EXECUTIVE SUMMARY:

THE VIABILITY OF SOUTH AFRICAN SUGARCANE AS FEEDSTOCK FOR SUSTAINABLE AVIATION FUEL PRODUCTION

In this executive summary, we put together the most important takeaways from the three-part research document entitled 'The Viability of South African Sugarcane as Feedstock for Sustainable Aviation Fuel Production', published by the Roundtable on Sustainable Biomaterials (RSB) and the South African Canegrowers Association (SA Canegrowers) in October 2020.

The full report can be downloaded at ***www.rsb.org***

OVERVIEW

Demand for sustainable aviation fuel (SAF) that offers not only a minimum of 50% reduction in greenhouse gas (GHG) emissions compared to conventional jet fuel, but also credible environmental and social sustainability certification, is growing globally — driven by new policy mandates, passenger demand, and industry targets.

Sugarcane — a crop grown in significant quantities in South Africa — provides a wholly viable feedstock for the production of SAF. As such, the sugarcane sector in SA should strongly consider SAF as a diversification option.

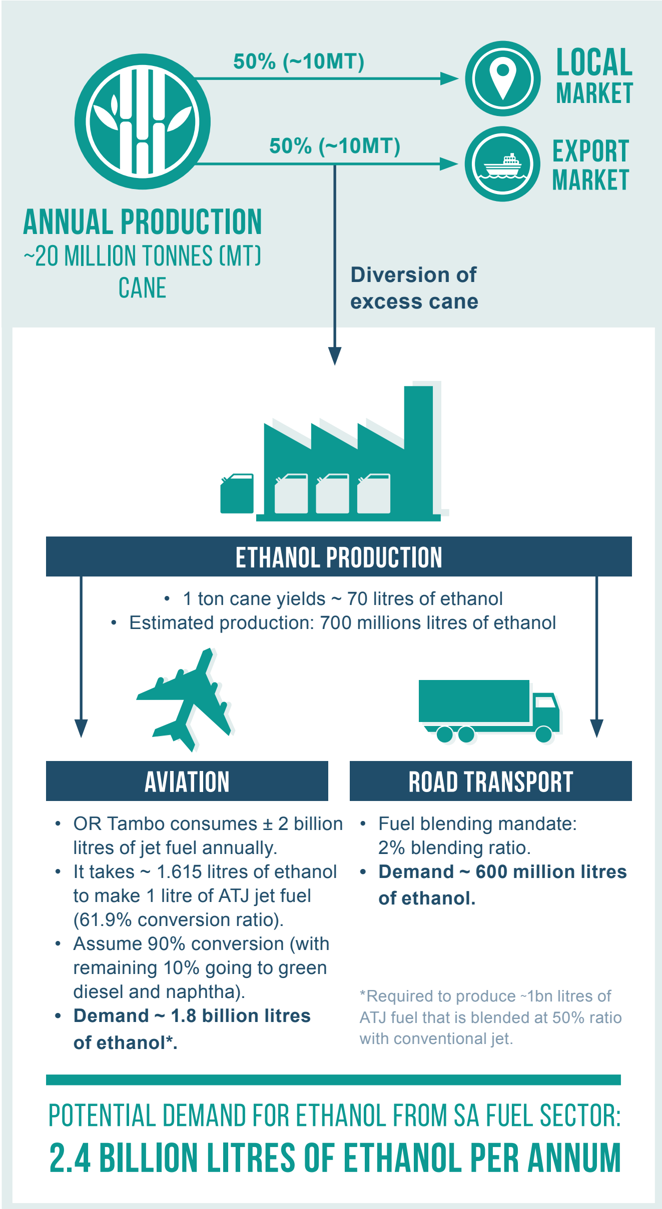
However, irrigated sugarcane in SA is unfortunately still a GHG-intensive crop because of the coal-based energy mix it relies on. The diversification of South Africa's energy mix in favour of renewables has the potential to dramatically strengthen the competitive advantage of local irrigated feedstock — including sugarcane — in the global SAF marketplace.

