led by a multi-stakeholder steering board. Each member of the Steering Board represents one of the 7 RSB “chambers”, which comprise all biofuel sectors and stakeholders, including farmers, biofuel producers, the transportation industry, environmental and social NGOs, research institutes, governments and investors. RSB EU RED was formally recognized by the EC as a voluntary scheme on 19 July 2011. The global version of the scheme (i.e. without the RED requirements) is also a recognized voluntary scheme in New South Wales, Australia.

The RSB scheme has received considerable interest from the aviation industry. Airbus, Boeing, IATA, SkyNRG, the Sustainable Aviation Fuel Users Group (SAFUG) and Swiss International Air Lines are all RSB members[70], and two airlines have reportedly committed to exclusively sourcing RSB-certified biofuels[71]. In March 2013, KLM operated the first flight from Amsterdam to New York powered by SAF made from RSB-certified Used Cooking Oil supplied by SkyNRG[72]. Furthermore, in October 2013 Camelina Company España, who is promoting camelina as a biojet fuel feedstock, became RSB certified. A month later so did PGF Biofuels Ltd, who is promoting brassica carinata[73] as a SAF feedstock.

[70] http://rsb.org/about/organization/rsb-members/

[71] http://www.nrdc.org/energy/aviation-biofuel-sustainability-survey/files/aviation-biofuel-sustainability-survey-IB.pdf

[72] http://www.isealalliance.org/online-community/news/klms-first-transatlantic-flight-powered-by-rsb-certified-biofuel

[73] http://rsb.org/certification/participating-operators/

Table 15. Overview of the RSB EU RED voluntary scheme

Aspect	Information
Basic information on scheme	
Feedstock coverage	Multiple agricultural feedstocks
Geographical coverage	Global
Supply chain coverage	Full supply chain (feedstock production to biofuel production)
Accredited certification bodies	Det Norske Veritas (DNV), NCS International Pty Ltd, SCS Global Services[74]
No. of companies using the scheme or certified area	12 certificates have been issued[75] by RSB EU RED and global version.
Recognition of other voluntary schemes	• RSB EU RED accepts any EC recognized scheme for agricultural feedstock, but then only an EU RED compliant claim can be made. • RSB accepts Sustainable Agricultural Network and FSC
Sustainability criteria	
Environmental	• RED land criteria: Preservation of High biodiversity land, High carbon stock land, Peatlands (Note: Feedstock production on natural or non-natural grassland is not allowed subject to EC Decision on highly biodiverse grasslands) • Soil, water and air protection • Waste management
Social	• Labour rights and working conditions, Land Use Rights • Contribution to rural and social development • Maintaining or enhancing local food security • Stakeholder involvement according to Free Prior and Informed Consent (FPIC) in land acquisition
Economic	• Business plan of the economic operator has to reflect a commitment to long-term economic viability
GHG criteria and calculation methodologies	
GHG savings	• 35% for all biofuels (increasing in line with the RED)
What options are available for calculating GHG emissions?	• RED default values • Actual values (RED methodology)
Units	• gCO_2eq/MJ fuel
Chain of Custody and Traceability	
COC options available	• Mass balance (incorporating RED requirements), • Identity of product preserved,

74

75

Aspect	Information
	• Segregation of product (the latter two options are more stringent than Mass balance and therefore permitted under the RED)
Mass balance (RED) characteristics: • continuous • deficit and balancing-up period	• Continuous (deficit is not permitted)
Prevention of double counting/claiming	• Unique reference number of each consignment • Participating operator has to verify the product documentation
What information is tracked through the supply chain?	• Name and address of customer and first processing site • Date of supply • Type and quantity • Unique identification number • RSB participant code • Reference to site at economic operator responsible for supply • Type of COC • RSB compliance claim • All documentation associated with the consignment (which might include country of origin
Auditing	
Unit of certification	• First gathering point and supply base

Is Group auditing permitted?	• First gathering point: Evaluation of central office and management systems
	• Supply chain: Two methods for sampling, of which the one with the highest sample has to be chosen:
	  ○ Square root of total number of involved entities
	  ○ Sample according to risk class: 5% at lowest risk class and 25% at highest risk class

Certificate validity	• Depending on risk class • 2 years (risk class 1) • 3 months (risk class 6)
Burden of complying with scheme	
Relative cost of achieving compliance with scheme compared to other schemes	**High –** RSB is the most comprehensive voluntary system and asks economic operators to not only demonstrate compliance with sustainability criteria, but also demands promotion of rural development and ensuring of food security.

