From Paddock to Plane: Feedstock White Paper

Unlocking Australia’s domestic sustainable aviation fuel feedstock potential

GrainCorp

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Note: all currency in Australian Dollars, unless otherwise specified

Context

The Australian Jet Zero Council requested GrainCorp prepare a paper covering the barriers and opportunities in developing a feedstock supply chain capable of supporting domestic sustainable aviation fuel (SAF) production.

This document presents a summary of the analysis developed by GrainCorp using publicly available information, to inform the white paper, covering:

- Low Carbon Liquid Fuel (LCLF) technologies
- SAF feedstocks
- SAF demand outlook
- Australia's feedstock supply potential
- Barriers to feedstock uptake
- SAF abatement economics
- SAF feedstock evaluation framework
- Recommendations
- Case studies
- SAF feedstock deep dives

Sections

1. Low Carbon Liquid Fuel (LCLF) technologies
2. SAF feedstocks
3. SAF demand outlook
4. Australia’s feedstock supply potential
5. Barriers to feedstock uptake
6. SAF abatement economics
7. SAF feedstock evaluation framework
8. Recommendations
9. Case studies
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1

Low Carbon Liquid Fuel (LCLF) technologies

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Feedstocks must be understood in the context of refining technologies

Context

A feedstock's theoretical availability or farm-gate cost can be misleading if poorly aligned with the chosen technology

Refineries set the technical and economic conditions which feedstock supply must meet

Conversion pathways impose specific requirements on quality, consistency, moisture, contamination, and chemical composition. This drives pre-treatment needs, logistics complexity, and delivered feedstock cost

Choice of refinery technology and specific conditions determines achievable yields, co-product profiles, capital intensity, and operating risk - factors that materially affect the value a refinery can afford to pay for feedstock

Scaling feedstock availability must happen in lockstep with refinery technology choices, ensuring supply characteristics, infrastructure, and economics are compatible with the conversion pathway rather than assumed to adapt later.

Refining technologies assessed in this paper

HEFA
Hydro-processed Esters and Fatty Acids

Process fats and oils into jet fuel using a method similar to traditional oil refining. It's proven commercially, reliable, and already in use globally.

CH
Catalytic Hydrothermolysis

Mimics natural oil formation by using heat and pressure to turn algae, wet waste, or oilseeds into crude oil, which is then refined into jet fuel.

AtJ
Alcohol-to-Jet

Starts with alcohols like ethanol (from sugarcane or wheat starch) and refines them into jet fuel. It links well with existing ethanol refining capability in Australia, and with the sugar and wheat sector.

HDCJ
Hydrotreated Depolymerized Cellulosic Jet

Utilises lignocellulosic biomass and converts it into bio-crude oil, which can be further refined into jet fuel. HDCJ is high in aromatic compounds, and the technology is still in testing.

FT
Fischer-Tropsch Synthetic Paraffinic Kerosene

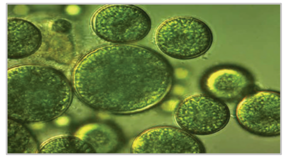
Turns waste like crop leftovers, wood, or rubbish into gas, then converts that gas into jet fuel. It turns waste into a valuable product, but the technology is still being developed for large scale use.

PtL
Power-to-Liquids

Uses renewable electricity to split water into hydrogen and combines it with captured CO2 to make jet fuel. Fully renewable, but expensive and not yet widely used.

Source: 'Sustainable Aviation Fuel Roadmap' CSIRO / Boeing (2023); 'Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential' CEFC / Deloitte (2025)

Each refinery technology is at a different level of maturity and has different feedstock requirements

Category	HEFA	AtJ	FT	CH	HDCJ	PtL
Technical Description	Hydrotreating of fats/oils to produce paraffinic hydrocarbons	Dehydration of ethanol to olefins, oligomerisation, hydrogenation	Gasification of biomass/MSW to syngas, converted via FT synthesis	Hydrothermal liquefaction of lipids/biomass to bio-crude, then hydroprocessed	Pyrolysis or hydrothermal liquefaction (HTL) of lignocellulosic biomass to bio-oil, then hydrotreated into jet fuel	Electrolysis of water + CO2 to syngas, converted via FT or methanol-to-jet
Feedstocks	Lipids  *Examples: UCO, tallow, canola, carinata, camelina, pongamia*	Alcohols (e.g., ethanol, isobutanol)  *Examples: Sugarcane ethanol, corn ethanol, cellulosic ethanol*	Biomass, municipal solid waste (MSW), agricultural residues  *Examples: Wheat straw, sugarcane trash, forestry residues, MSW*	Lipids and waste oils  *Examples: Tallow, UCO, algae, wet biomass*	Lignocellulosic biomass (forestry residues, agricultural residues, MSW)  *Examples: Wood residues, wheat straw, corn stover, bagasse.*	CO_2 + green hydrogen  *Examples: Green hydrogen, captured CO2,*
Technology Maturity	TRL[1] 9 (commercial, multiple operating plants)	TRL 6-7 (early commercial / first-of-a-kind plants)	TRL 4-5 (pilot to early commercial integration)	TRL 6-7 (Demonstrated at pilot and demonstration scale)	TRL 5–7 (pilot and demonstration; ASTM approval still pending)	TRL 5–7 (pilot and demonstration scale, limited commercial operation)
Example Commercial Deployment	15+ commercial plants (Neste (Singapore, Rotterdam), World Energy (Paramount, CA), ENI (Italy), Repsol, TotalEnergies, and others.)	LanzaJet Freedom Pines (US, 10 m gal/yr - first fuel 2025); Gevo Net-Zero 1 (US, 60 m gal/yr - pre-FID, targeting 2026+)	Fulcrum[2] BioEnergy (UK – NorthPoint), Velocys (UK – Altalto, planned; Uruguay – NovaSAF 1, planned 2027)	Licella (Australia), Aemetis (US) - demo/pilot stage	BTG-BTL/Empyro (pyrolysis, Netherlands), Licella Cat-HTR (HTL, Australia) - pilot/demo stage	Synhelion DAWN (Germany - operational since 2024, demo scale); Norsk e-Fuel (Norway - planned ~2026–27); INERATEC (Germany - under construction)
End Products	SAF, renewable diesel, naphtha, propane	SAF, gasoline-range hydrocarbons, minor diesel	SAF, synthetic diesel, naphtha, waxes	SAF, renewable diesel, heavy bio-oils, bio-naphtha	SAF, renewable gasoline, diesel	SAF (eSAF), synthetic hydrocarbons
End Uses	Jet fuel blending, road diesel, petrochemicals, LPG	Jet fuel, road fuels	Jet fuel, diesel, industrial waxes, heat generation	Jet fuel, road diesel, marine fuel, bio-chemicals	Jet fuel (high aromatics), road transport	Jet fuel (net-zero), future long-haul aviation

Note: (1) Technology Readiness Level (TRL) scale used to indicate relative technology maturity from TRL 1 (basic principles observed) to TRL 9 (commercial operation); pathway definitions and feedstock categories based on internationally recognised SAF conversion routes (HEFA, ATJ, FT, CH/HTL, HDCJ, PtL); technology maturity ranges and commercial deployment examples reflect publicly reported plant status and ASTM approval status as of 2023–2025 (2) Fulcrum BioEnergy filed for bankruptcy in 2024. The future of its plants is uncertain

Source: CSIRO & Boeing, 2023, Sustainable Aviation Fuel Roadmap; IEA Bioenergy Task 39, 2024, Technology Pathways for Sustainable Aviation Fuels; International Civil Aviation Organization (ICAO), 2023, SAF Conversion Processes; International Energy Agency (IEA), 2023, Sustainable Aviation Fuels Guide; CEFC & Deloitte, 2025, Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential; ASTM International, 2023, Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Pathway; Gevo, 'ATJ-60 Project, Lake Preston, South Dakota' (project information page, accessed February 2026).

