Biofuels: Australian Canola's Place in the Sustainable Aviation Space

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Executive Summary

From the board room to the kitchen table, sustainability has become one of, if not the most discussed topics throughout Australia. Sustainability covers a broad range of issues which is why the term environmental and social governance has been so prevalent. Society now expects government and business to initiate policy structures which lead to better environmental outcomes. As a result, the biofuel industry worldwide has seen increased demand and new markets are opening for sustainable feedstocks.

As we set our sights towards the Australian Government’s 2030 and 2050 sustainability goals, coupled with recent legislation in the aviation sector, demand for biofuels and their associated feedstocks is predicted to increase. Herein lies the opportunity for Australian farmers.

Biofuels are a renewable fuels made predominantly from used cooking oil, tallow and vegetable oils. They are drop-in fuels which have the potential to reduce greenhouse gas emissions from vehicles by up to 65%. For the aviation industry these fuels can be used in existing aircraft without any modifications to their engines or refueling infrastructure. Due to a shortage in used cooking oils and tallow, land use change impacts on soybeans and the phase out of palm oil by 2030, Australian canola has the potential to support a surge in biofuel production which the aviation industry hopes will lead to increased production of sustainable aviation fuel.

As of 2024, over 70% of Australian canola is being exported to the European Union for conversion into biofuels. Whilst this provides a secure market going forward for Australian farmers, it leaves them susceptible to macro factors, logistics, freight and competition. The benefit of biofuels could be multiplied by the development of a sustainable aviation fuel industry domestically, assisting in decarbonising the aviation sector, providing protein for the domestic livestock market, secure fuel sovereignty and increase job opportunities for those unemployed by the current slowdown in critical minerals.

It is evident that production of SAF through the HEFA pathway is the most cost-effective, mature and immediately scalable technology available to decarbonise the aviation industry. Due to the HEFA pathway being similar to traditional fossil fuel refining, Australia has retired refining assets which could be converted to refine canola oil at much lower CAPEX expenditure than a greenfield facility. By aligning its efforts with global sustainability goals and leveraging its expertise in canola production, Australia is poised to shape a greener future for aviation and establish itself as a prominent player in the sustainable biofuel sector.

Key words: “Canola,” “Sustainable Aviation Fuels,” “Biofuels.

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Foreword

Until recently, when welcoming our first child into our lives I was unaware of the immense impact agriculture has had on me and the way it has shaped my family's lives. It has only been during recent reflection, looking at the way I want my children to be brought up have I decided there is no better place; where a life full of adventure, learning and play is just outside the front door. I now realise this is as important for a child as it is for an adult to achieve a full life. I confess this was not always the case, at times whilst growing up on the same farm I found myself longing for a quiet seaside life, away from the ever-calling presence of the farm and its demands. As I grow into the person I would like to be, I realise a life off the land would not have been true to myself and I am forever grateful for the opportunity to live and work where we do.

Figure 1. Author and Daughter, Windermere (source: Author)

My family have owned our property 'Willow Creek' in Western Victoria since the 1880s, my parents being 4th and my family 5th generation custodians of the land. This is where my two sisters and I grew up, the homestead always being home to us. After graduating high school, I moved away from home and enrolled in a construction management course. This lasted a year before taking up a building apprenticeship, three years later becoming a qualified carpenter. In 2016, after six months of travel through South America it was time to return home.

During my time away there had been a strategic shift in the farm's business model. What had traditionally been an intensive piggery, broadacre cropping and sheep operation added another venture – oilseed processing. The decision to start oilseed processing was initially to improve efficiencies for the farm, become more circular in nature and provided an avenue to scale and bring family into the business. At the time we were growing canola, selling the seed and then buying back oil and meal. The idea of doing everything on-site was appealing and meant we would not need to sell the property and move further out of town. After five years off the farm, there was scope for me to come home and join the team.

In 2016, the processing side had organically grown to more than 50% of our business. It was decided that more time would be spent scaling this side of the operation and to simplify the remaining income streams. Broadacre cropping was pulled from the program, planting perennial ryegrass and lucerne instead for lamb production. Investment in capex was pulled from the piggery, with the eventual sale of our last pigs in 2022.

Since returning home I have played a crucial role in expanding our oilseed processing operations. This has involved planning, technology investments, and learning the intricacies of the oilseed processing industry. Today we run a simplified business model focusing on two income streams – oilseed processing and lamb production.

I had been home for two and a half years when the opportunity to apply for a Nuffield scholarship arose. We were in the process of expanding our crushing facility and installing a new purpose-built shed. Being a large consumer of energy, I was looking at ways to reduce our carbon footprint and improve efficiencies along the supply chain. As a result, I had been working extensively on the designs for an anaerobic digestor to provide methane to feed our boilers instead of the natural gas we were currently using. We had a supply of waste from the piggery and an ability to grow fuel crops; it was a positive outlook. When I was awarded the scholarship in 2019 this was still the direction I was planning to explore. My topic being:

Increasing agricultural efficiencies through the reduction, utilisation or recycling of agricultural waste products and use of alternative renewable energy sources

Sadly, with Covid taking over the world, an expanding business and family, my travel plans were delayed until 2023. During this time, between 2019 and late 2023 our business experienced strong growth and is in a very different situation by the time of writing this report. Since 2019 we have completed a significant expansion, implemented efficiencies in the new process and been able to reduce our carbon footprint considerably. In addition, "Australia has enshrined in law its targets of reducing greenhouse gas emissions by 43% from 2005 levels by 2030 and net zero by 2050" (Australian Trade and Investment Commitment, 2024). As a result, the electricity network in Australia has gone through a monumental transition period moving from a 21% renewable network in 2019 to 35.9% in 2023 (Clean Energy Council, 2023). This is up from 10.5% 10 years earlier in 2010 (Department of Climate Change, Energy, the Environment and Water, 2024). Most of this gain coming from wind (12.8%) and solar (9.3%) (Department of Climate Change, Energy, the Environment and Water, 2024). On the 9th March 2024, renewable electricity to the network hit a record 70% contribution, a sign of significant progress.

With Australia set to hit 81% renewable power contribution by 2030 and aiming to become 100% carbon neutral by 2050, coupled with a three-year hiatus from travel I began reflecting on my topic of study. We now had the ability to purchase 100% renewable electricity from the grid and the business model no longer made sense to implement an expensive digestion process on-site or to install acres of solar panels with battery backup – although this did occur organically over the last two years. Due to the dramatic changes in the Australian energy landscape, the increased demand for biofuels and the potential to develop a new industry in Australia the focus for this report has changed and will now focus on:

Biofuels: Australian Canola's Place in the Sustainable Aviation Space

Acknowledgements

I want to express my gratitude to The William Buckland Fund, whose financial support made this report possible. Their generosity to the Nuffield program over the years has been held in the highest regard and I sincerely appreciate their sponsorship, allowing me to delve into this transformative journey.

To my parents and business partners, Alistair and Jo, I owe immense thanks. While I was away, you managed the business front with a stoicism that I am very grateful for. Operating a process plant running 24/7 alone is no small feat, and your respect for my Nuffield journey has been invaluable.

To my beloved partner, Kate, your understanding and patience has been my rock throughout this Nuffield journey. I carried a heavy heart, feeling guilty about leaving you while pregnant with our first child but your unwavering support has been invaluable. You have allowed me to go on this journey while you continued along independently at home. You are an incredibly strong woman, ticking off your own life goals and I thank you for your strength and love which has sustained me throughout this journey.

Lastly, I want to extend my heartfelt appreciation to all the incredible individuals I have had the privilege to meet during my travels. Your warmth and hospitality were unparalleled, and the time you freely shared enriched my Nuffield experience in ways I could never have imagined. It was the connections with people like you that made this journey uniquely rewarding and extremely meaningful. Thank you for your time, it has been very rewarding.

Figure 2. Africa GFP Group, Kenya (source: author)

Table 1. Travel Itinerary

Travel Dates	Location	Visits
13th - 20th March 2020	Tangalooma Island, Queensland, Aus	Martin Davies David Jones
November 2020 - March 2021	Zoom meetings during Covid	Yoani Kakuzi Ausquest Kisima
12th - 15th Oct 2022	Nuffield National Conference Tamworth	Goonoo Goonoo Station Killara Feedlot Merrilong Pastoral Company Thomas Foods International Peel Valley Milk
22nd Mar - 6th Apr 2023	Nuffield Triennial Conference & post conference tour	Fonterra Darfield Pamu Farms Haldon Station Mt Cook Alpine Salmon Cardrona Distillery Wilkins Farming Mt Nicholas Farming Royal Burn Farm Earnscleugh Station Moa Flat Southern Dairy Hub Makarewa
6th - 15th April 2023	Kenya	Dudutech, Naivasha Kisima AgVenture Blackbeard Shamba Kakuzi - Sarah Flowers Yaoni International Livestock Research Institute Ausquest - Stuart Barden
15th - 25th April 2023	Chile	PropalCasablanca Valley vineyards - Antonio BunsterAgricola GarcesFERREROANCALIAgricola La SelvaHuertos VilkunAgricola Vilcun