5. RSPO-RED

RSPO is a not-for-profit multi-stakeholder initiative founded in 2004. Founding members were Aarhus United UK, Migros, Malaysian Palm Oil Association, Unilever and WWF. Its stakeholders now include organizations that represent oil palm producers, palm oil processors or traders, consumer goods manufacturers, retailers, banks and investors, environmental or nature conservation NGOs and social or developmental NGO. RSPO's Secretariat is based in Kuala Lumpur, Malaysia, with an RSPO liaison office in Jakarta, Indonesia.

The RSPO Certification System was launched in 2007, followed by the RSPO Supply Chain Certification System in 2009. RSPO more recently extended its system with a voluntary add-on to the RSPO Principles and Criteria called the 'RSPO-RED - Requirements for compliance with the EU Renewable Energy Directive requirements'. The RSPO system plus the RSPO RED requirements are collectively referred to as the "RSPO-RED" system. RSPO-RED was formally recognized by the EC as a voluntary scheme on 23 November 2012.

Table 16. Overview of the RSPO-RED voluntary scheme

Aspect	Information included in the overview
Basic information on scheme	
Feedstock coverage	Palm oil
Geographical coverage	Global
Supply chain coverage	Full supply chain (feedstock production to biofuel production)
Accredited certification bodies	BM Trada, Control Union, DNV, IBD Certifications, ICEA, ISA Certification, SIRIM QAS International, SGS Malaysia, TÜV Nord Indonesia, TÜV Rheinland[76]
No. of companies using the scheme and/or certified area	2.7 mha certified area, 9.3 mt CSPO and 2.1 mt CSPK[77] production, 9 countries but mainly Indonesia and Malaysia (>85%)[78]
Recognition of other voluntary schemes	RSPO does not recognise other voluntary schemes
Sustainability criteria	
Environmental	• RED land criteria: Preservation of High biodiversity land (but *not* highly biodiverse grasslands), High carbon stock land, Peatlands • Soil, Water, Air protection
Social	• Labour rights and working conditions, Land use rights

[76] http://www.rspo.org/en/sccs

[77] CSPO (Crude Sustainable Palm Oil), CSPK (Crude Sustainable Palm Kernel)

[78] http://www.rspo.org/en/Market_Data_-_As_at_15th_Oct_2013

Aspect	Information included in the overview
Economic	• Commitment to long-term economic and financial viability
GHG criteria and calculation methodologies	
GHG savings	• 35% for all biofuels (increasing in line with the RED)
What options are available for calculating GHG emissions?	• RED default values • Actual values (currently on hold)
Units	• gCO_2eq/MJ fuel
Chain of Custody and Traceability	
COC options available	• Mass balance (incorporating RED requirements), • Segregated, • Identity Preserved and • Book-and-claim (not permitted in RSPO-RED)
Mass balance (RED) characteristics: • continuous • deficit and balancing-up period	• Continuous (deficit is not permitted)
Prevention of double counting/claiming	• Through web-based Transaction Registration Systems developed by UTZ Certified • RSPO eTrace[79] • Physical trading of Certified Sustainable Palm Oil from CPO mill to last refinery (Mass balance, Segregated, Identify Preserved) • GreenPalm • Trading of green certificates (Book-and-claim)
What information is tracked through the supply chain (RED)?	• Including min. of: Loading/delivery date, Date document issued, Names and addresses of seller/buyer, Product description and quantity, Supply chain model (e.g. Mass balance), Supply chain certificate reference no.,
Auditing	
Unit of certification	• Mill and supply base
Is Group certification permitted?	• Raw material production: Group certification of smallholders currently not permitted • Mill: Square root of the mill management sub-units and all mills are assessed annually • Supply chain: Multi-site certification of supply chain permitted - Central office and square root of the number of sites are audited annually