Not all feedstocks are suitable for all refinery technologies, and the performance of each technology varies by feedstock type

Feedstock	HEFA	AtJ	FT	CH	HDCJ	PtL
Used Cooking Oil (UCO)	Excellent fit	Not suitable	Not suitable	Compatible	Not suitable	Not suitable
Tallow (Animal Fats)	Excellent fit	Not suitable	Not suitable	Compatible	Not suitable	Not suitable
Canola Oil	Excellent fit	Not suitable	Not suitable	Compatible	Not suitable	Not suitable
Carinata / Camelina	Excellent fit	Not suitable	Not suitable	Compatible	Not suitable	Not suitable
Pongamia	Compatible	Not suitable	Not suitable	Strong fit	Not suitable	Not suitable
Wheat/Starch Slurry	Not suitable	Excellent fit	Not suitable	Not suitable	Not suitable	Not suitable
Sugarcane / Molasses	Not suitable	Strong fit	Not suitable	Not suitable	Compatible	Not suitable
Lignocellulosic Sugars	Not suitable	Good fit	Emerging fit	Not suitable	Not suitable	Not suitable
Agricultural Residues	Not suitable	Emerging fit	Strong fit	Emerging fit	Strong fit	Not suitable
Forestry Residues / Mallee	Not suitable	Not suitable	Strong fit	Strong fit	Strong fit	Not suitable
Municipal Solid Waste (MSW)	Not suitable	Emerging fit	Strong fit	Emerging fit	Emerging fit	Not suitable
Algae / Wet Biomass	Compatible	Not suitable	Not suitable	Excellent fit	Emerging fit	Not suitable
CO2 + Renewable Electricity	Not suitable	Not suitable	Not suitable	Not suitable	Not suitable	Only fit

Source: 'Sustainable Aviation Fuel Roadmap' CSIRO & Boeing (2023); 'Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential' CEFC & Deloitte (2025); 'Sustainable Aviation Fuel State-of-Industry Report' NREL (2023); 'Fuel Qualifications (Alcohol-to-Jet pathway description)' CAAFI (2026); 'Fischer–Tropsch Synthesis' NETL 'Gasifipedia'; 'Progress in Commercialisation of Biojet / Sustainable Aviation Fuels' IEA Bioenergy Task 39 (2024); 'Review of Technological Developments and LCA of SAF Pathways (pyrolysis & upgrading / HDCJ)' Frontiers in Fuels (2024); 'Power-to-Fuel Conversion – Reverse Water-Gas Shift (PtL: RWGS → FT → upgrading)' (2020); 'Synthetic SAF Production (PtL via FT: RWGS → FT → upgrading)' Atlanthy; 'The Basics of SAF Technology (HEFA and CH step summaries)' SkyNRG

Each refining technology requires bespoke primary processing, pretreatment, and supply chain infrastructure

	HEFA	AtJ	FT	CH	HDCJ	PtL
Primary processing	Oil extraction (i.e., 'crush' plant)	Fermentation and distillation of ethanol or isobutanol	Biomass drying, size reduction, gasification feed prep	Algae cultivation or wet biomass aggregation, screening	Feedstock preparation (drying, sizing/grinding of lignocellulosic biomass or other solid residues)	Electrolysis of water for H2, CO2 capture or delivery
Core refining infrastructure	Feed pre-treatment/cleanup (remove water, metals, solids, soaps) Hydrodeoxygenation / hydrotreating (remove O as H_2O/CO_2; saturate double bonds) Hydrocracking + hydroisomerisation (tune carbon chain length + cold-flow properties for jet) Separation / fractionation (jet cut + diesel / naphtha / LPG)	Alcohol dehydration (ethanol/isobutanol → olefins) Oligomerisation (build C_8–C_{16} range molecules) Hydrogenation (saturate olefins to paraffins) Fractionation/distillation (jet fraction + co-products)	Feed preparation (size reduction/drying) Gasification (biomass / MSW / etc → syngas) Syngas cleanup & conditioning (particulates/tars/acid gases removal; adjust H_2/CO via shift as needed) FT synthesis (CO + H_2 → hydrocarbon wax/liquids) Upgrading (hydrocracking / isomerisation, finishing) Fractionation (jet cut + diesel / naphtha)	Hydrothermal conversion / catalytic hydrothermolysis (lipids → biocrude-like intermediates) Hydrotreating (remove heteroatoms, saturate, stabilise) Hydrocracking and / or hydroisomerisation (jet-range distribution + cold-flow) Fractionation (jet cut + co-products)	Fast pyrolysis (or related thermochemical liquefaction) to bio-oil/bio-crude Hydrotreating / hydrodeoxygenation (stabilisation) of bio-oil Hydrocracking / hydroisomerisation to jet-range molecules Fractionation (jet cut + co-products	Renewable electricity → electrolysis (make green H_2) CO_2 capture/conditioning Reverse Water-Gas Shift (RWGS) (CO_2 + H_2 → CO + H_2O; makes syngas) FT synthesis (syngas → hydrocarbons) Upgrading (e.g., hydrocracking/isomerisation) Fractionation (jet cut)
Other relevant supply chain & logistics needs	Feedstock storage Truck / rail logistics	Ethanol storage and handling, proximity to ethanol producers	Large-scale biomass collection, drying, ash disposal, bulk freight access	Wet feedstock handling, bio-oil collection, local waste integration	Lignocellulosic biomass collection and transport (bulky, dispersed), potential co-location with forestry/agricultural operations, bio-oil intermediate storage and handling	Grid connection, water supply, CO_2 pipelines or transport, hydrogen storage

Source: 'Sustainable Aviation Fuel Roadmap' CSIRO & Boeing (2023); 'Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential' CEFC & Deloitte (2025); 'Sustainable Aviation Fuel State-of-Industry Report' NREL (2023); 'Fuel Qualifications (Alcohol-to-Jet pathway description)' CAAFI (2026); 'Fischer–Tropsch Synthesis' NETL 'Gasifipedia'; 'Progress in Commercialisation of Biojet / Sustainable Aviation Fuels' IEA Bioenergy Task 39 (2024); 'Review of Technological Developments and LCA of SAF Pathways (pyrolysis & upgrading / HDCJ)' Frontiers in Fuels (2024); 'Power-to-Fuel Conversion – Reverse Water-Gas Shift (PtL: RWGS → FT → upgrading)' (2020); 'Synthetic SAF Production (PtL via FT: RWGS → FT → upgrading)' Atlanthy; 'The Basics of SAF Technology (HEFA and CH step summaries)' SkyNRG