The RSB Standard sets out social and environmental sustainability principles for biofuel production and has been used as a framework to assess the potential sustainability of SAF produced from South African sugarcane. RSB supports government and industry to transition to a sustainable bioeconomy by providing expertise and technical advice on best practice for sustainability.

Joint publication by the ***Roundtable on Sustainable Biomaterials (RSB)*** *and the* ***South African Canegrowers Association (SA Canegrowers)****, made possible with the support of* ***The Boeing Company****.*

SUGARCANE IN SOUTH AFRICA

The diversification of the South African sugar industry into products including fuel ethanol will be essential to ensure the long-term survival of the industry. According to the results of a 2016 economic assessment of bioethanol production from sugarcane in South Africa[1], ethanol production provides a significant opportunity for the industry to generate value under challenging market conditions. Sugarcane cultivation and processing is one of the country's key agro-industrial activities, meaning that its sugar industry is well-established and has significant investments in both the local economy and the Southern African Development Community (SADC) region.



DEMAND

Considering both aviation and road transportation, high-level estimates suggest that local South African demand for fuel ethanol could be approximately 2.4 billion litres annually, with 75% (1.8 billion litres) from aviation, and 25% (600 million litres) from the national fuel blending mandate. Assuming that 50% of the cane produced can be diverted from the export market to domestic ethanol production — based on current yields — South Africa can produce approximately 700 million litres of ethanol from sugar cane, representing about 30% of the estimated potential ethanol fuel demand.

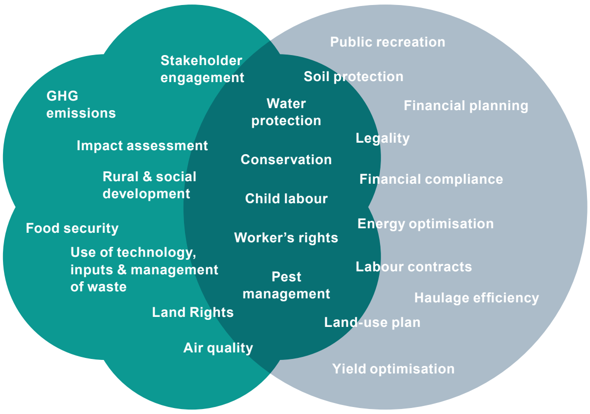
SUSTAINABILITY

In terms of sustainability, the industry is widely supported by the Sustainable Sugarcane Farm Management System (SUSFARMS) — a continuous improvement system developed by the South African Sugarcane Research Institute (SASRI). The system is relatively closely aligned with the RSB Principles & Criteria, following a similar approach in terms of promoting sustainability and best management in the local context. With the exception of Principle 3 (GHG emissions) and Principle 6 (Local Food Security), which are not covered by SUSFARMS, all other RSB Principles are supported by this system — although not comprehensively.

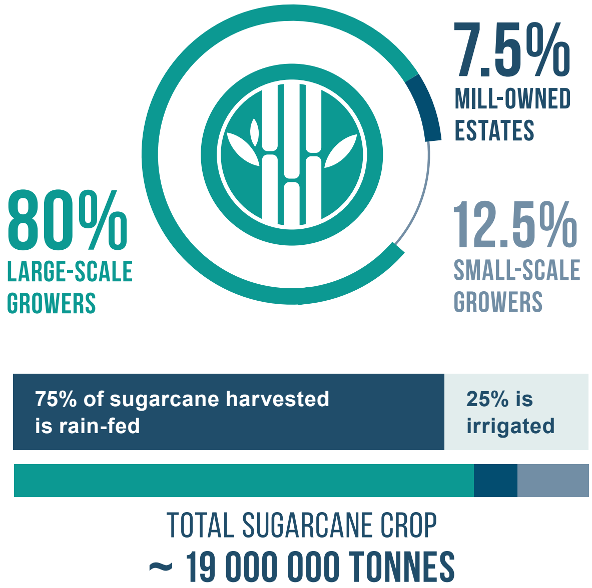
1 An Economic Assessment of Bioethanol Production from Sugar Cane: The Case of South Africa. Available: https://econrsa.org/system/files/publications/working_papers/working_paper_630.pdf