[79] http://www.rspo.org/en/etrace_faqs

Aspect	Information included in the overview
Certificate validity	• 5 years
Burden of complying with scheme	
Relative cost of achieving compliance with scheme compared to other schemes	**Medium –** RSPO has social and economic criteria as well. Economic operators have to use web-based tracking system for consignments.

Glossary

1st generation biofuel	=	biofuel produced from biomass that may compete with food production
2nd generation biofuel	=	biofuel made from sustainable, non-food biomass such as algae, jatropha, etc.
Alternative fuel	=	fuel from non-petroleum source
ASTM D1655	=	ASTM Standard Specification for Aviation Turbine Fuels
ASTM D7566	=	Standard Specification for Aviation Turbine Fuels Containing Synthesized Hydrocarbons
Barrel	=	volume measure of 159 liters or 42 US gallons
Biodiesel	=	alkyl esters derived from fatty acids
Biofuel	=	fuel produced out of biomass
Biojet fuel, also referred to as SAF, aviation biofuel	=	jet fuel produced out of biomass
Biomass	=	renewable biological raw material such as plants, algae, organic waste etc.
Bioport	=	fuel distribution system within airport allowing all operators to be fueled using biofuel
Biorefinery	=	a facility that produces fuels from biomass
Blend	=	mixing of different types of fuel
Blending point	=	a point in the fuel supply and distribution chain where biofuel is blended with conventional fuel
Book and claim system	=	system where fuel use can be claimed anywhere in the world independent of where it is used
Camelina	=	historically cultivated as an oil plant; is now used as a feedstock for biofuel.
Carbon footprint	=	new amount of carbon dioxide emissions addressed to the applied product
Carbon neutral	=	with zero carbon footprint (CO_2 emissions = CO_2 absorption)
Catalyst	=	material that facilitates a chemical reaction
Control point	=	a defined point in the biofuel supply chain where biofuel content can be verified and past which all fuel is assumed to be used for commercial aviation
Conventional jet fuel	=	fossil-based jet fuel
Decoupling	=	growth in aviation without increased aggregate emissions
Density	=	mass per unit volume
Drop-in fuel	=	alternative fuel that is indistinguishable from conventional fuel, with no changes of aircraft, engine or supply infrastructure required.
Feedstock	=	raw material such as biomass, oils, fats, coal and gas
Forest residues	=	by-products from forestry industries
Industry fuel efficiency	=	measured by IATA as liters of fuel used per revenue ton kilometer

Gallon	=	3.785 Liters
Hydrocarbons	=	molecules made out of carbon and hydrogen, used as fuels
ICAO State Action Plans	=	outlines specific voluntary measures states intend to implement in order to improve efficiency and reduce climate impact
Internal rate of return	=	used in capital budgeting to measure and compare the profitability of investments
Jatropha	=	genus of approximately 170 plants used as a feedstock for biofuel
Marginal lands	=	land with low levels of productivity, poor soil quality, and unsuitable for housing or other uses
Market-based mechanism	=	policy instrument intended to reduce environmental externality (e.g. emissions)
Mass balance system	=	a means of accounting for the flow of material within a defined system, within a specific time period
Meta-standard	=	iterations of achievement
Net Present Value	=	sum of the present values of incoming and outgoing cash flows over a period of time
Offtake agreements	=	commitment from a third-party to purchase (e.g. biojet fuel)
Open Skies	=	bilateral air transport agreement to liberalize air services between the EU and the US
Pathways	=	an approved method for sourcing biofuel
Peatlands	=	tropical moist forests where waterlogged soil prevents dead leaves and wood from fully decomposing
Sustainable biomass	=	renewable and environmentally friendly biomass
Upstream GHG emissions	=	emissions in the supply-chain of a product of service
Valley of death	=	represents a breakdown in the innovation sequence where proven technology cannot be commercialized