Each refining technology produces a different set of co-products

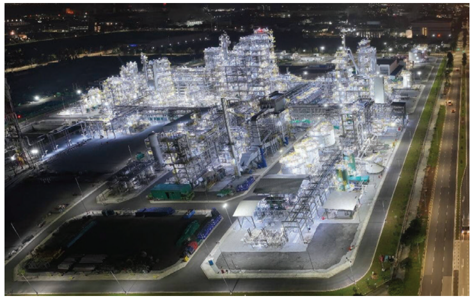
	HEFA	AtJ	FT	CH	HDCJ	PtL
Primary Processing **Co-Products**	Meal (from canola/carinata crush), soapstock, gums	DDGS (distillers grains), CO_2 from fermentation	Char, ash, tar from gasification prep, excess lignin	Sludge, ash, nutrient-rich water (potential fertiliser use)	Char, non-condensable gases and aqueous phase from fast pyrolysis / hydrothermal liquefaction of biomass	Oxygen (from electrolysis), no conventional feedstock input
Primary Processing **Potential Uses of Co-Products**	Animal feed, oleochemicals, soil amendments	Livestock feed, beverage carbonation, dry ice	Soil amendment, low-grade heat, biocarbon markets	Soil conditioner, circular agriculture, biogas digestion	On-site heat and power generation (char and gases), potential soil amendment or carbon products depending on upgrading	Industrial gas supply, integration into hydrogen hubs
Refining **Key Co-Products**	Renewable diesel, naphtha, propane, fuel gas	Gasoline-range hydrocarbons, diesel (minor)	Synthetic diesel, naphtha, waxes, steam	Bio-crude (heavy fractions), renewable diesel, bio-naphtha	Renewable gasoline, diesel fractions, aromatics	Oxygen (from electrolysis), heat (from FT process)
Refining **Potential Uses of Co-Products**	Diesel for road transport or export; naphtha for plastics/petrochemicals; propane for LPG markets	Gasoline used in regional transport or refining; diesel as secondary product in road or mining fleets	Diesel for trucking and rail; waxes for industrial or cosmetic use; heat for co-located facilities	Bio-crude to marine fuel or heavy industry; diesel for rural fleets; bio-naphtha for chemicals	Gasoline as high-octane blend stock; aromatics can reduce reliance on fossil-derived jet additives	Oxygen for industrial or medical use; heat recovery to improve plant energy efficiency
Overall **Economic / Strategic Value**	High Refining co-products (diesel, propane) provide critical revenue; primary meal and soapstock have strong ag and industrial value.	Moderate Gasoline co-product supports SAF economics; DDGS and CO_2 add agricultural and industrial value, especially in ethanol-rich regions.	High Valuable diesel and waxes improve revenue resilience; gasification byproducts like char and ash may have circular economy benefits.	Moderate Renewable diesel and marine fuel from bio-crude offer potential value; nutrient-rich water and sludge support circular agriculture.	Moderate Potential future value from on-spec aromatics and gasoline/diesel co-products; char and gases can provide on-site energy but markets are still emerging.	Low to Moderate Primary oxygen output may have value; refining co-products limited, but integration with H_2, and industrial gas networks improves strategic relevance.

Source: 'Sustainable Aviation Fuels: Technology Overview' IEA Bioenergy Task 39 (2022); Aviationbenefits.org; 'Sustainable Aviation Fuel Roadmap' CSIRO & Boeing (2023); 'Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential' CEFC & Deloitte (2025); NREL, 'Review of Biojet Fuel Conversion Technologies (cap. de fast pyrolysis / HDCJ)'; PNNL, 'Fast Pyrolysis and Hydrotreating Bio-oil Pathway (SOT report)'

Case study

Neste's Singapore facility operates as an integrated aggregation-to-refining hub, enabling global feedstock sourcing and export-scale SAF production

Project Description and Timeline



HEFA Neste's Singapore facility

- Largest dedicated SAF facility globally; integrated HEFA platform converting waste oils into SAF at scale
- SAF supply agreement signed with Singapore Airlines

800	~2.6 (~1 SAF)
Capacity (2010) ktpa	**Capacity (2023)** mtpa

- **2007** Project announced (Asia-Pacific renewable diesel commitment)
- **2010** Initial plant commissioned (800 ktpa)
- **2018** Major expansion announced (EUR 1.6bn to enable SAF scale-up)
- **2022** Mechanical completion of expansion
- **2023** SAF production reaches 1 Mtpa capacity

Enabling environment (Singapore)

- 1% SAF mandate (from 2026)
- Carbon tax framework (rising to S$45/t$CO_2$)
- Jurong Island industrial integration
- Asia-Pacific aviation hub positioning

Integrated supply chain

Global feedstock sourcing: UCO, tallow, residues from Asia, Europe, North America

Vertical integration: Collection networks, aggregators, renderers

Pre-treatment on site: High-impurity waste upgrading via PTUs

Hydrogen integration: On-site SMR; pathway to lower-carbon H_2

Storage & blending: Dedicated tanks, real-time batching

Export hub: Positioned for Asia-Pacific SAF distribution

Why It Enables Scale

Co-location	**Feedstock**
Pre-treatment, refining & storage reduces logistics friction	Aggregated global waste streams ensure quality & volume
Operations	**Hub Position**
Integrated H_2 & utilities lower complexity	Strategic location supports regional distribution

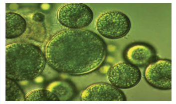
Source: Neste website; Neste News & Insights, 2024, Singapore Refinery Expansion; Neste, 2025, Neste Celebrates 15 Years of Refining in Singapore and 60 Years in Porvoo; Biofuels-News.com, 2025, Neste Supplies Singapore Airlines with CORSIA-Certified SAF; EDB Singapore, 2024, Neste's Plan to Power Aircraft with Sustainable Aviation Fuel from Singapore; GreenAirNews.com, 2023, Neste Opens Expanded Singapore Refinery with 1 Mt SAF Capacity; SimpleFlying.com, 2023, Neste Opens Refinery and Builds SAF Supply Chain to Changi Airport; Technip Energies (TEN.com), Neste Case Study / Singapore Refinery Expansion

2
SAF feedstocks

Understanding feedstock tradeoffs is essential to building a scalable SAF industry

Why Feedstock Matter		
1	**Feedstocks determine how much SAF can be produced**	The total volume of available sustainable biomass sets an upper limit on SAF production. Mature feedstocks like tallow and UCO are constrained, while residues and algae offer long-term scalability but need development
2	**Feedstocks drive SAF economics and capital allocation**	Feedstock costs in some cases comprise the majority of costs for most SAF refinery technologies. Prices, conversion yields, and availability vary widely by feedstock, heavily influencing final fuel cost and commercial viability.
3	**Feedstock choice impacts refinery design and operations**	Each feedstock requires different processing steps. HEFA feedstocks need pre-treatment; lignocellulosic ones require complex tech like gasification. Feedstock quality and consistency also affect plant uptime and efficiency
4	**Feedstock carbon intensity determines policy value**	SAF incentives depend on lifecycle emissions. Waste-based feedstocks like UCO receive higher credits, while crop-based ones may face ILUC penalties. Lower CI means more value under schemes like CORSIA or the IRA
5	**Feedstock strategy underpins long-term supply security**	Scaling Australia's SAF industry requires new feedstock sources, reliable logistics, and managing competition from other sectors. A resilient, diversified feedstock base is key to future growth.