Executive Summary

High-level comparison of the RSB Principles & Criteria and the SUSFARMS Sustainable Farm Management System

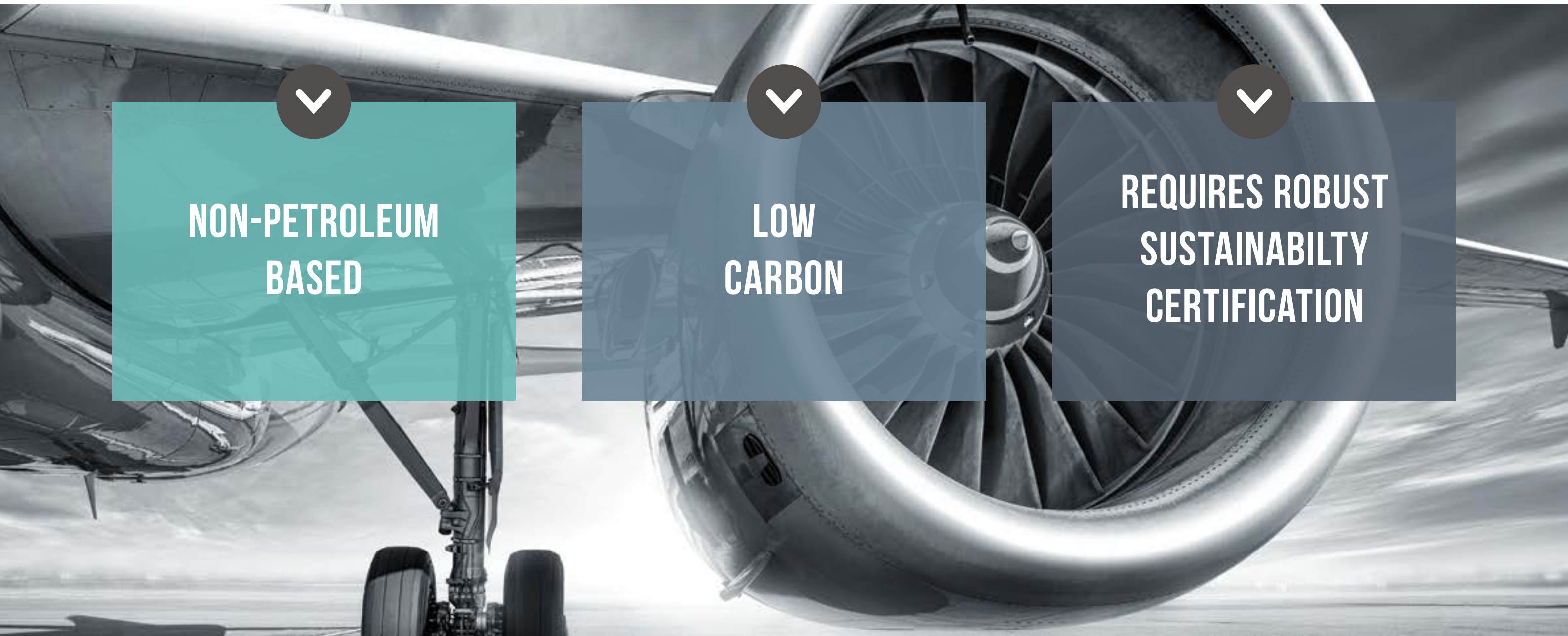


Overview of cane production in the South African sugar yield optimisation



WHAT IS SAF?