Acronyms

2BSvs	=	Biomass Biofuel Sustainability Voluntary Scheme
ABRABA	=	Brazilian Alliance for Aviation Biofuels
AFTF	=	Alternative Fuels Task Force
aireg	=	Aviation Initiative Renewable Energy in Germany
AISAF	=	The Australian Initiative for Sustainable Aviation Fuels
ATJ	=	Alcohol-to-Jet
BRA	=	Brazilian Alliance for Aviation Biofuels
BtL	=	Biomass-to-Liquid
CAAFI	=	Commercial Aviation Alternative Fuels Initiative (USA)
CAEP	=	Committee for Aviation and Environment Protection
CAPEX	=	Capital Expenditure
CO_2	=	Carbon Dioxide
CoC	=	Chain of Custody
COP21	=	Conference of Parties 21
CPET	=	United Kingdom Central Point of Expertise for Timber (United Kingdom)
CSIRO	=	Commonwealth Scientific and Industrial Research Organization
DCHC	=	
DOD	=	Department of Defense (USA)
EC	=	European Community
EISA	=	Energy Independence and Security Act (USA)
EPA	=	Environmental Protection Agency (USA)
EPAct	=	Energy Policy Act
ETS	=	Emissions Trading System
EU	=	European Union
FQD	=	Fuel Quality Directive
FT	=	Fischer Tropsch
GAEC	=	Good Agricultural and Environmental Condition
GFAAF	=	Global Framework for Aviation Alternative Fuels
GHG	=	Greenhouse Gas
GMTF	=	Global Market-based Measure Technical Task Force (GMTF)
HEFA	=	Hydrotreated Esters and Fatty Acids
IATA	=	International Air Transport Association
ICAO	=	International Civil Aviation Organization
IEA	=	International Energy Agency
ILO	=	International Labour Organization
IRR	=	Internal Rate of Return

ISCC	=	International Sustainability & Carbon Certification
ITAKA	=	Initiative Towards Sustainable Kerosene for Aviation
LUC	=	Land use change
MASBI	=	Midwest Aviation Sustainable Biofuels Initiative
MBM	=	Market Based Mechanism
MoU	=	Memorandum of Understanding
MSW	=	Municipal Solid Waste
MT	=	Megatonne
NISA	=	Nordic Initiative for Sustainable Aviation
NO_x	=	Nitrogen Oxide
NPV	=	Net Present Value
NSW	=	New South Wales (Australia)
PNPB	=	Brazil National Production and Use of Biodiesel
PPP	=	public-private-partnerships
PtL	=	Power-to-liquid
R&D	=	Research and Development
RED	=	Renewable Energy Directive
RFS	=	Renewable Fuel Standard
RFS2	=	Renewable Fuel Standard 2
RINs	=	Renewable Identification Numbers
RSB	=	Roundtable on Sustainable Biomaterials
RSPO	=	Roundtable on Sustainable Palm Oil
RVO	=	Renewable Fuel Volume Obligations
SABB	=	Sustainable Aviation Biofuels for Brazil
SAF	=	Sustainable Alternative Fuels, also known as aviation biofuel
SAFN	=	Sustainable Aviation Fuels Northwest
SAFUG	=	Sustainable Aviation Fuel Users Group
SENASA	=	Services and Studies for Air Navigation and Aeronautical Safety
SIP	=	Renewable Synthesized Iso-Paraffinic
SKA	=	Synthetic Paraffinic Kerosene with Aromatics
UCO	=	Used Cooking Oil
UCOME	=	Used Cooking Oil Methyl Ester
USD	=	US Dollar

INTENTIONALLY LEFT BLANK

to order:

www.iata.org/publishing

custserv@iata.org

+1 800 716 6326

Follow us on Twitter: www.twitter.com/iata

Join us on Linkedin: www.iata.org/linkedin

Follow us on Youtube: www.youtube.com/iatatv