One feedstock per category has been selected for a deep dive

	Oilseeds	Sugar Crops	Starch Crops	Used cooking oil (UCO)	Tallow	Crop Residues	Forestry Residues	MSW (Organic Fraction)	Energy Crops	Perennials	Algae
											
Feedstock Description	Oil-bearing crops cultivated for food and feed that can be processed into vegetable oils.	Sugar-rich crops processed into fermentable sugars for ethanol production.	Starch-based grains that can be converted to ethanol via fermentation.	Post-consumer vegetable oils collected from food service and processing sectors.	Rendered animal fats derived from meat processing operations.	Agricultural by-products remaining after harvest of primary crops.	Woody biomass residues generated from forest harvesting and milling.	Biogenic organic fraction of municipal solid waste streams.	Dedicated non-food crops cultivated for energy or oil production.	Long-lifecycle biomass crops cultivated for high lignocellulosic yield.	Photosynthetic microorganisms cultivated for lipid or biomass production.
Representative Feedstocks *Million tonnes/year*	▪ **Canola (~6.3 Mt)** ▪ Others <1 Mt combined (sunflower, soybean, peanut, safflower, hemp, cottonseed)	▪ **Sugarcane (~32 Mt)** ▪ Others negligible (beet none; sweet sorghum trial)	▪ **Wheat (~34Mt)** ▪ Barley (10–14 Mt) ▪ Sorghum (2–3 Mt) ▪ Others <1 Mt (corn, cassava)	▪ **Used cooking oil** (~0.1Mt)	▪ **Beef tallow (~0.5Mt)** ▪ Others <0.2 Mt (lamb, poultry)	▪ **Wheat straw (15–20 Mt theoretical)** ▪ Others 1–10 Mt (barley, canola, cane trash, sorghum)	▪ **Logging + mill residues (~8–12 Mt est.)** ▪ Mallee coppice negligible ▪ Sawdust negligible	▪ **Food waste (7–8 Mt)** ▪ Garden organics (3–4 Mt)	▪ Products on trial ▪ **Carinata** ▪ Pongamia ▪ Camelina ▪ Crambe ▪ Oil Mallee	▪ Products on trial ▪ **Miscanthus** ▪ Switchgrass ▪ Giant Reed ▪ Short Rotation Coppice	▪ Products on trial ▪ **Algae (microalgae and macroalgae)** ▪ Duckweed
Selected Feedstock	**Canola**	**Sugarcane**	**Wheat**	**UCO**	**Beef Tallow**	**Wheat straw**	**Sawmill residues**	**Organic fraction**	**Carinata**	**Miscanthus**	**Algae**
Selection Rationale	Largest domestic oilseed base; crushing infrastructure; HEFA ready	Highest production; concentrated milling; ethanol pathway	Largest grain base; bulk logistics; ethanol footprint	Nationwide collection; HEFA compatible; no land-use	Largest rendered fat stream; processing hubs; export trade	Largest distributed residue base	Lower aggregation complexity	Continuous urban collection; landfill diversion	Non-food crop; scalable potential Northern Australia	High yield perennial biomass	High theoretical yield/ha; long-term pathway
Theoretical SAF potential[1] *Million litres/year*	**Export Canola**: ~1,600ML	**Export Sugar**: ~1,000ML **Excess Bagasse**: ~600ML	**Export Wheat**: ~200ML	**Export UCO**: ~50ML	**Export Tallow**: ~200ML	**Excess Crop Residues**: ~1,700ML	**Low quality Residues**: ~1,200ML	**Organic non-recycled**: ~900ML	**Theoretical potential**: ~3,200ML	**Theoretical potential**: ~3,200ML	**Trials**
% of FY30 SAF Demand	~18%	**Export Sugar**: ~11% **Excess Bagasse**: ~7%	~2%	~0.6%	~3%	~20%	~14%	~10%	~36%	~36%	N/A

Notes: No commercial-scale production volumes reported for perennials or algae in Australia. (1) Assumption that all exports or surplus exports can be allocated to SAF production.
Source: ABARES, Agricultural Commodities reports; AgriFutures Australia, Emerging Industries reports; CSIRO, bioenergy publications; ARENA, project database.

3
SAF demand outlook

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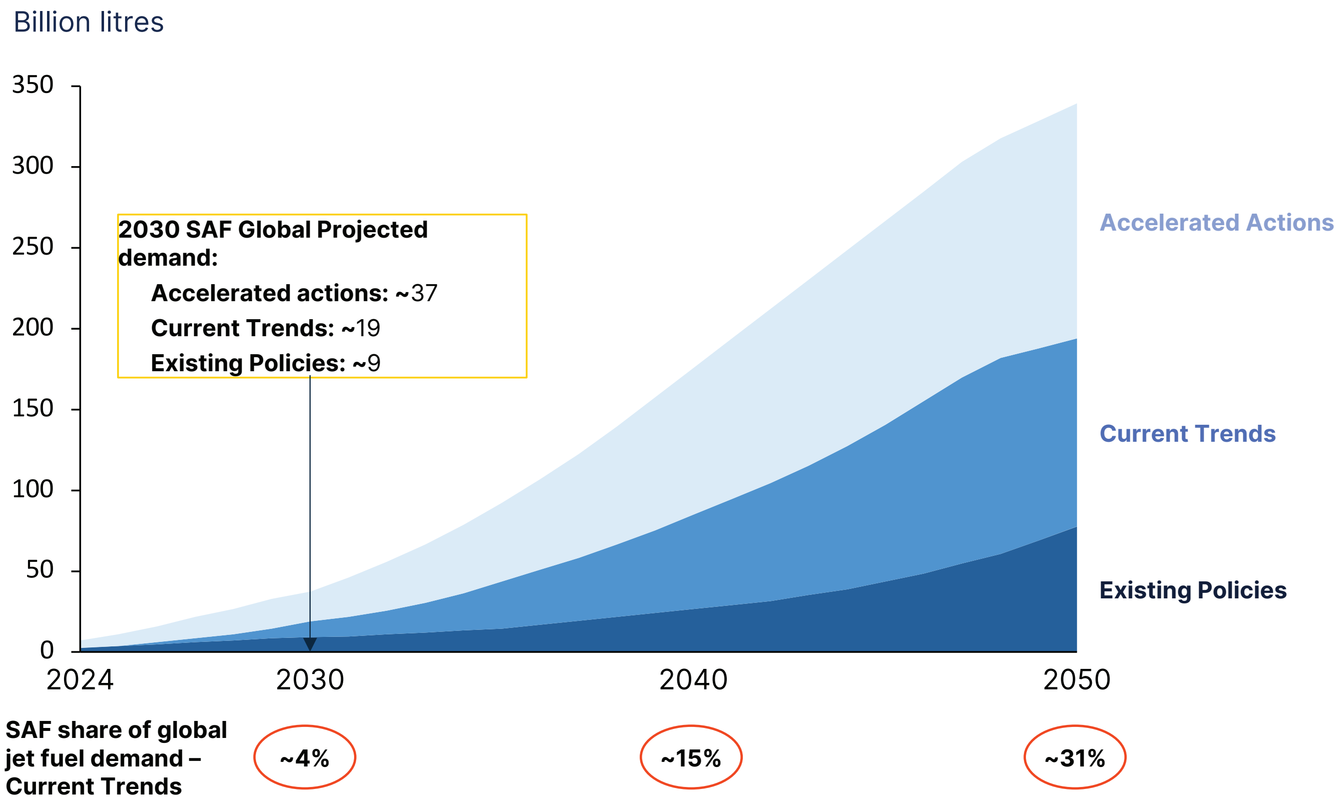
Global SAF demand could scale to ~19 bn litres by 2030 and ~200 bn litres by 2050 under the Current Trends scenario

SkyNRG 2025 Global SAF Demand Trajectories Under Varying Policy Ambitions[1]



Policy ambitions will influence whether SAF becomes a supplementary or primary fuel by 2050