Abbreviations

AOF	Australian Oilseeds Federation
ARENA	Australian Renewable Energy Agency
ASTM	American Society of Testing Materials
ATJ	Alcohol to Jet
CJF	Conventional Jet Fuel
CO_2	Carbon Dioxide
CORSIA	Carbon Offsetting Reduction Scheme for International Aviation
EU	European Union
FFA	Free Fatty Acids
FT	Fischer-Tropsch
GFP	Global Focus Program
GHG	Greenhouse Gas
GRDC	Grains Research and Development Corporation
HEFA	Hydrotreated Esters and Fatty Acids
HRD	Hydrotreated Renewable Diesel
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ILUC	Induced Land-Use Change
ISCC	International Sustainability and Carbon Certification
LCA	Life Cycle Assessment
LUC	Land Use Change
PFAD	Palm Fatty Acid Distillate
PtL	Power to Liquid
RSB	Roundtable for Sustainable Biomaterials
SAF	Sustainable Aviation Fuel
UCO	Used Cooking Oil

Objectives

1. Introduce and highlight the importance of SAF
2. Acknowledge canola as a source for SAF
3. Recognise global trends in SAF
4. Highlight Australia’s role in the sustainable aviation space
5. Identify challenges and recommendations

1. Introduction

1.1 Overview of sustainable aviation

The aviation sector is responsible for around 2.5% of all greenhouse gas (GHG) emissions and 3% of the oil products consumed in the world (International Energy Agency, 2023). Still, the average energy intensity of aircraft operations, which is exclusively supplied by fossil resources, is threefold higher than buses and rails, and similar to passenger cars, which have already consolidated initiatives for biofuel use. Ambitious goals for the aviation sector were set for future years (International Energy Agency, 2023). These include improving Carbon Dioxide (CO_2) efficiency, achieving carbon-neutral growth from 2020, and reducing carbon emissions by 50% in 2050 compared with 2005 levels (International Energy Agency, 2023).

One of the most promising solutions for cutting GHG emissions in aviation is Sustainable Aviation Fuel (SAF). SAF is a type of renewable fuel specifically designed for use in aircraft. SAF is certified jet fuel (Jet-A/A1). However, unlike traditional jet fuel fully derived from fossil resources, today's SAF is a blend of conventional fossil fuel and synthetic components made from a range of renewable "feedstock" such as used cooking oils, fats, plant oils, municipal, agricultural and forestry waste (Airbus, 2024). These fuels are designed to significantly reduce GHG emissions by 66% to 94% compared to conventional jet fuel, depending on the production method and feedstock used (Airbus, 2024).

For a fuel to be classified as SAF three strict characteristics must be abided by:

1. **Sustainable:** is defined as something that can be continually and repeatedly resourced in a manner consistent with economic, social and environmental aims, and conserves an ecological balance by avoiding depletion of natural resources. In the context of SAF it must cut GHG emissions by at least 50% (Air Travel Action Group, 2023).
2. **Alternative feedstock to crude oil:** an alternative to traditional energy sources for aviation, in this case non-conventional or advanced fuels, and includes any materials or substances that can be used as fuels, other than conventional, fossil sources (such as oil, coal, and natural gas). It is also processed to create jet fuel in an alternative manner (Air Travel Action Group, 2023).
3. **Fuel:** refers to drop-in fuel that meets the technical requirements for use in commercial aircraft and can be used in existing technology and fuel systems, ensuring the most important aspect of aviation operations – safety – is maintained (Air Travel Action Group, 2023).

1.2 Importance of SAF

It is imperative for the aviation industry to decarbonise. As Graph 1 demonstrates, the CO_2 emissions in the aviation sector have been increasing at between 4 and 5% per year for the past three decades. Globally, the sector faces a significant emissions challenge, one that is mirrored within the Australian context. Agriculture potentially holds the key to mitigating this issue. Emissions from Australian aviation have risen markedly, from constituting 2% of national emissions in 2005 to 4.6% by 2019 (Kamal, 2022). With the continued surge in demand for air travel, projections indicate that emissions will escalate further unless the industry promptly intensifies its decarbonisation efforts. Projections suggest that the demand for jet fuel in Australia could soar by an additional 75% by 2050 (CSIRO, 2023).

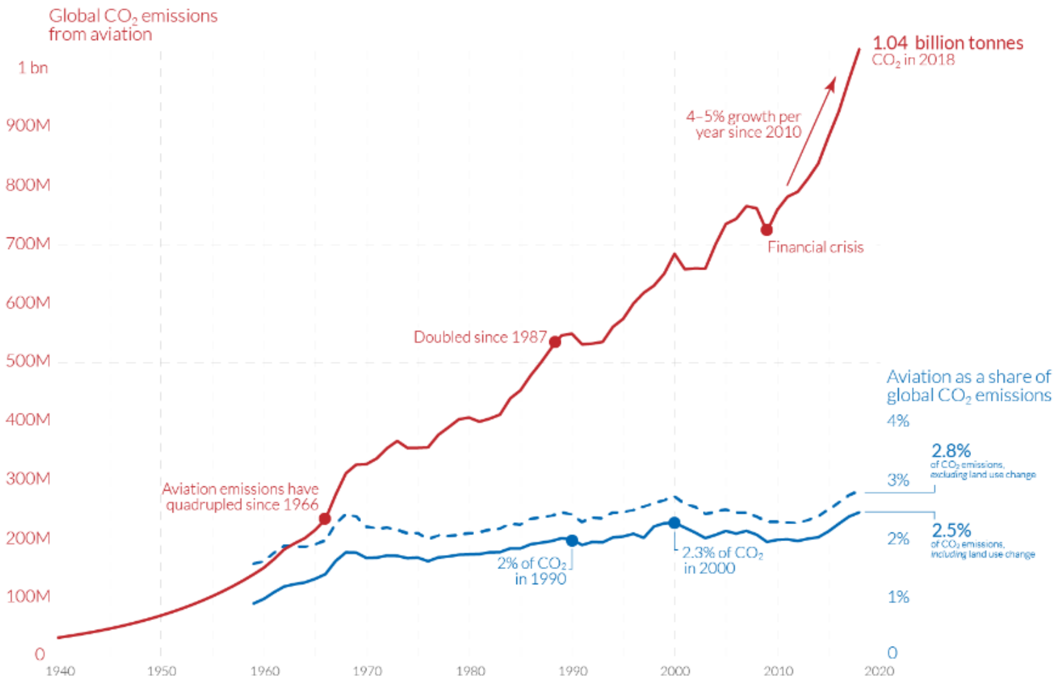


Figure 3. Global carbon dioxide emission from aviation, (Ritchie, H. 2024).

The decarbonisation of the aviation sector necessitates a fundamental shift in the energy sources used in aircraft. As noted by digital services company ICF International (2023), "sustainable aviation fuels will be the backbone of aviation decarbonisation." While the current volume of SAFs in Australia is modest, these fuels are projected to account for approximately two-thirds of the decarbonisation needed to achieve net zero emissions in aviation by 2050 (Kamal, 2022). SAFs represent a mature technology already being utilised commercially across various global regions, and their production processes have demonstrated efficiency. The infrastructural modifications required – affecting both aircraft and fuel logistics – are minimal, making SAFs an imminently viable solution.

Projections indicate a 75% increase in jet fuel demand by 2050, with increased population growth leading to an increased number of flights annually. As a result, it is necessary this fuel comes from sustainable sources in place of fossil derived jet fuels. It is forecast that with the development of a SAF industry in Australia, domestic production can immediately meet up to 60% this of demand using feedstocks like Used Cooking Oil (UCO), Tallow, Canola oil and agricultural residues. New technologies in the future may take this to 90% of demand.

As the only immediately available alternative to traditional jet fuel, SAF is the preferred choice to rapidly decarbonise the aviation industry. Other alternatives such as batteries and hydrogen present more complex challenges and longer timelines. Battery-powered aircraft are not yet commercially available, and even with advances in battery energy density, they are expected to be suitable only for commuter and short regional flights, which constitute a mere 3% to 4% of the aviation industry's total emissions (Avogadro & Redondi, 2024). Similarly, the advent of hydrogen-powered aircraft is hampered by technological refinements required, and the inability to retrofit existing fleets; instead, entirely new aircraft would be needed. In addition, airports and fuel logistics systems would have to undergo significant adaptations, a transformation that could span well over a decade.

Global production of SAFs remains modest, even though it doubled in 2023 to 0.5 million tonnes (equating to 0.6 billion litres). When juxtaposed with current global production figures for ethanol (exceeding 100 million tonnes) and biodiesel/renewable diesel (over 55 million tonnes) used in road transport, SAF production volumes are relatively small, constituting about 0.3% of all renewable fuels produced globally (International Aviation Transport Authority, 2023). Nevertheless, the growth trajectory for SAFs is promising. Projections for 2024 suggest a tripling of production to 1.5 million tonnes (or 1.9 billion litres), which would enable SAFs to make up 0.5% of global aviation fuel consumption (International Aviation Transport Authority, 2023). As evident in Graph 2 below, the world requirements of SAF required to reach net zero by 2050 are staggering and will continue to rise. As a result, the forthcoming decade will see a higher demand from agricultural products such as oilseeds, sugar, and grains as these are poised to emerge as critical feedstocks for SAF production. This will bridge the gap between agriculture and renewable energy, as well as offering substantial benefits to farmers in the process.