Sustainable Aviation Fuels (SAF) — sometimes known as aviation biofuels or bio-jet fuels — are low-carbon fuel alternatives for the aviation industry*. These non-petroleum-based drop-in aviation fuels are generally produced from bio-based feedstocks including waste, residues and end-of-life products, or fossil waste such as waste industrial gases, waste plastics, and tyres. Sustainability certification such as that offered by RSB is required for these fuels as proof of GHG reduction and sustainability impact.*



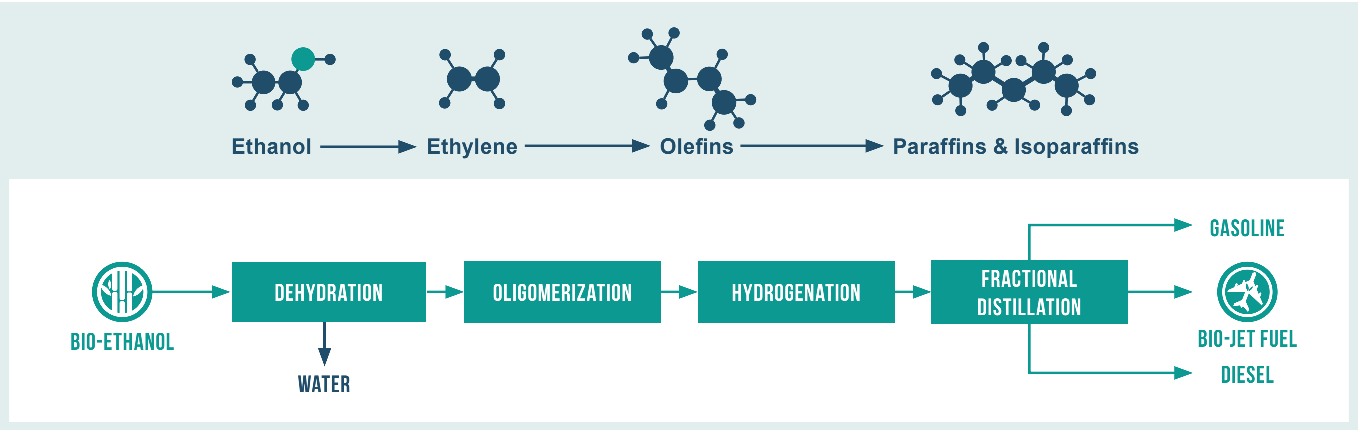
Approved ASTM Pathways for SAF Production

ASTM APPROVED PROCESS	DATE OF APPROVAL	FEEDSTOCK OPTIONS	BLENDING RATIO BY VOLUME
FT-SPK Fischer-Tropsch hydro-processed synthesised paraffinic kerosene	2009	**Lignocellulosic biomass** *Agricultural and forestry residues (e.g. sugarcane bagasse, sugar cane trash, treetops, corn stover and corn stalks) and municipal waste*	Up to 50%
HEFA-SPK Synthesised paraffinic kerosene produced from hydro-processed esters and fatty acids	2011	**Oils and fats** *Camelina, jatropha, castor oil, palm oil, animal fats, and used cooking oil*	Up to 50%
HFS-SIP Synthesised iso-paraffins produced from hydro-processed fermented sugars	2014	**Microbial conversion of sugars to hydrocarbon** *Sugarcane, cassava, sorghum, and corn*	Up to 10%
FT-SPK/A Synthesised kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	2015	**Lignocellulosic biomass** *Agricultural and forestry residues (e.g. sugar cane bagasse, sugarcane trash, treetops, corn stover and corn stalks) and municipal waste*	Up to 50%
ATJ-SPK (isobutanol) Alcohol-to-jet synthetic paraffinic kerosene	2016	**Biomass used for sugar production and lignocellulosic biomass** *Sugarcane, cassava, sorghum, corn, and ethanol*	Up to 50%
ATJ-SPK (ethanol) Alcohol-to-jet synthetic paraffinic kerosene	2018	**Biomass used for sugar production and lignocellulosic biomass** *Sugarcane, cassava, sorghum, corn, and ethanol*	Up to 50%
CHJ Catalytic hydrothermolysis synthetic jet fuel	2020	**Triglyceride-based feedstocks** *Waste oils, algae, soybean, jatropha, camelina, and carinata*	Up to 50%
HHC-SPK High hydrogen content synthetic paraffinic kerosene	2020	**Biologically derived hydrocarbons** *Algae*	Up to 10%