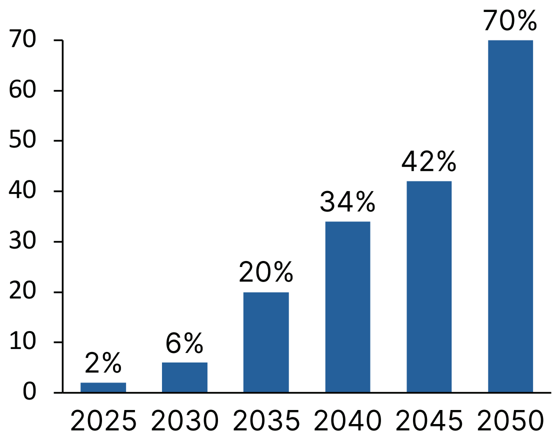
1. SAF demand starts to scale by 2030 with global demand under Current Trends reaching ~19 bn litres or 4% share of total jet fuel demand by 2030
2. Realisation of announced long term targets is expected to drive expansion of SAF demand to ~200 bn liters by 2050 (under current trends)
3. Accelerating ambition could unlock a step-change in the scale of demand
   - Under Accelerated Actions, demand could reach 37 bn litres by 2030
   - And up to ~340 bn litres by 2050

Notes: Existing Policies = only implemented mandates (minimum volumes); Current Trends = committed targets with policies under development (reasonable forecast); Accelerated Actions = additional policies accelerating toward net-zero targets. Conversion assumes SAF density of 0.825 kg/L.
Source: S&P Global, 'Global SAF supply to fall 23 million mt short of demand by 2035'; SkyNRG and ICF, SAF Market Outlook (2025); McKinsey & Company, Scaling sustainable aviation fuel today for clean skies tomorrow, p. 8 (2020).

EU SAF mandates rise from 2% in 2025 to 70% by 2050, underpinning longterm demand

Europe Established the First Binding Long-Tearm SAF Demand Curve[1]

Share of SAF in all EU airports, percent



- The EU set the first legally binding long-term SAF demand curve globally
- ReFuelEU Aviation mandate:
  - Binding compliance obligations and penalties
  - Sub-targets for advanced fuels and e-fuels

Asia Builds Mandate Momentum[2]

Binding or near-binding mandates emerging

- **Singapore**: 1% SAF from 2026, ramping to 3–5% by 2030 (legislated)
- **South Korea:** 1% from 2027; rising to 7–10% by 2035

Major economies setting formal 2030 targets

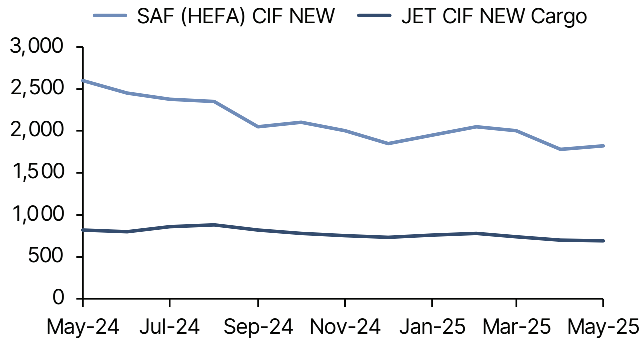
- **Japan:** 10% SAF share by 2030 (roadmap under development)
- **India:** 5% by 2030 (policy target)

Regional policy momentum broadening

- Multiple APAC governments progressing roadmaps and incentive frameworks (e.g., South Korea, Indonesia, Singapore)

Global Market Dynamics are Reflecting Policy-Driven Demand[4]

USD/Mt



- European SAF prices fell from ~$4,350/t (USD ~2,850/t) to ~$2,700/t (USD ~1,770/t) in 12 months, but remain ~2.3× wholesale Jet A1 (~$980/t; USD ~640/t)
- Several SAF projects came online ahead of mandate-driven demand in the EU, increasing available volumes in the short term
- The resulting regional oversupply and softer near-term market conditions put downward pressure on prices

Source: RefuelEU Aviation, European Commission; 'APAC SAF Outlook', Argus (2025); International Air Transport Association (IATA), Sustainable Aviation Fuels webpage; S&P Global Commodity Insights Platts (2025), article on global SAF supply and demand; SkyNRG and ICF, SAF Market Outlook (2025).

Australian domestic SAF demand signals are largely driven by Qantas' 10% SAF blending target implying possibly ~600m litres p.a. by 2030

Structural Shift in Aviation Fuel Mix

Domestic SAF demand could commence at the end of this decade

- Qantas' 10% group-level SAF target implies ~600m litres p.a. by 2030 and possibly 60% by 2050
- Equivalent domestic 10% mandate implies ~900m litres p.a.
- Early commitments signal the emergence of a material SAF demand in AU

2050 pathways imply structural demand transformation

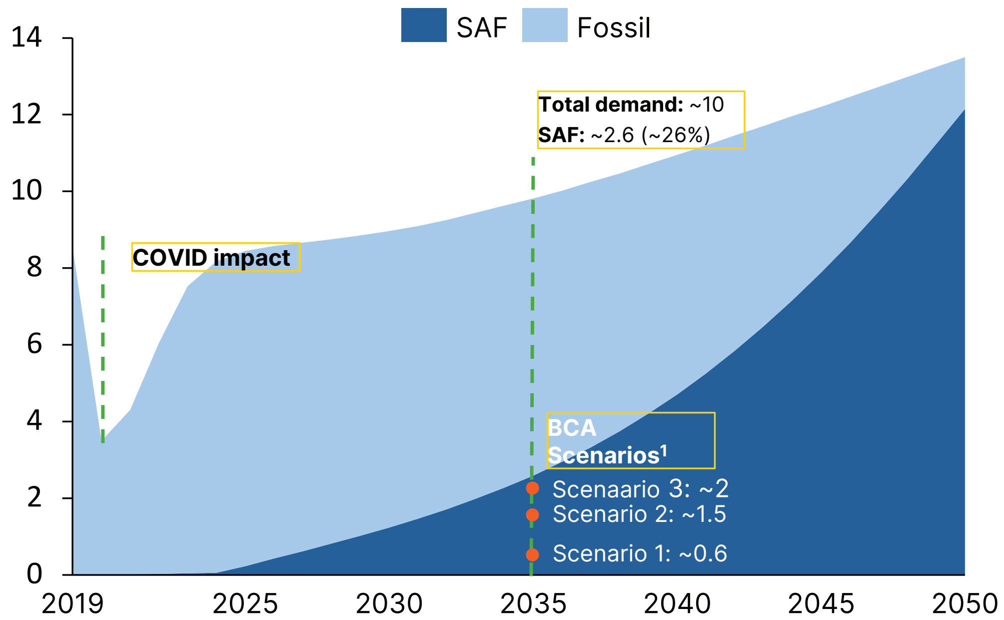
- Jet fuel demand projected at ~13.5bn litres by 2050
- High ambition decarbonisation pathway implies up to ~12.6bn litres of SAF
- Majority of volume growth occurs post-2035

Post-2030 acceleration drives the majority of volume growth

- SAF volumes remain limited in the late 2020s
- Majority of cumulative demand growth occurs post-2035
- Ramp profile suggests steep scaling requirements in the 2030s

Jet Fuel Consumption

Total jet fuel consumption by fuel type, billion litres (Billion L)



Projected 2035 demand SAF share (~26%) exceeds industry target and EU regulatory range

Notes: (1) BCA outlines three domestic SAF blending scenarios for 2035, Scenario 1: 5% (industry aspiration level), Scenario 2: 15% (aligned with the lower-bound of proposed EU regulations), and Scenario 3: 20% (aligned with the upper-bound of proposed EU regulations)

Source: Australia Aviation Outlook, Boeing Cascade (2025); CSIRO Futures, Sustainable Aviation Fuel Roadmap (2023); Qantas Group, 'Sustainable aviation fuel' (webpage, updated 2024); Business Council of Australia, Australia 2035: Maximising Our Potential.