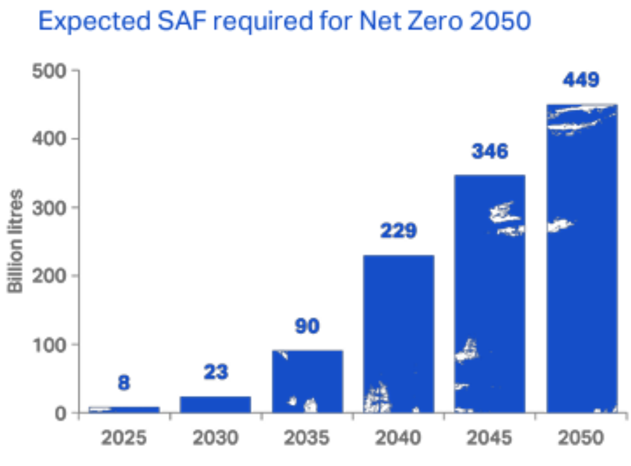


Figure 4. Expected SAF required for Net Zero 2050, (Kamel, D, 2022).

1.3 Potential feedstocks for SAF

SAF has emerged as a promising pathway to reduce GHG emissions within the aviation sector. As can be seen in Table 1 below, the production of SAF involves various feedstocks and conversion processes, each offering distinct benefits and limitations. The effective integration of SAF into the aviation fuel supply chain requires adherence to strict certification standards and a deep understanding of the sustainability implications of each feedstock. Table 1 aims to clarify the current production landscape for SAF, explain the different generations of feedstocks, and outline the processes used to convert these feedstocks into SAF

Table 2. Sustainable Aviation Fuel Roadmap, (CSIRO, 2023).

			MAIN FUEL PATHWAYS		
	FEEDSTOCK	CURRENT NON-SAF USES	HEFA	FT	ATJ
Carbohydrates	Sugar	Food, ethanol			●
	Bagasse	Onsite heat and steam		●	●
	Sorghum	Food and animal feed			●
Wastes	Tallow	Biofuels, soap, candles	●		
	Used cooking oil	Biofuels	●		
	Municipal solid waste (MSW)	Landfill, bioenergy		●	●
Residues and coppicing	Agricultural residues	Left on the field for soil health, animal feed		●	●
	Sawmill residues	Woodchips, onsite energy		●	●
	Oil mallees	No commercial use		●	
Oilseeds	Canola	Cooking oil, biofuels, animal feed	●		
	Cottonseed	Cooking oil, biofuels, animal feed	●		
	Other oilseeds	Cooking oil, biofuels, animal feed	●		
Power to liquids	Hydrogen (H_2)	Chemical and industrial processes		●	●
	Carbon dioxide (CO_2)	Vented to atmosphere, food and beverage		●	●

HEFA – Synthesised paraffinic kerosene from hydroprocessed esters and fatty acids
FT – Fischer-Tropsch hydroprocessed synthesised paraffinic kerosene
ATJ – Alcohol-to-jet synthetic paraffinic kerosene

There are three primary generations of feedstocks used in SAF production. The first generation includes plants that also serve as food or animal feed, such as corn, grain, sugar beet, rapeseed / canola, palm, and soy oil (Hutchinson, 2022). These feedstocks are primarily converted into SAF through the Hydroprocessed Esters and Fatty Acids (HEFA) process. HEFA is currently the most widely used method for producing SAF. The process involves refining vegetable oils, animal fats (tallow), or used cooking oil into a mixture of hydrocarbons that can be easily blended with traditional jet fuel (Delnegro, 2023).

One of the primary advantages of the HEFA process is its maturity and commercial-scale availability. However, this process also demands large amounts hydrogen and consumes significant energy, while predominantly using waste feedstocks that are in limited supply. It is necessary that renewable hydrogen be used to further reduce GHG emissions.

First generation biofuels can offer GHG reductions of up to 50% on conventional jet fuels and they do compete with food crops for agricultural land. As such, the European Union (EU) has committed to start phasing out first-generation biofuels in 2030, with limited evidence that second generation fuels will be available at scale, and the current *ReFuelEU Aviation* plan excludes crop-based SAFs due to sustainability concerns (imove, 2024).

Second generation feedstocks comprise of plants or parts of plants that are not edible, along with residual materials such as food waste. These feedstocks do not compete with food production, which helps to defuse ethical concerns related to food shortages. SAF can be produced from these second-generation feedstocks using various processes as indicated in Table 2 below. The Fischer-Tropsch (FT) process is a well-established method that converts biomass or waste materials into gas, which is then converted into liquid hydrocarbons through a series of chemical reactions. Although the FT process can utilise various feedstocks and produces high-quality fuel suitable for aviation, it is complex, expensive, and more energy intensive than first generation fuels. Another process, Alcohol to Jet (ATJ), involves converting bio-based alcohols, such as ethanol or butanol, into jet fuel through a series of chemical reactions (Delnegro, 2023). While ATJ processes can use a range of feedstocks and produce quality fuel, this method requires further development before it becomes commercially viable and has only been completed on a laboratory scale.

Table 3. SAF Production Pathways, (Rhodium Group, 2024).

	Technology status	Feedstocks	Approved max blending limit (%)	GHG reduction potential (%)	Producers
Gas-FT	Commercial pilot	Cellulosic biomass, municipal solid waste	50%	85%-94%	Fulcrum, Velocys
HEFA	Mature	Oil crops, used cooking oils	50%	73%-84%	Neste Oil, ENI, World Energy, SkyNRG
AtJ	Commercial pilot	Corn, sugarcane, cellulosic biomass	50%	85%-94%	Gevo, Red Rock, LanzaJet
PtL	In development	CO_2, H_2	50%	Up to 99%	Sunfire, Caphenia

The third generation feedstocks include biological residues such as straw, residual wood, sawdust, and algae. Algae-based biofuel is a promising feedstock due to its high oil content, which can be extracted and processed into renewable fuel for aircraft (Hutchinson, 2022). One of the most significant advantages of using algae is that it does not compete for land or water resources needed for food crops however cultivation at scale remains a problem. As the feedstocks are so varied, various conversion methods are in use or development to process these third generation feedstocks into SAF. On the right-hand side of Table 2, under producers, it is evident that significant investment is going into these technologies, with multinational companies like Neste and Fulcrum either producing at scale or with sizable research plants being developed.

Knowing the origins of SAF is crucial for accurate regulatory and voluntary reporting, particularly under frameworks such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Different feedstocks have diverse impacts on sustainability, including potential issues like deforestation, biodiversity loss, and water pollution (Hutchinson, 2022). Therefore, tracing SAF back to its source is essential to prove its sustainability, especially when the fuel is used as part of a carbon offsetting strategy. Certification organisations like Roundtable for Sustainable Biomaterials (RSB) and International Sustainability and Carbon Certification (ISCC) ensure that SAF complies with sustainability criteria, making the fuel eligible for CORSIA.

1.4 Benefits of utilising vegetable and UCO for SAF

1.4.1 Reduced emissions

For the basis of this report, it is acknowledged that the current baseline life cycle emission value for traditional jet fuel is equal to 89 $gC0_2e/MJ$ (International Civil Aviation Organisation, 2022).

Carbon emission reductions differ across feedstocks (or SAF raw materials) and production pathways, with most achieving a reduction of between 60–100% compared to Conventional Jet Fuel (CJF) (International Civil Aviation Organisation, 2022). Table 3 demonstrates the potential HEFA SAF feedstocks currently approved under the CORSIA model, their pathway specifications to SAF and their associated emissions values calculated as $gC0_2e/MJ$. This emissions value is twofold:

- **Core Life Cycle Assessment (LCA) emissions**, which include the emissions associated with feedstock cultivation, feedstock harvesting, collection and recovery, feedstock processing and extraction, feedstock transportation to processing and fuel production facilities, feedstock to fuel conversion processes, fuel transportation and distribution, and fuel combustion in an aircraft engine (International Civil Aviation Organisation, 2023).
- **Induced Land-Use Change (ILUC) emissions**, which could occur where the new CORSIA Eligible Fuel production is taking place (direct land use change) but also in other locations due to the displacement of crops or animals for which the land was previously used (indirect land use change). ILUC emissions assessment accounts for these different effects, by evaluating GHG released from conversion of natural vegetation (forest, other natural land), soil organic carbon, oxidation of peatlands, and sequestered biomass (International Civil Aviation Organisation, 2023).

Table 4. CORSIA – Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Conversion Process, (International Civil Aviation Organisation, 2022).