SAF: A NEW MARKET FOR SOUTH AFRICAN SUGARCANE

Sugarcane-derived ethanol can be utilised in producing SAF via the alcohol-to-jet oligomerisation.

Overview of the alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK) process using ethylene as an intermediate



WHAT MAKES SAF SUSTAINABLE?

SAF NEEDS THE FOLLOWING IN PLACE TO BE CONSIDERED SUSTAINABLE:

- *SAF must have a substantially better (>50%) GHG balance than its fossil fuel alternative.*
- *The production/use of SAF must not cause environmental harm.*
- *The production/use of SAF must not cause socioeconomic harm.*
- *The production/use of SAF must not deplete natural resources.*

THE RSB STANDARD

The sustainability standard developed by the Roundtable on Sustainable Biomaterials (RSB) is widely recognised by the industry to be best-in-class, covering every sustainability aspect — including food security, rural development, and the protection of ecosystems. Certification to the RSB Standard covers the production of any bio-based feedstock, biomass-derived material, or advanced fuel — as well as complete supply chains and new technologies. Certification contributes towards the development of a sustainable bioeconomy while also enabling fuel and feedstocks producers and users to identify and mitigate sustainability risks in their supply chains[2].

GHG EMISSIONS REDUCTION POTENTIAL

In a bid to reduce aviation industry GHG emissions and promote the development of low-carbon SAF, regulatory requirements and standards schemes have implemented minimum GHG emissions reduction requirements for SAF — which become more stringent for new SAF production plants.

HOW ARE GHG LIFECYCLE EMISSIONS CALCULATED?

GHG emissions associated with the production of SAF are determined using a lifecycle assessment approach. This approach covers all emissions across the lifecycle of the SAF, from the cultivation of sugarcane through to combustion of the final product in a jet engine.

The CORSIA methodology mandated by the International Civil Aviation Authority (ICAO) also includes requirements on induced Land Use Change emissions in the calculation. This value refers to the impact of diverting pasture or agricultural land previously destined for the food, feed, and fibre markets to biofuel production.

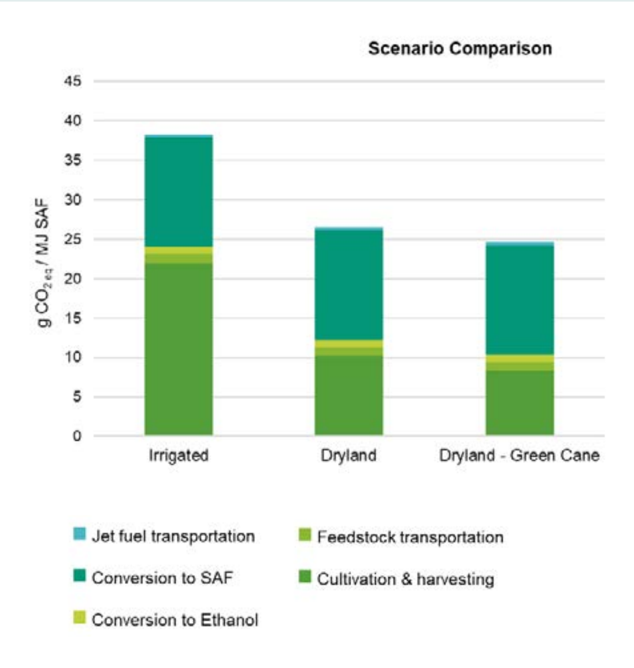
The 'well-to-wing' life-cycle GHG emissions for SAF produced via the ATJ-SPK process using bioethanol produced from South African sugarcane are approximately:

- *38.3 g $CO_{2\,eq}$ / MJ SAF for irrigated cane*
- *26.6 g $CO_{2\,eq}$ / MJ SAF for dryland cane*
- *24.6 g $CO_{2\,eq}$ / MJ SAF for dryland cane with green harvesting*

GHG EMISSIONS FROM SOUTH AFRICAN SUGARCANE

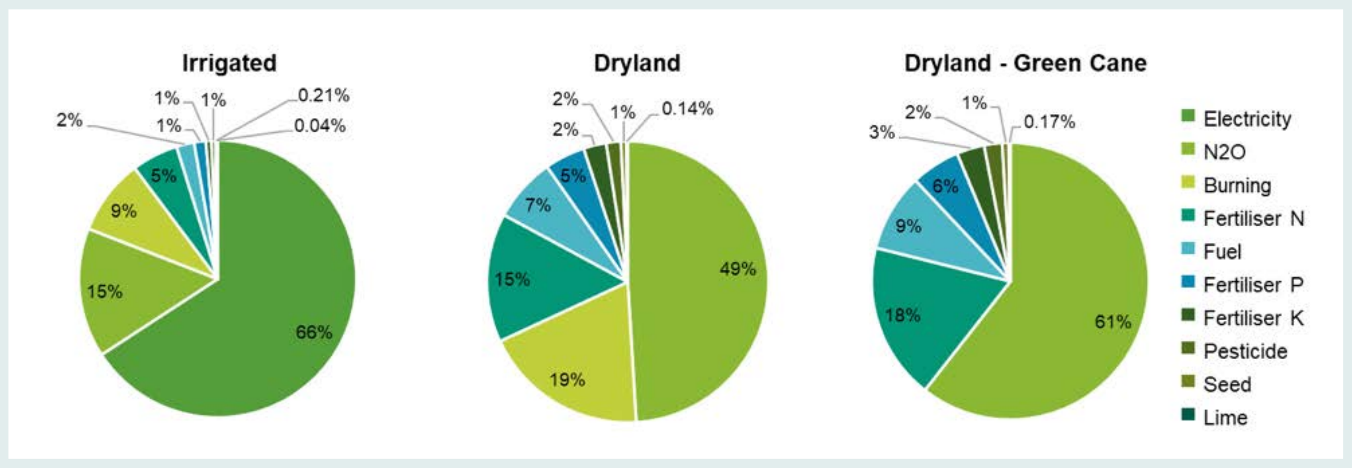
The breakdown of the emissions per supply chain stage is shown in the graphs below. Cultivation, harvesting, and the conversion of ethanol to SAF are the biggest contributors to the total GHG emissions in all three scenarios. The difference in cultivation emissions between the irrigated and dryland scenarios can be attributed to the high electricity demand for pumping required during irrigation.

Lifecycle GHG emissions for SAF produced from South African irrigated and dryland sugarcane



2 For more information on RSB Certification refer to the following: https://rsb.org/certification/about-certification/

Percentage contribution of farm-level inputs to the GHG emissions for the cultivation and harvesting of South African irrigated and dryland sugarcane



For irrigated cane, electricity production contributes 66% of the overall farm-level CO2 emissions. Farm electricity demand is typically met by grid electricity provided by Eskom — the national utility company. Eskom's electricity generation mix is heavily dominated by coal (91%)[3] and as such the CO2 emissions attributed to electricity in South Africa are high when compared to countries with a greater percentage of renewable energy sources in their national grid mix.

The percentage saving is calculated by dividing the emission-saving amount (baseline minus emissions) by the baseline amount.