4

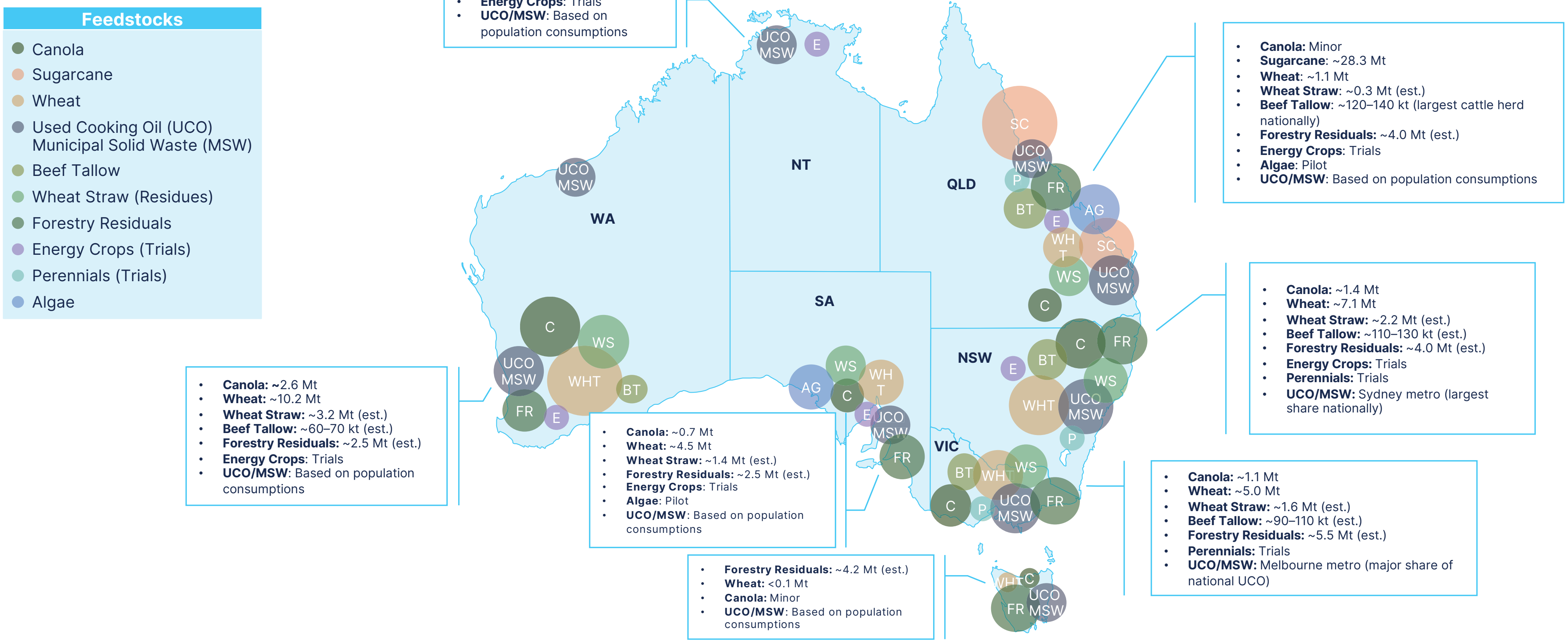
Australia's feedstock supply potential

GrainCorp

Australia diverse feedstocks production types and regions provide a scalable foundation fora domestic sustainable aviation fuel industry

Australia's Feedstock Production

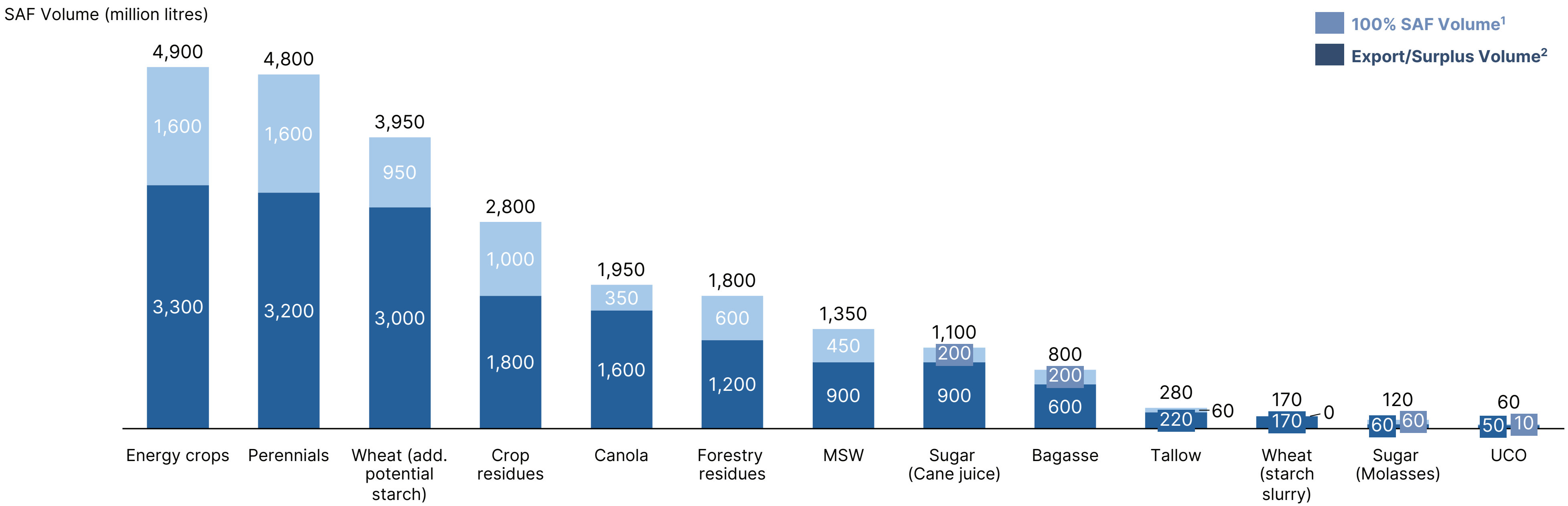
Tonnes/year



Notes: Wheat, Canola and Sugarcane production figures reflect 2023–24 reported 'production sold' values. Wheat straw volumes are estimated by applying a residue-to-grain ratio of 1.3 to reported wheat production, and overlaying a non-return percentage of 24%, consistent with Australian agricultural practices. Beef tallow volumes are estimated using state cattle slaughter data and average carcass weights, applying a standard rendering yield factor of approximately 4–5% to derive indicative tallow output. Forestry residues are estimated by applying a 0.5t/m3 of sawlogs factor to reported state sawmilling volumes. UCO/MSW state distribution is population-weighted, as no official state-level dataset is published. Carinata, pongamia, perennials and algae are reported as trial-scale only.
Source: Australian Bureau of Statistics (ABS), Australian Agriculture: Broadacre Crops, 2023–24 financial year; ABS, Livestock Slaughter and Meat Production, Australia, 2023–24; ABARES, Australian Biomass for Bioenergy (ABBA) and Forest and Wood Products Statistics, 2023–24; Meat & Livestock Australia (MLA) rendering conversion ratios and industry yield assumptions; Intergovernmental Panel on Climate Change (IPCC), Guidelines for National Greenhouse Gas Inventories.