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LS_f (gCO_2e/MJ)
Global	Tallow		22.5	0.0	22.5
Global	Used cooking oil		13.9		13.9
Global	Palm fatty acid distillate		20.7		20.7
Global	Corn oil	Oil from dry mill ethanol plant	17.2		17.2
USA	Soybean oil		40.4	24.5	64.9
Brazil	Soybean oil		40.4	27.0	67.4
Global	Soybean oil		40.4	25.8	66.2
EU	Rapeseed oil		47.4	24.1	71.5
Global	Rapeseed oil		47.4	26.0	73.4
Malaysia & Indonesia	Palm oil	At the oil extraction step, at least 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	37.4	39.1	76.5
Malaysia & Indonesia	Palm oil	At the oil extraction step, less than 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	60.0	39.1	99.1
Brazil	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-20.4	14.0
USA	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-21.4	13.0
Global	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-12.7	21.7
Global	Camelina oil	Feedstock is grown as a secondary crop that avoids other crops displacement	42.0	-13.4	28.6
India	Jatropha oil	Meal used as fertilizer or electricity input	46.9	-24.8	22.1
India	Jatropha oil	Meal used as animal feed after detoxification	46.8	-48.1	-1.3

The above table highlights:

- UCO, tallow, palm fatty acid distillate and corn oil are considered waste byproducts and therefore only the processing factor applies to these feedstocks, making them highly attractive as a feedstock.
- The three largest edible oils in terms of supply: Canola (rapeseed), Soybean and Palm oil share a very similar emissions value.
- Non-edible oils: Carinata, Camelina and Jatropha provide a positive contribution to ILUC as they can be grown on marginal country and act as a rehabilitation crop and therefore have a lower emissions value than edible oils.

When assessing the data represented in the Table 3, it can be assumed that the best way for the aviation industry to reduce its GHG emissions would be to use non-edible oils only in the production of SAF. This would reduce their emissions by potentially 90-100%. These oils however are not grown at scale and supply is next to non-existent. Therefore, for the aviation industry to decarbonise immediately we move our attention to the waste oils of tallow, UCO, Palm Fatty Acid Distillate (PFAD) and corn oil. These should and are used as the primary feedstock for SAF. They represent a reduction in GHG emissions over traditional jet fuel from

75-85%. The issue with these oils is scalability. All these oils are in drastically short supply because of the recent upsurge in biofuel production. This has been evident in the value of tallow in Australia during 2023, where it peaked at $2,500 per tonne, well above the 10-year average of $900 making producers look to the next best alternative, edible vegetable oils. These oils represent a GHG saving of between 45-55% over conventional jet fuel and have three strong advantages: scale, logistics and ease of processing.

2. Canola as a source for SAF

On a global scale, canola holds immense potential for contributing to the SAF market. Canola, with its high oil content, efficient conversion processes and composition as a drop-in fuel is poised to be a key feedstock for HEFA SAF. With significant production capacities in regions such as Canada, the European Union (EU) and Australia, the global canola supply chain is well-positioned to meet the expanding needs of the SAF industry.

The technological readiness and commercial viability of canola-based SAF make it a strategic choice for scaling up production quickly and effectively. As the SAF industry continues to grow, driven by international policy directives and airline commitments to reduce carbon emissions, the role of canola as a feedstock will become increasingly prominent. This growth is expected to create a beneficial structural increase in demand for canola, providing an economic boost to agricultural sectors worldwide.

Moreover, global agricultural infrastructure is already equipped to handle the increased production and processing of canola for biofuels. This further facilitates its possible adoption as a key SAF feedstock. As the global market for SAF expands, integrating canola into the supply chain would assist in stabilising supply dynamics and ensure a consistent, renewable source of fuel.

2.1 Characteristics and composition of canola

Canola (*Brassica napus*), a member of the Brassicaceae family, is renowned for its attractive yellow flowers and its significant agricultural and economic importance. This oilseed crop is characterised by its robust growth and adaptability to various climate conditions. Canola often yields impressive harvests that typically range between two to four tonnes per hectare, depending on regional practices and environmental factors. Canola seeds are valued for their oil content, which can constitute between 40-49% of the seed's weight.

The oil extracted from canola seeds is distinguished by its favourable composition, being low in saturated fats (approximately 7%) and rich in monounsaturated fats (about 63%), particularly oleic acid (Loganes, Ballali & Minto, 2016). It also contains linoleic acid (omega-6) at around 21% and alpha-linolenic acid (omega-3) at approximately 9% (Loganes, Ballali & Minto, 2016). These properties not only make canola oil a healthy choice for culinary uses but also render it highly suitable for conversion into biofuels. It is low in sulphur and has a high oxidative stability which enhances its performance and longevity as a biofuel, reducing engine wear and emissions.

In the context of GHG emissions, canola cultivation is relatively efficient. However, due to the high nitrogen use during cultivation, canola oil has a slightly higher (47.5gCO_2e/MJ) GHG value than soy (40.4gCO_2e/MJ) and palm oil (37.4gCO_2e/MJ) (International Civil Aviation Organisation, 2022). It is important to note that soybeans have an average oil content of 19% versus canola at up to 49%. As CO_2 emissions are attributed to both oil and meal, soybeans attribute 81% of their GHG emissions to meal, whereas canola is 51%. This dramatically reduces the GHG emissions for soybean, however a larger quantity of soybeans is required to produce the same proportion of oil.

2.1.1. Compatibility with current engines

Another reason canola is gaining recognition as a promising source for SAF is due to its remarkable compatibility with existing refining infrastructure and its seamless integration into current jet engines. Utilising the HEFA process, canola oil can be effectively converted into high-quality jet fuel using the same facilities already employed for conventional (gasoline) and biofuel production. Moreover, as a drop-in fuel, canola-based SAF can be used in existing aircraft without requiring any modifications. Given the immediate push for decarbonisation in aviation this ease of adoption is particularly attractive. The aviation industry can leverage existing partners like Neste, Bp and LanzaJet who have existing infrastructure in place capable of processing vegetable oils into SAF. By embracing the HEFA process and vegetable oils as a source for SAF, the industry can take significant steps toward sustainability without the need for extensive overhauls or interruptions.

2.2 Lifecycle of canola as a biofuel

2.2.1 Cultivation and harvesting

Canola is a widely grown and valuable oilseed crop, with a high oil content making it an essential feedstock for SAF. The cultivation process involves several critical inputs and practices, including soil preparation, seed selection, fertilisation, pest and weed management, and the use of fuel and energy. Canola thrives in well-drained soils with a neutral pH, and soil preparation often includes conventional or reduced tillage to optimise seedbed conditions. High-quality, locally adapted seeds are sown to ensure resilience against pests and diseases. Synthetic nitrogen fertilisers are heavily used, with application rates significantly influencing yield and GHG emissions. Phosphate, potassium, and sulphur fertilisers are also applied to promote plant health. Herbicides, fungicides, and pesticides are used to manage weeds and pests, ensuring healthy crop growth. Diesel fuel is essential for operating farm machinery, and electricity is used for irrigation and other operations. The most significant source of GHG emissions in canola cultivation is from synthetic nitrogen fertiliser application, contributing substantially to the life cycle GHG emissions of canola-derived SAF. Efficient management of these inputs is crucial for optimising yields and reducing environmental impacts.

2.2.2 Oil extraction

A critical step in the production of SAF is removing the oil from the canola seed. To extract oil, two primary methods are used: mechanical extraction and solvent extraction. Each method has distinct processes, advantages, and disadvantages all of which impact the yield, cost, and quality of the extracted oil, as well as the environmental and social implications.

Mechanical extraction process

Mechanical extraction, also known as expeller pressing, involves physically pressing the canola seeds to extract the oil. The pressing process results in two primary outputs: crude oil and a residual solid known as press cake. Generally, mechanical extraction yields about 80-85% of the total oil content from the seeds. While this yield is lower compared to solvent extraction, the process has several notable advantages. One of the key benefits is the simplicity of the mechanical extraction process, which involves less complex machinery and is easier to operate. Additionally, mechanical extraction does not involve the use of chemical solvents, which makes the oil more natural and retains a higher level of nutrients, appealing to culinary and health-conscious markets.

The press cake, a by-product of mechanical extraction, is high in protein and often utilised as animal feed, providing an additional revenue stream for producers aiding in the fuel versus food debate. However, due to its lower efficiency, higher input volumes of seeds are required to produce the same amount of oil. As the cultivation value is where the highest GHG contributions occur it is less sustainable than solvent extraction. Additionally, this lower efficiency results in higher operational costs, which can be a limiting factor for large-scale industrial production.

Solvent extraction process

Solvent extraction, in contrast, involves using chemical solvents, typically hexane through an extractor to dissolve and extract oil from the canola seeds. Solvent extraction is known for its high efficiency, achieving between 95-98% of the total oil content in the seeds. This higher yield makes solvent extraction a highly efficient method for large-scale operations. The process is also cost-effective on a per-tonne basis due to the higher yield and lower relative production costs. As a result, solvent extraction is well suited for industrial operations where maximising oil recovery is essential.

Despite its efficiency, solvent extraction has several drawbacks. The use of chemical solvents necessitates careful handling and adherence to safety regulations to prevent environmental contamination and ensure worker safety. The complexity of the solvent extraction process, including the need for solvent recovery and reuse systems, requires more sophisticated equipment and higher initial capital investment. Additionally, the residual meal from solvent extraction may be less desired for high-quality animal feed due to potential solvent residues, despite being a viable product for other industrial uses.