Dryland cane presents a particularly strong option for achieving GHG savings in the production of SAF — markedly so over irrigated cane — cutting 72% in emissions when the EU RED II fossil baseline is applied and an additional 2% with green harvesting included. The savings remain significant if the CORSIA baseline is applied, giving 60% savings for dryland cane and an additional 3% when using green harvesting techniques. Irrigated cane could demonstrate better savings if its current coal-based electricity use was replaced with renewable energy sources, in order to reach the thresholds mandated under EU RED.

Summary of GHG savings and market access potential for biofuels produced with South African sugarcane ethanol

	EU Aviation Market Reduction threshold: Year of Production start: <2015 = 50% 2015-2020 = 60% >2021 = 65%		**Global Aviation Market** Reduction threshold: 50% core LCA 10% LCA + iLUC	
	GHG SAVINGS	**QUALIFIES?**	**REDUCTION THRESHOLD:**	**QUALIFIES?**
Irrigated cane	59%	No	50% core LCA 10% LCA + iLUC	Yes
Dryland cane	72%	Yes	60%	Yes
Dryland cane + green harvesting	74%	Yes	63%	Yes

RSB GHG TOOL

The RSB GHG Tool incorporates both the EU RED and ICAO CORSIA GHG methodologies and can be utilised by SAF supply chain actors to calculate the carbon intensity along the supply chain as well as the final reduction compared to fossil baseline.

3 However, when adding electricity generated by independent power producers, municipalities, and imports, the relative contribution from coal drops to 85%. https://www.get-invest.eu/market-information/south-africa/energy-sector/

ESTIMATED COSTS OF PRODUCING SAF WITH SUGARCANE ETHANOL IN SOUTH AFRICA

The table below contains a comparison of the estimated 2018 SAF rand values for the key processing pathways.

The South African A-1 jet fuel market price is R207/GJ (approximately R7.22/l, using an energy density basis of 34.9MJ/l). *SAF projections fall into the predicted range of being between two and seven times costlier than conventional fossil-based jet fuels.*

The benchmark price for SAF should however not be that of conventional jet fuel, but instead be calculated as ***conventional jet fuel pricing plus the cost of carbon pricing*** *(usually in the form of carbon offsetting or carbon tax).*

Additional production and supply costs for a facility also impact the feasibility of the SAF production process. Ultimately, the price differential between SAF and conventional jet fuel is expected to improve in the next decade, due to the following:

- *Scaling up of refineries (economies of scale)*
- *Regulatory pressure to curb CO2 emissions (development of policy instruments)*
- *Increasing number of commercial airlines committing to sourcing SAF (increased demand/offtake agreements)*
- *Increase in oil price*

Comparison of bio-jet fuel minimum fuel selling price (MFSP) for key processing pathways

PROCESSING PATHWAY	PRODUCTION COST RANGE EUR$_{2013}$/litre**		EXTRAPOLATED PRODUCTION COST RANGE ZAR$_{2018}$/litre
	Modelled estimates	Range of feedstocks, reported estimates	Range of feedstocks, extrapolated estimates
Hydroprocessed Esters and Fatty Acids (HEFA)	0.98	0.68-0.95	15.2-22.3
Fischer-Tropsch (FT)	1.3-1.9	0.61-1.4	13.9-40.7
Alcohol-to-Jet (ATJ)	**1.8-2.6**	**0.81-0.91**	**18.3-61.0**

SAF: DRIVERS OF DEMAND

OFFTAKE AGREEMENTS[4]

- *250.000 flights have used SAF since 2011.*
- *6 billion litres of offtake agreements.*
- *SAF currently accounts for 0.01% of global jet fuel use and is likely to hit 2% by 2025 with the right policy support.*
- *Airports that integrate SAF in their distribution networks include Oslo (Norway), Amsterdam (Netherlands), Los Angeles (USA).*

4 https://aviationbenefits.org/downloads/fact-sheet-5-aviations-energy-transition/

KEY POLICY INSTRUMENTS

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Regulated by the International Civil Aviation Organisation (ICAO), CORSIA is the only international market mechanism to offset and reduce carbon emissions in aviation and achieve carbon neutral growth from 2021.