Significant feedstock volumes are exported today, representing domestic SAF redirection potential

Potential Feedstock SAF Supply



	Energy crops	Perennials	Wheat (add. potential starch)	Crop residues	Canola	Forestry residues	MSW	Sugar (Cane juice)	Bagasse	Tallow	Wheat (starch slurry)	Sugar (Molasses)	UCO
% Export/Surplus	~67%	~67%	~76%	~67%	~81%	~67%	~67%	~82%	~74%	~80%	~100%	~50%	~80%
% of 2030 Demand (Exp./Surplus)	~36%	~36%	~34%	~20%	~18%	~14%	~10%	~10%	~7%	~3%	~2%	~1%	~1%

Notes: Energy Crops and Perennial volumes represent potential future volumes. Energy Crops, Perennials, Crop Residues and MSW surplus percentages are taken as 67%, benchmarked to the volume of 'low quality' forestry residues. For detailed information refer to the 'SAF Feedstock Deep Dives'. (1) 100% SAF Volumes refer to the potential SAF production volumes if all feedstock production in that category is redirected for use in SAF production. (2) Export/surplus volume refers to if only exported volumes or volumes surplus to domestic requirements are redirected for SAF production. Refer to feedstock deep dive sections for more information.
Source: Australian Government - Department of Agriculture, Fisheries and Forestry, 'Future opportunities for using forest and sawmill residues in Australia' (2020).

5
Barriers to feedstock uptake

Realising Australia's feedstock supply potential will require aligning refining and feedstock pathways, supply chain readiness and abatement cost dynamics, while also addressing downstream SAF demand uncertainty

Challenges to realising Australia's feedstock supply potential

1. Refining Technology & Feedstock Suitability

- Not all feedstocks are suitable for all refinery technologies with conversion performance varying significantly by feedstock type and specification
- Scaling feedstock supply must be linked with refinery technology choices, ensuring supply characteristics, supporting infrastructure and project economics are aligned with the selected HEFA, AtJ, Fischer-Tropsch (FT) or other refining pathways

2. Supply Chain: Location, Time & Quality

- Australia has geographically dispersed feedstock resources served by logistics networks optimised for food and export value chains
- Some crops (e.g. canola, wheat or sugarcane) could leverage existing collection, aggregation and distribution systems; however, others require significant new supply chain investment including in some cases pre-treatment processing plants to address variability in feedstock composition

3. Abatement Cost Dynamics

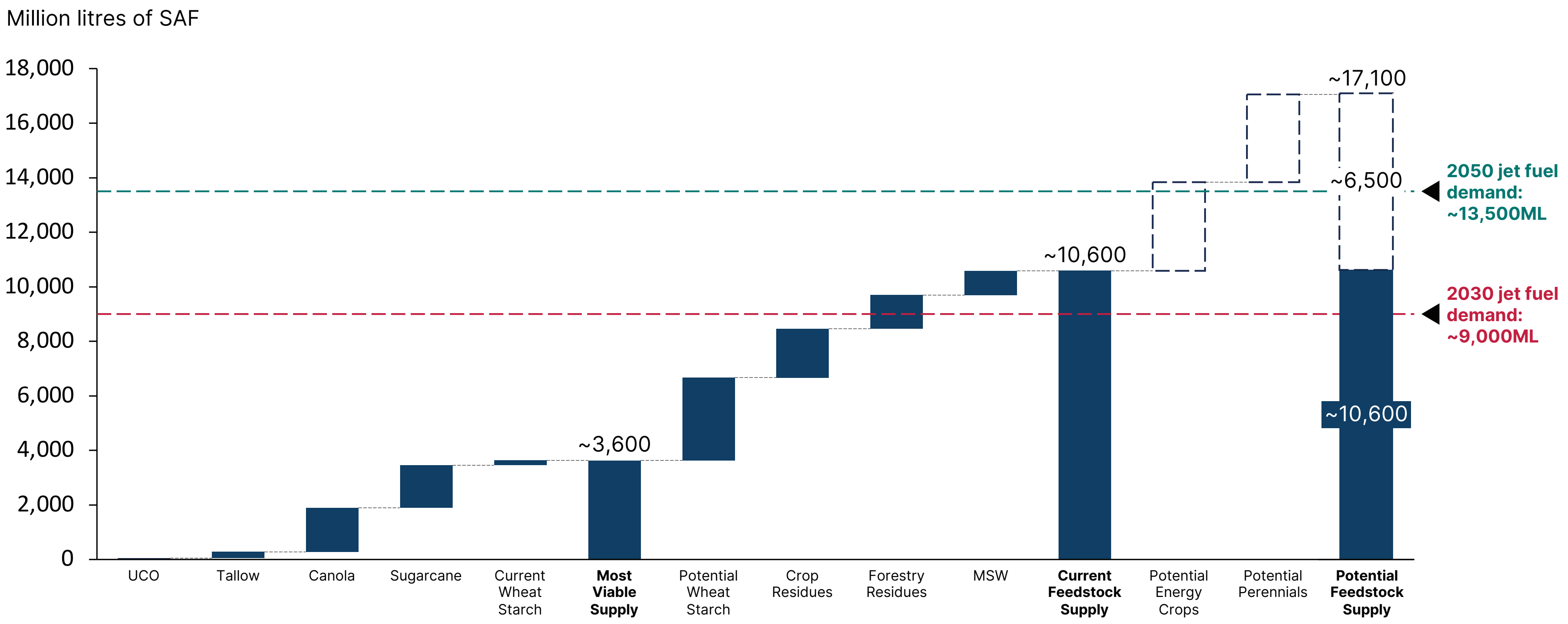
- Several feedstocks have high-value downstream and competing uses (e.g. food, feed, exports, renewable diesel), creating elevated and internationally influenced farm gate price floors with greater volatility
- Carbon intensity varies by feedstock and pathway; in credit-based markets, lower-CI SAF can attract higher value, partially offsetting opportunity costs and higher feedstock prices

4. Downstream SAF Demand Uncertainty

- Feedstock producers face persistent uncertainty regarding future domestic SAF uptake, limiting willingness to commit to long-term supply contracts or capital investment. Two structural drivers perpetuate this uncertainty:
  - A significant cost gap between domestically produced SAF and fossil-based Jet A-1
  - Heavy reliance on voluntary corporate SAF demand commitments rather than binding government policy mandates to secure offtake

Australia's current feedstock volumes can supply ~10,600 ML of SAF, potentially increasing up to ~17,100 ML with further crop increases