Regardless of the extraction method, the by-products of canola processing add substantial value beyond biofuel production. The meal left after oil extraction is a high-protein feed component for livestock, containing approximately 36-40% protein with a balanced amino acid profile, making it a valuable dietary element for ruminants, poultry, and swine. This protein-rich meal helps to improve the growth and health of animals, thereby supporting the agricultural feed industry. Additionally, on the oil refinement side, canola processing generates by-products such as glycerine, Free Fatty Acids (FFAs), and lecithin. Glycerine, a by-product during the biodiesel production process, has various industrial applications, including pharmaceuticals, cosmetics, and food industries as a sweetener or humectant. FFAs can be used in the manufacture of soaps, detergents, and oleochemicals. Lecithin, another valuable by-product, is widely used as an emulsifier in food products, pharmaceuticals, and animal feeds.

2.3 Refining and Conversion to Biofuel

SAF can be produced from various feedstocks and production pathways approved under the American Society for Testing Materials (ASTM). These pathways are outline below:

- **Hydroprocessed Esters and Fatty Acids (HEFA):** This pathway involves the conversion of vegetable oils or animal fats into SAF through hydro-processing. HEFA is currently the most scalable SAF production pathway (PACE, 2024).
- **Alcohol to Jet (ATJ):** This pathway involves the conversion of alcohols, such as ethanol or methanol, into SAF through dehydration and oligomerisation (PACE, 2024).
- **Fischer-Tropsch (FT):** This pathway involves the conversion of syngas, which is a mixture of carbon monoxide and hydrogen, into SAF through a series of chemical reactions (PACE, 2024).
- **Renewable Hydrogen:** This pathway involves the production of hydrogen from renewable sources, such as wind or solar power, and its subsequent use in the production of SAF (PACE, 2024).
- **Recycled Carbon Aviation Fuels:** This pathway involves the capture of carbon dioxide from industrial processes or direct air capture and its subsequent conversion into SAF (PACE, 2024).

HEFA refines vegetable oils, waste oils, or fats into SAF through a sophisticated hydrogenation process. As this is the most widely acceptable pathway for SAF production and the easiest to scale, this report will focus on this pathway.

The HEFA Process

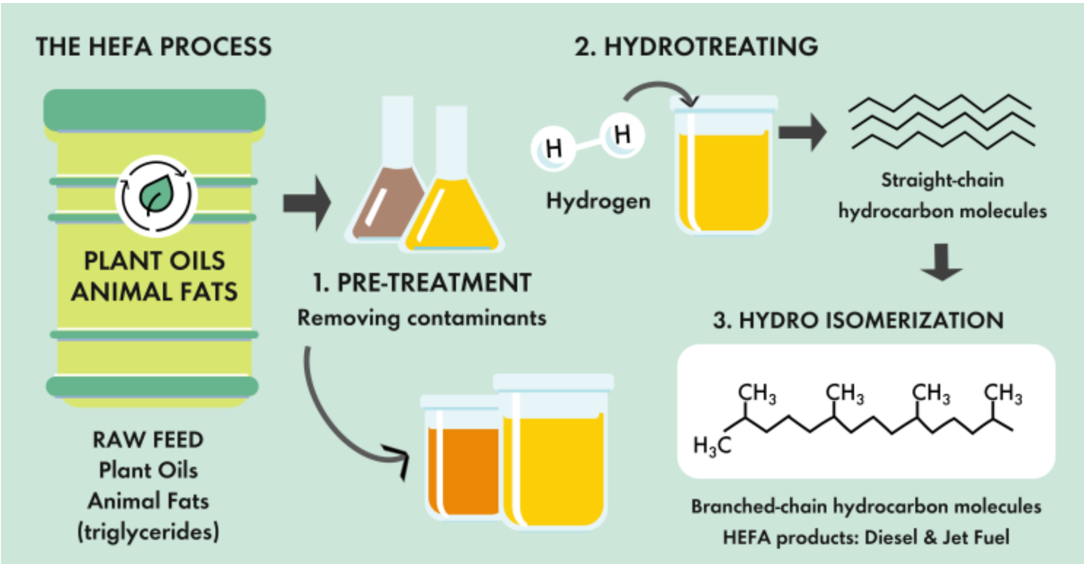


Figure 5. The HEFA Process, (Margerum, 2024).

As Image 1 above shows, this process begins with the crucial step of hydrodeoxygenation, where hydrogen is introduced to remove oxygen atoms from the fatty acids present in the feedstock oils. This step effectively converts triglycerides and free fatty acids into hydrocarbons by breaking down the oxygen bonds and releasing them as water. The resulting mixture primarily consists of long, straight-chain paraffinic hydrocarbons. Following hydrodeoxygenation, the hydrocarbons undergo cracking and isomerisation (Ratoushi, Moukaya & Nkazi, 2024).

Cracking is essential to break down the long hydrocarbon chains into shorter, branched chains that are more suitable for use as jet fuel. This process requires more severe conditions compared to those used for producing Hydrotreated Renewable Diesel (HRD), leading to greater breakdown of the molecular structure (Ratoushi, Moukaya & Nkazi, 2024).

Isomerisation, on the other hand, rearranges the molecular structure of the hydrocarbon chains to create branched isomers, which are crucial for achieving the right properties for aviation fuel, such as improved cold flow performance and thermal stability (Ratoushi, Moukaya & Nkazi, 2024).

The isomerised hydrocarbons are then distilled to isolate the jet fuel-range molecules, typically in the C_8-C_{16} carbon chain length, ensuring they meet the stringent specifications required for aviation fuels.

Yield of HEFA process

Figure 6. Used Cooking Oil, (Adobe Stock, 2023).

Figure 7. Refined Jet A Fuel, (Berti, 2023).

Table 4 below demonstrates the yield potential from 1000 kilograms of vegetable oil into SAF via the HEFA pathway and the inputs needed for the reaction to occur. In essence, it is taking the vegetable oil in Image 2 above and converting it into refined jet fuel as shown in Image 3. As evident from Table 4, the HEFA process has an average yield of 61% and will generate 610 kilograms of SAF from every 1000 kilograms of oil used. With a specific gravity of 0.8kg/L this equates to 762.5 litres of SAF.

Table 5. Sustainable Aviation Fuel Roadmap, (CSIRO, 2023).

Item	Unit	Input	Output
Pre-treated UCO	kg	1,000	
Hydrogen	kg	44	
Electricity	kWh	46.5	
Steam	MJ	4,445	
UCO-HEFA	kg		610.0
UCO-HVO	kg		135.7
Propane	kg		84.0
Naphta	kg		93.9

One critical benefit of HEFA SAF is its blend ratio. Currently, HEFA SAF can be blended with conventional jet fuel at a maximum ratio of 50% for commercial flights, however testing has been completing with blend ratios of 95%. The maximum blend ratio for any SAF pathway is 25%. This blend ensures that HEFA SAF can be used without requiring any modifications to existing aircraft engines or refuelling infrastructure, allowing for a seamless transition towards more sustainable aviation fuel solutions.

3 Global Trends in Sustainable Aviation Fuel

3.1 Overview of global SAF initiatives

Countries and airlines worldwide are investing in SAF to achieve their emission reduction goals. Notable initiatives, such as the European Union's *Renewable Energy Directive II* and the United States' *SAF Grand Challenge*, demonstrate a global commitment to enhancing SAF production and usage. Below is a summary of the larger SAF initiatives worldwide and an overview of their priorities.

CORSIA

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), established by the International Civil Aviation Organization (ICAO), is a pioneering initiative designed to control and reduce GHG emissions from international aviation. CORSIA aims to cap CO_2 emissions at 2020 levels, requiring airlines to offset any annual emissions that exceed this baseline. The scheme is structured in three phases;

- a voluntary pilot phase from 2021 to 2023,
- a first phase from 2024 to 2026 involving early adopter states,
- a second mandatory phase starting in 2027 that includes nearly all international flights (International Civil Aviation Organisation, 2022).

To comply with CORSIA, airlines must purchase emission reduction units, or offsets, representing verified carbon reductions from projects such as reforestation, renewable energy, and energy efficiency initiatives. For instance, an airline might offset excess emissions by purchasing carbon credits from a wind power project that displaces coal-fired electricity generation. Additionally, CORSIA promotes the use of SAF by recognising its lower lifecycle emissions. Airlines can reduce their offsetting obligations by integrating SAF into their fuel mix, with recognised criteria ensuring the environmental benefits of SAF use (International Civil Aviation Organisation, 2022).

CORSIA incorporates rigorous monitoring, reporting, and verification requirements to maintain transparency and accuracy in emissions tracking. Airlines must report their CO_2 emissions annually, and these reports undergo third-party verification to ensure compliance. Furthermore, CORSIA sets stringent eligibility criteria for acceptable emission units, ensuring that offsets come from high-quality projects with real, additional, and permanent carbon reductions (International Civil Aviation Organisation, 2022).

United States

In the US, the federal government has established a *SAF Grand Challenge* to reduce cost, enhance sustainability, expand production and use of SAF. The overarching goal of the effort is to scale SAF production to 3 billion gallons per year in 2030 and 35 billion in 2050 (O'Rear et al., 2021). This multi-agency initiative includes coordination on research and development investments, demonstrations, and SAF supply chain support. In addition, the federal Renewable Fuels Standard and California's Low Carbon Fuel Standard include provisions allowing jet fuel producers to opt-in to these lifecycle GHG reduction programs with compliance credits acting as a supplemental revenue stream to support production (O'Rear et al., 2021).