RSB's ICAO CORSIA Standard specifies requirements for operators along the SAF supply chain to produce SAF that complies with RSB's sustainability requirements and is eligible under CORSIA.

European Renewable Energy Directive (EU RED)

EU RED establishes an overall policy for the production and promotion of energy from renewable sources in the European Union (EU). It requires the EU to fulfil at least 20% of its total energy needs (including aviation fuels) with renewables by 2020 — to be achieved through the attainment of individual national targets.

All EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020. This share is expected to increase to 32% with the publication of the revised directive (EU RED II) in 2021.

National blending targets

Norway: 0.5% blending target from 2020

France: 2% blending target from 2025; 5% from 2030; 50% from 2050

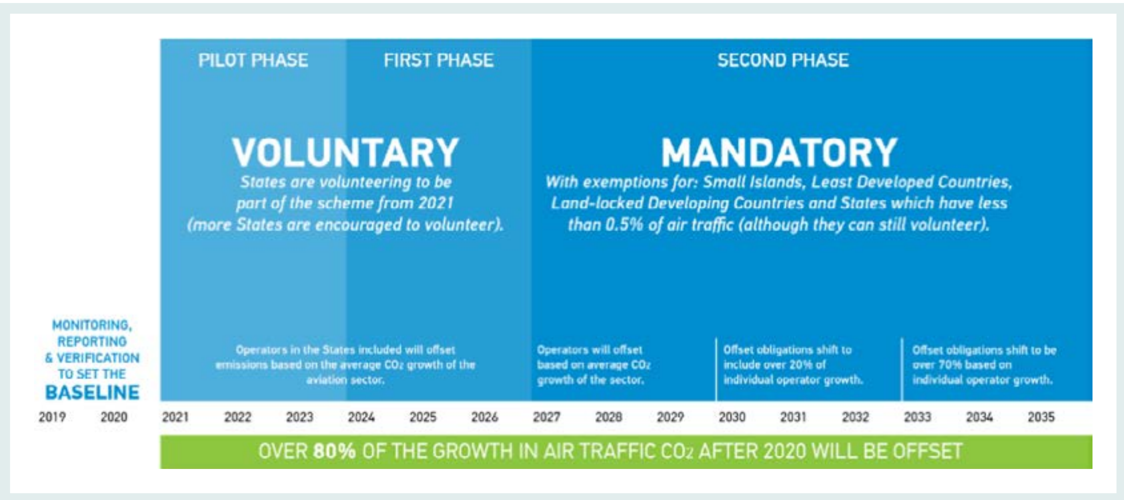
Netherlands: 14% by 2030

South African carbon tax

South Africa's Carbon Tax Bill stipulates that any airline consuming more than 100 000 litres per year of fuel for domestic aviation will be eligible to pay carbon tax.

The carbon tax is being implemented in a phased approach, with the first phase extending from June 2019 to December 2022 and seeing a tax rate of R120/tonne CO_2e emitted, with allowable tax breaks reducing the effective rate to R6 – R48/tonne CO_2e.

CORSIA Implementation Approach



ABOUT RSB

RSB is a global, multi-stakeholder organisation that offers advisory, membership and certification services for the bioeconomy on a global scale. Together with its partners, members and certified projects, RSB represents best practice in sustainability and proactively drives the development of a sustainable bio-based and circular economy in the energy and materials sector.

For more information visit ***www.rsb.org***

ABOUT SA CANEGROWERS

The South African Canegrowers Association was established in 1927 to create a common platform to address grower issues. Today, our mission is to play a leading role in growing sugarcane and diverse production opportunities for cane growers through innovation, research, specialised services and products throughout the value chain

For more information visit ***www.sacanegrowers.co.za***