Oneworld

Oneworld brings together 14 world-class airlines – Alaska Airlines, American Airlines, British Airways, Cathay Pacific Airways, Finnair, Iberia, Japan Airlines, Malaysia Airlines, Qantas, Qatar Airways, Royal Air Maroc, Royal Jordanian, S7 Airlines and Sri Lankan Airlines, and more than 20 of their affiliates (Oneworld, 2021). The Oneworld alliance has set a collective target to use SAF for 10% of its combined fuel volumes by 2030, reinforcing its commitment to environmental sustainability and its pledge to achieve net carbon emissions by 2050. This ambitious goal, supported by the World Economic Forum Clean Skies for Tomorrow Coalition, emphasises the need for collaboration with policymakers and stakeholders to create the necessary regulatory and financial frameworks to facilitate the transition to SAF (Oneworld, 2021). Oneworld's member airlines are committed to deploying SAF at a commercial scale, ensuring it is affordable and certified by recognised authorities.

European Union – Refuel EU

The Refuel EU Aviation initiative is a regulation that is part of the EU's *Fit for 55* package. The initiative aims to reduce the EU's net GHG emissions by at least 55% by 2030, compared to 1990 levels, by increasing both demand for and supply of SAF (PACE, 2024). These regulatory measures now establish legally binding climate targets across all major sectors of the economy. Under the Refuel EU Aviation Regulation, aviation fuel suppliers are mandated to progressively blend increasing amounts of SAF with kerosene.

3.2 Leading countries in SAF production and usage

3.2.1 Leading countries in SAF production

As of 2023, the United States is at the forefront of SAF production, with a targeted capacity of approximately 11.36 billion litres annually by 2030, driven by initiatives like the *SAF Grand Challenge*. The European Union collectively follows with growing production capacities fuelled by the *Renewable Energy Directive II*. The United Kingdom is developing at least five commercial SAF plants to produce around 260,000 tonnes per year. Japan is also scaling up to meet its target of 10% SAF use in aviation by 2030.

3.2.2 Leading countries in SAF consumption

The United States leads globally in SAF consumption, with major airlines like United, Delta, and American Airlines integrating SAF into their operations, supported by national policies aiming for billions of gallons by 2030. The European Union is a close contender, with airlines like Lufthansa, KLM, and British Airways significantly increasing their SAF usage due to regulatory mandates and sustainability commitments.

4 Australia's role in the sustainable aviation space

4.1 Australia's agricultural capabilities

4.1.1 Canola production in Australia

Australia is a top global canola producer, making up on average 15-20% of the world's export trade or 4-5 million metric tonnes annually (Australian Export Grains Innovation Centre, 2023). Graph 3 below shows the export tonnage from 2006/2007 harvest through to 2023/2024 harvest. It is clear the export tonnages have risen in this time but that has kept pace with the world average. Between October 2022 and September 2023 6,540,444 million metric tonnes of canola seed was exported, an all-time high for the Australian canola sector. Domestic consumption has only risen marginally from 1 million tonnes to 1.3 million tonnes over the past 10 years.

Figure 8. Export Vs Domestic Use, (Voznesenski, 2024).

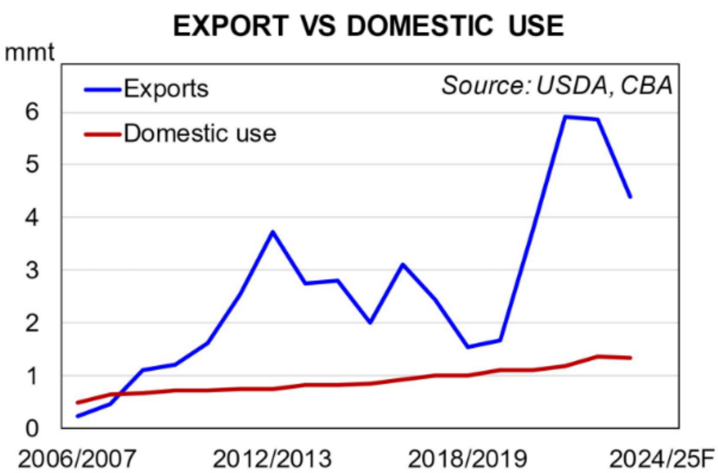
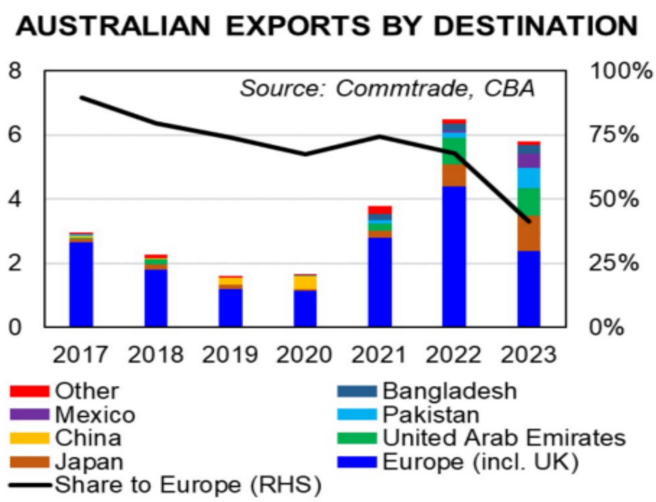


Figure 9. Australian Exports by Destination, (Voznesenski, 2024).



Primary export markets included the EU (50.7%), Japan (14.93%), UAE (13.95%) Mexico (4.78%) and Pakistan (9.47%) (Voznesenski, 2024) as shown in Graph 4. From Table 5 below the 2022/2023 canola harvest generated 7,934,00 million metric tonnes, indicating an export percentage of 82%, with a domestic consumption of only 1,393,556 million metric tonnes.

These results are significantly higher than the five-year average of 4,500,000 million metric tons (Voznesenski & Gordon, 2012). As indicated in Table 6 below, this increase is partly due to the increased area planted to canola, rising from 2,970,000 hectares in 2021/2022 to 3,841,000 in 2022/2023 and also increased from better farming practises and also favourable growing conditions.

Table 6 and 7. Canola Exports 2023 and 2024, (ABS, 2024)

Canola 2022/23

	2021/22 Final	
	Harvested Area (hectares)	Production (tonnes)
NSW	700,000	1,637,000
VIC	500,000	1,144,000
SA	230,000	418,000
WA	1,540,000	3,130,000
TOTAL	**2,970,000**	**6,329,000**

Canola 2023/24

	2022/23 Final	
	Harvested Area (hectares)	Production (tonnes)
NSW	887,000	1,652,000
VIC	630,000	1,369,000
SA	307,000	655,000
WA	2,017,000	4,258,000
TOTAL	**3,841,000**	**7,934,000**

4.1.2 Outlook for canola production over the next 10 years

Although areas planted to canola in 2024/2025 have decreased by 9% to 3.2 million hectares it is expected the current trends and projections of the potential for the Australian canola crop over the next 10 years look promising. Price dynamics, notably the relationship between canola and cereals, have been crucial in driving increased canola cultivation in Australia. With past instances of higher canola prices compared to wheat and barley leading to expanded planting areas, farmers have shown a strong sensitivity to price incentives. Despite certain limitations such as crop rotation requirements and reliance on specific rainfall zones, Australia is poised to sustainably increase its planted area to over four million hectares under favourable conditions over the next 10 years. Market influences, particularly the EU's initiatives like the palm oil phase-out and the Green Deal, are expected to further drive demand for Australian canola as a biofuel feedstock, potentially accelerating production growth if palm oil is phased out earlier than projected. Overall, the outlook for the Australian canola crop indicates steady growth over the next decade, supported by market demand, pricing dynamics, and strategies to optimise yield and production efficiency.

4.2 Government initiatives and policies

4.2.1 Renewable energy targets

The Australian Government's Powering Australia plan aims to create jobs, reduce pressure on energy bills, and lower emissions by boosting renewable energy. The Australian Government's emissions reduction targets are 43% by 2030 and net zero by 2050 (Department of Climate Change, Energy, the Environment and Water, 2024).

In creating a road map for this to occur the Australian Government has developed the *Future Made in Australia* program in the 2024-25 budget to guide the transition to net zero.

The *Future Made in Australia* agenda aims to harness these opportunities through significant private sector investment in priority industries. Targeted public investment will also be considered to align economic incentives with national interests, promoting private investment at scale. This agenda is structured around a National Interest Framework with two streams:

- The **Net Zero Transformation Stream** will include industries that will make a significant contribution to the net zero transition and are expected to have an enduring comparative advantage, and public investment is needed for the sector to make a significant contribution to emissions reduction at an efficient cost (The Treasury, 2024).
- The **Economic Resilience and Security Stream** will include industries where some level of domestic capability is necessary or efficient to deliver adequate economic resilience and security, and the private sector would not invest in this capability in the absence of public investment (The Treasury, 2024).

4.2.2 Industry support

Within Australia there are a number of key stakeholders promoting the use of canola as a feedstock for sustainable aviation fuel. Both the Australian Oilseeds Federation (AOF) and the Grains Research and Development Corporation (GRDC) have shown support for increased investment in the area. In supporting this vision, the AOF led by chair Rosemary Richards, is championing the growth and sustainability of the Australian canola industry. In a significant initiative called *Canola Vision 2035*, Richards outlined a comprehensive plan aimed at ensuring a sustainable future for the industry. She emphasised that this vision is about fostering a larger, more diversified, and resilient canola sector across a more profitable, connected, and adaptable value chain (Grains Research and Development Corporation, 2024). This will include the use of Australian canola as a feedstock for SAF.

"It's a call-out to industry, domestically and globally, to work together to enhance growth," Richards stated. The vision is based on six strategic pillars:

- **Market Diversification**: Expanding into new markets to ensure a stable demand for canola products.
- **Sustainability**: Promoting environmentally friendly practices throughout the industry.

- **Productivity and Performance**: Enhancing the efficiency and quality of canola production.
- **Value Chain**: Building robust connections from production to end-use, ensuring profitability and resilience.
- **Innovation**: Encouraging new technologies and methods to advance the industry.
- **Influence**: Strengthening the industry’s voice in both domestic and international arenas.

AOF chair, Rosemary Richards, together with GRDC managing director, Nigel Hart, are actively promoting this vision. By implementing *Canola Vision 2035*, Australia aims to secure a leading role in the sustainable aviation fuel market, thus significantly reducing the aviation industry’s carbon footprint and contributing to global sustainability goals.

4.3 Incentives for SAF production in Australia

Australia's Bioenergy Roadmap has highlighted aviation as a particularly challenging industry for emission reductions, presenting significant market opportunities for the country's bioenergy sector. In November 2021, the Federal Government allocated $30 million to the Australian Renewable Energy Agency (ARENA) to foster the development of an advanced biofuels sector (Australian Renewable Energy Agency, 2023).

The Objective of the SAF Funding Initiative is to fund Activities that contribute to one or more of the following Outcomes:

- Advance the technology readiness level (TRL) and commercial readiness index (CRI) of SAF technologies for at-scale deployment (Australian Renewable Energy Agency, 2023).
- Facilitate a pathway to the technical and commercial viability of producing SAF from renewable feedstocks in Australia (Australian Renewable Energy Agency, 2023).
- Build industry capacity in the production of SAF from renewable feedstocks in Australia (Australian Renewable Energy Agency, 2023).

The federal government has also pledged $18.5 million over four years starting from 2024-25 to establish a certification scheme for low-carbon liquid fuels, including SAF and renewable diesel, by expanding its guarantee of origin program to meet long-term industry demand (Budget 2024-25, 2024). An additional $1.5 million will be allocated over two years from 2024-25 to assess the regulatory impacts of introducing mandates for low-carbon liquid fuels, with provisions for consultations on potential production incentives for domestic developers.

Additionally, funding from the A$1.7 billion *Future Made in Australia* innovation fund will support liquid fuels research, managed by the Australian Renewable Energy Agency to commercialise net zero technologies (Budget 2024-25, 2024).

5 Challenges and solutions

5.1 Economic challenges and opportunities

As highlighted throughout this report there is significant short to medium term opportunities to the Australian canola industry by targeting export markets feeding biofuel and SAF pathways. Moving forward toward the governments mandated net zero by 2050, there is two potential paths Australia could take, each with their own set of risks and rewards. The two pathways are: Growing feedstock to support a worldwide SAF demand or elevating this further by developing a SAF industry in Australia with processing facilities located domestically. These are both further explored below.

Growing feedstock to support a worldwide SAF demand

Between 2024 and 2030 there is expected to be a large increase in demand for SAF feedstocks via the HEFA pathway. Australian canola is well placed to take advantage of this. European biodiesel production is forecast to stagnate up until 2030 due to constraints on available feedstocks opening the door for Australian canola producers. As seen in Graph 6 below, the EU has legislated the phase out of palm oil in biofuel by 2030. The EU have also legislated a number of constraints on EU growers i.e. decreased fungicide use and limited use of nitrogen fertilisers, meaning EU production yields will be on the decline. Similarly due to land use change requirements, this void will not be filled by soy oil and increased competition for waste oils will mean shorter supply of UCO, tallow and trap greases. This will allow more canola oil to make up the difference. Graph 5 indicates increased seed imports to satisfy crush demand. Demand for Canola oil in EU biodiesel will increase to 8.2 million tonnes, meaning a deficit of 7.5 million tonnes of seed from current levels.

Figure 10. EU Canola Import Set To Rise, (Voznesenski, 2024)

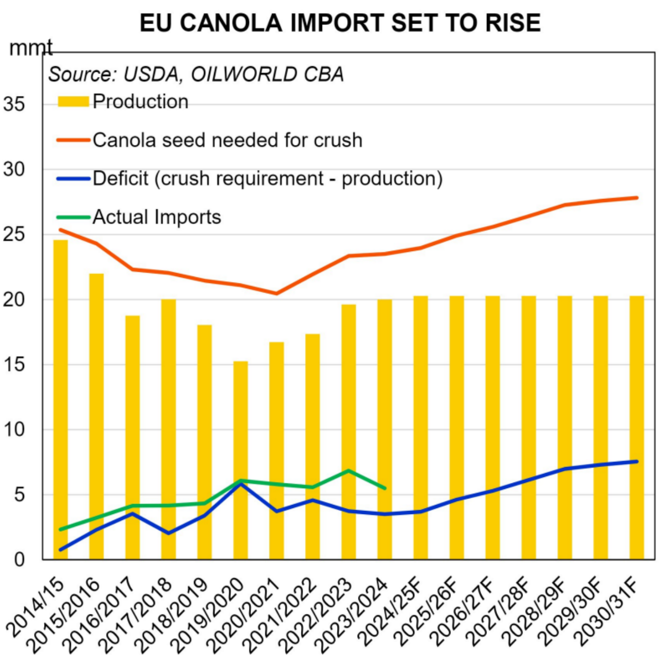
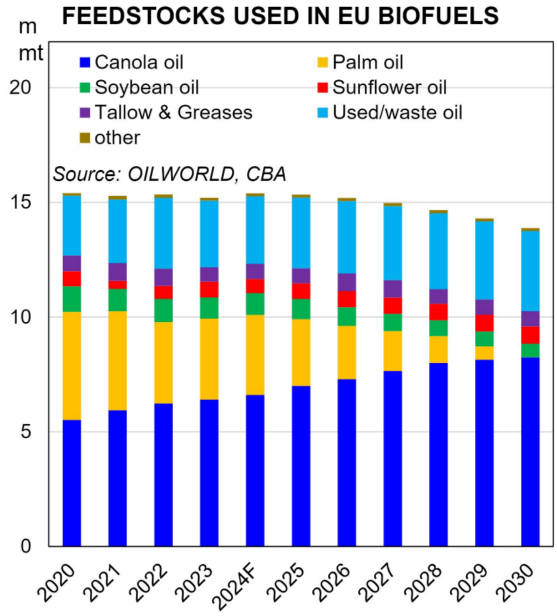
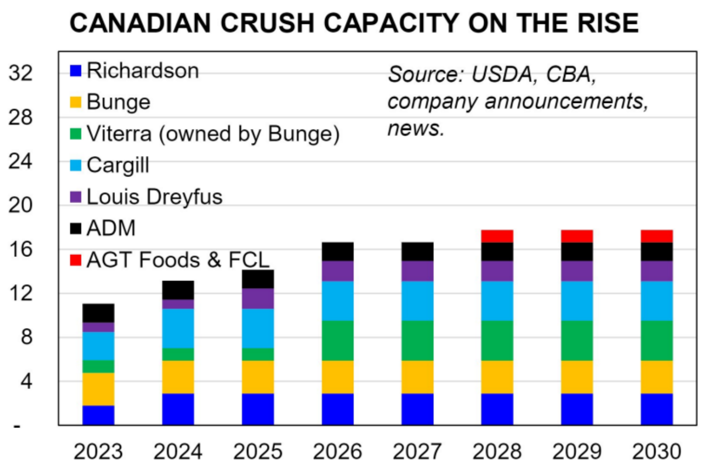


Figure 11. Feed Stocks Used in EU Biofuels, (Voznesenski, 2024).



This shortfall can be filled from 3 countries: Australia, Ukraine and Canada. Ukraine currently has an export capacity of 3-3.5 million tonnes which is expected to rise considerably when the war with Russia subsides and farmers adopt modern farming practices. In the short to medium term this is not expected to become reality. Canada has the potential to supply large quantities of canola on the world stage, exporting 10 million tonnes annually. However, Graph 7 below indicates large amounts of domestic crush capacity coming online in 2025 and beyond putting pressure on export capacities.

Figure 12. Canadian Cush Capacity on the Rise, (Voznesenski, 2024).

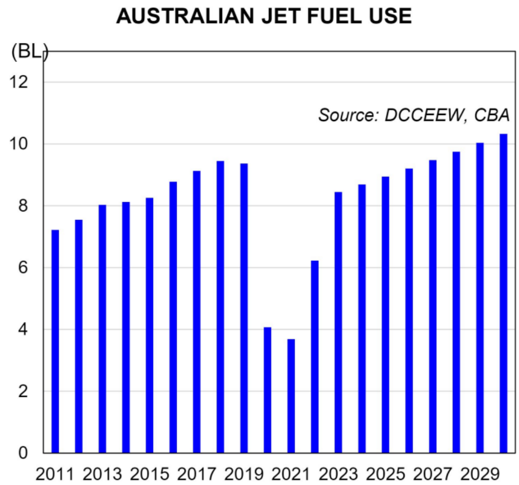


This coupled with increased demand from the US biofuels and SAF market, better logistics to the Americas and less demanding restraints than the EU indicate that excess Canadian canola will not be available for the EU market. This will be particularly evident during a drought year on the Canadian Prairies. As a result, Australia will be left in the prime position to capitalise on the increased seed demand in Europe, leading to elevated pricing domestically through to 2030.

Developing a SAF industry in Australia

Developing a SAF industry based on canola in Australia not only supports economic growth but also aims to bring forth a range of additional benefits. Currently Australia's crush capacity is predominantly located on the East Coast, with all but two of the domestic crush facilities located here. This is in contrast with the domestic production volumes where two-thirds of production is located on the West Coast. With a domestic consumption of 1.3 million tonnes and an export surplus of 4 million tonnes plus, there is currently significant interest in building SAF production facilities domestically to supply the required jet fuel used each year. As Graph 8 below demonstrates jet fuel consumption is set to increase at around 2.5% per year for the next six years.

Graph 13. Australian Jet Fuel Use. (Voznesenski, 2024).



With the government set to mandate 10% SAF blending requirements by 2030, this would require production of 1.3 billion litres or 1.04 million tonnes. As calculated in Section 2, HEFA production yields are 610 kilograms of Jet A fuel per 1000 kilograms of input, therefore 1.7 million tonnes of canola oil would be required. When extrapolated out to seed inputs, this would require an increase in domestic crush capacity of 3.8 million tonnes. This seed quantity would not be available on the East Coast of Australia indicating that Western Australian farmers would be best positioned to benefit from a domestic SAF plant. Crushing 3.8 million tonnes of seed also pushes 2.1 million tonnes of canola meal onto the Australian market which will provide an abundant protein source to the stockfeed market, decreasing supplementary feed costs for livestock.

However, it is not only the farmers who would benefit from a domestic SAF production facility. Currently one of Australia's biggest risks is fuel sovereignty. Utilising a just-in-time logistics strategy, Australia imports 91% of all fuels into the country, including jet fuel (Carter, Quicke, & Armistead, 2022.) As of writing this report, there are currently 20 days of diesel storage and 24 days of petrol storage located onshore – given the fickle nature of world politics during 2024 this represents a significant risk. By reducing the reliance on imported liquid fuels, the creation of a SAF industry in Australia enhances fuel sovereignty, bolsters energy security, and decreases vulnerability to global supply chain disruptions and price fluctuations. This not only contributes to climate resilience but also secures a stable fuel supply for critical sectors like defence, agriculture and mining. Moreover, the local production of SAF will create job opportunities across various sectors such as farming, processing, distribution, and research, reducing unemployment rates and providing diverse employment options. This is particularly important given the slowdown of Australia's critical mineral industry which is slowing at significant rates. With mining heavily centralised on the West Coast, this makes the development of a SAF plant an ideal investment for government to boost employment and redirect people from the mining industry.

An Australian SAF industry is expected to be worth $3 billion annually and could create up to 15,600 jobs nationwide by 2050 (The State of Queensland, 2024). The growth extends beyond farming to include services supporting the biofuel industry, driving further regional development and sustainability. Additionally, with a developed SAF industry, Australia can explore export opportunities in the global market for sustainable aviation fuels, establishing new revenue streams, strengthening trade relationships, and solidifying its position as a key player in the Asia Pacific Region.

Conclusion

In conclusion, Australia's strategic position in the global production of Sustainable Aviation Fuel (SAF) is significantly bolstered by its thriving canola industry. With its extensive canola production capabilities and efficient conversion processes, Australia stands at the forefront of utilising canola as a key feedstock for SAF production on a global scale. The country's commitment to renewable energy targets and emission reduction goals underscores its potential to become a leading producer and exporter of canola-based SAF, playing a pivotal role in addressing climate change challenges within the aviation sector.

Australia's strategic roadmap emphasises the importance of leveraging its high-quality canola production to drive SAF production growth. By scaling up canola-based SAF production, fostering innovation in feedstock processing, and adopting sustainable practices, Australia can not only meet domestic demand but also emerge as a significant player in the global SAF market. Through strategic collaborations, investments in research and development, and a focus on sustainable biofuel production, Australia has the opportunity to solidify its position as a sustainable aviation fuel leader, paving the way for economic growth, emissions reduction, and a more environmentally conscious aviation industry.

Call for Action and Future Outlook

Australia's call to action is to capitalise on its strong position in canola production to drive the growth of SAF industry. Australia’s future outlook hinges on strategic investments, collaborations, and sustainable practices to position itself as a key player in the global SAF market. By leveraging its agricultural capabilities and efficient conversion processes, Australia has the potential to become a leading producer of canola-based SAF, contributing significantly to global emission reduction efforts in the aviation sector.

Australia's outlook involves scaling up canola-based SAF production, fostering innovation, and adopting sustainable practices to meet the escalating demand for eco-friendly aviation fuel. Through partnerships, investments in research and development, and a commitment to sustainability, Australia aims to create a more environmentally conscious aviation industry while unlocking economic opportunities and driving technological advancements in SAF production. By aligning its efforts with global sustainability goals and leveraging its expertise in canola production, Australia is poised to shape a greener future for aviation and establish itself as a prominent player in the sustainable biofuel sector.

Recommendations

Throughout this report a common thread has emerged: production of SAF through the HEFA pathway is the most cost-effective, mature and immediately scalable technology available to decarbonise the aviation industry. It is a drop-in fuel which can be produced in existing oil refineries with minimal modifications. If airlines and governments worldwide want to reach their emissions goals by 2030 and 2050 deadlines HEFA fuels will be crucial. It is clear from this report that the ideal feedstock to produce first generation SAF would be tallow, UCO and corn oil, however these are in drastically short supply and are not immediately scalable.

Herein lies the potential for Australian canola producers. As discussed, through selective breeding leading to increased yields and expanded areas planted, Australia has the potential to increase its average canola production by a further 20% to 10,000,000 metric tonnes over the next decade. On average 20% of this is currently consumed domestically for edible oils, we can assume that 8 million tonnes could be available to produce SAF via the HEFA pathway. As a direct result Australia has the potential to crush an additional 6.4 million tons of canola seed domestically, producing 2.88 million tons of canola oil. This can be further refined into SAF 1.756 million tonnes, 241,000 tonnes of propane and 270,000 tonnes of naphtha. Currently the bulk of canola is exported to Europe where 90% of the oilseed landed is used to produce biofuel. Therefore, it is suggested Australia develop SAF production facilities to incorporate the available feedstock, increase employment opportunities, secure fuel sovereignty and derive export income that would flow as a result.

The following recommendations are by no means exhaustive of the total tasks required to establish Australia as an SAF powerhouse but are intended to be a starting point.

Recommendation 1: Develop policy to support domestic distribution and use of certified SAF with a clear long-term support strategy for the industry.

- Develop and communicate a long-term Australian SAF strategy through the Jet Zero Council, considering state, territory, and international policies.
- Examine subsidy and tax credit options to incentivise SAF production.
- Align certification methodologies with global standards for the sustainability verification of SAF production.

Recommendation 2: Signal local demand for SAF across government, commercial, and defence users to provide investor certainty for new plants.

- Aggregate demand from multiple stakeholders, including government, commercial, and defence sectors, to create sufficient offtake agreements, leveraging economies of scale.
- Establish a national program to enable consumers to voluntarily purchase SAF for flights.

Recommendation 3: Invest in research and development to support emerging technologies and improve feedstock availability and sustainability understanding.

- Enhance data granularity for feedstock sources by updating the Australian Biomass for Bioenergy Assessment.
- Expand projects developing alternative oilseeds.
- Consider establishing a centralised advisory body for feedstock production or incorporating it into existing organisations like the GRDC.
- Provide funding through ARENA for developing technologies and near-commercial projects.
- Conduct life cycle assessments for Australian-specific feedstocks and proposed supply chains.

The role of government also cannot be understated in Australia's efforts to become a world leader in SAF production. The government must take definitive actions to enable the SAF sector to reach its potential. This involves delivering renewable energy infrastructure, supporting targeted innovation, partnering with the private sector on impactful infrastructure projects, and ensuring that regulatory frameworks and international trade settings foster well-functioning markets. Creating demand for low-emission products through standards, certifications, and competitive market practices over time will establish efficient price signals for green products.

In the short to medium term, government support may be necessary to align private price signals with broader public values, helping the industry overcome initial capital cost barriers. This could include direct production subsidies or contributions to the capital investments required for transitioning to green production processes. By strategically addressing these regulatory, market, and financial barriers, the Australian government can advance the SAF production sector, contributing significantly to the country's net zero goals and enhancing global competitiveness.

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