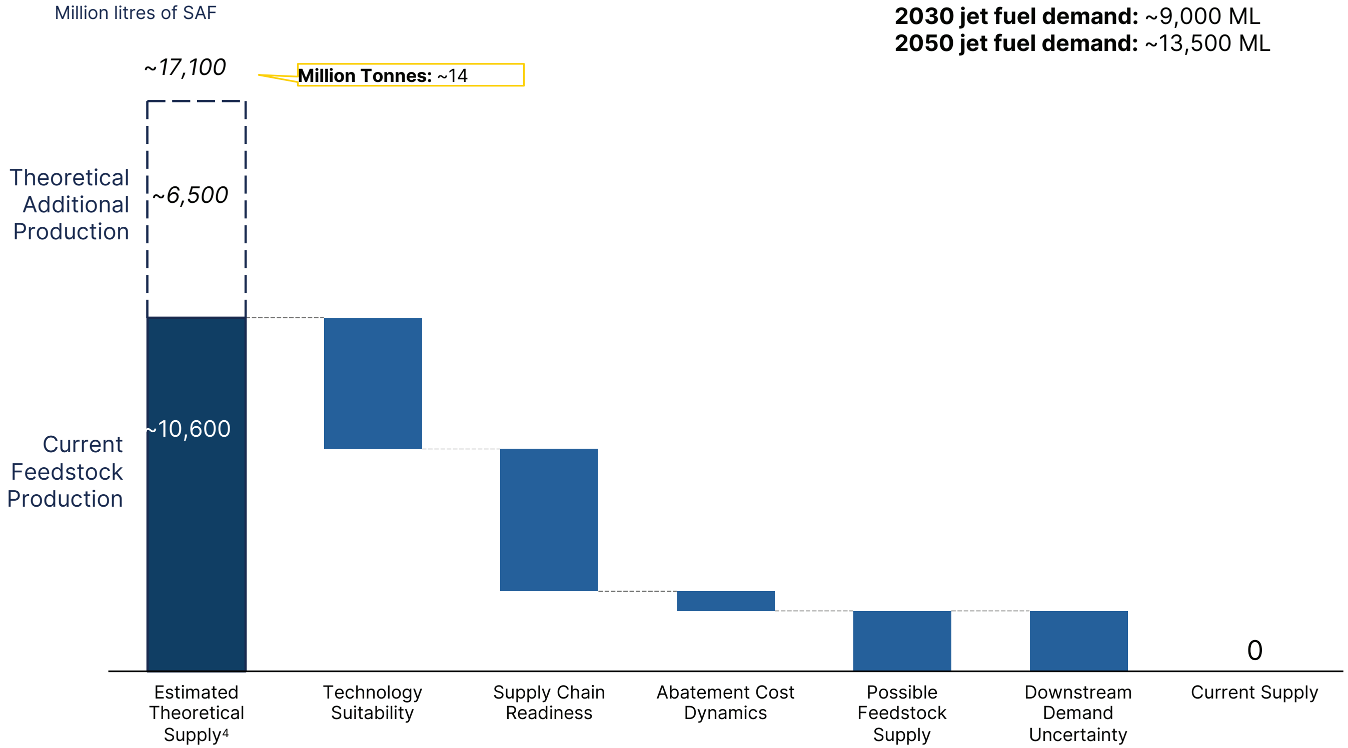
Estimated SAF Supply by Feedstock and Pillar



Notes: Supply volumes are calculated using export surpluses of crops, and usable percentages of other feedstocks only.
Source: See volume calculations in individual feedstock deep-dive sections.

Australia's SAF feedstock supply is currently constrained by technological barriers, supply chain readiness, structurally high abatement costs and downstream demand uncertainty

Estimated SAF Feedstock Supply By Constraining Factor



Factors Limiting Theoretical Supply

Four key constraints limit the theoretical feedstock supply to support domestic SAF production

1 Technology Suitability

Crop Residues, Forestry Residues and Municipal Solid Waste (MSW) rely on the FT conversion pathway, which is not currently commercially developed.[1]

2 Supply Chain Readiness

Potential Wheat byproduct supply is currently constrained by Wheat Gluten capacity, while Canola is constrained by domestic crush capacity.[2]

3 Abatement Cost Dynamics

Bagasse through AtJ is technologically ready and can leverage existing sugarcane supply chains. However, it is constrained by high abatements costs driven by high total production costs for lignocellulosic bioethanol production.

4 Downstream (SAF) Demand Uncertainty

The substantial cost gap for SAF feedstocks relative to fossil Jet A1 fuel and domestic demand reliance on soft corporate targets creates uncertainty for the feedstock supply chain to make long term feedstock supply and/or investment commitments.[3]

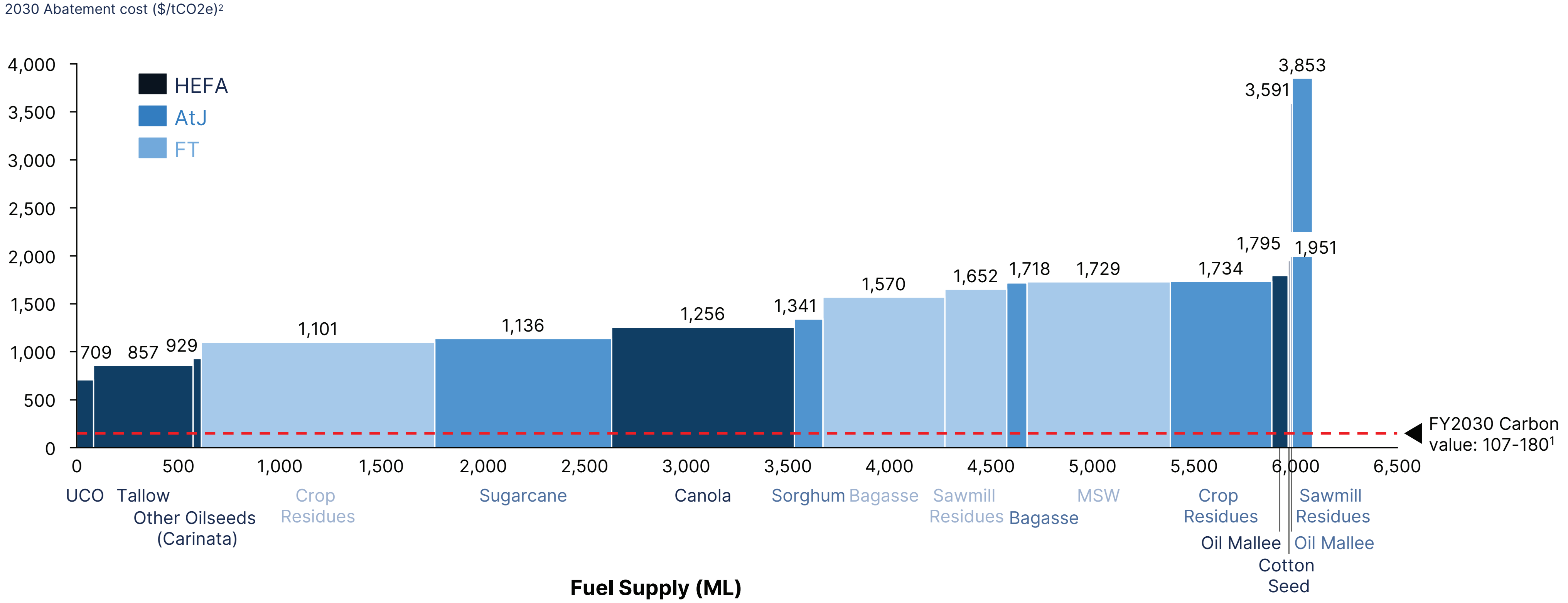
Notes: (1) Crop and Forestry Residues can also be converted to SAF through a lignocellulosic AtJ pathway, although it is less economical and results in a higher CI. (2) Wheat supply constrained in this category is estimated as total export byproduct yield – domestic wheat gluten capacity (estimated based on Manildra capacity). Canola domestic crush capacity is estimated at 1.2Mt. (3) This includes all UCO, Tallow and Sugarcane export volumes, as well as domestic Wheat Starch production and Canola crush capacity. (4) Dotted line represents Energy Crops and Perennials, which currently do not have any available volume. The total including all crops equals the total Pillar C supply previously shown.
Source: NSW Department of Primary Industries, 'Oilseeds' webpage.

6
SAF abatement economics

SAF Abatement Cost Supply Curve – Australia (2030)

2030 SAF abatement costs remain well above prevailing carbon prices

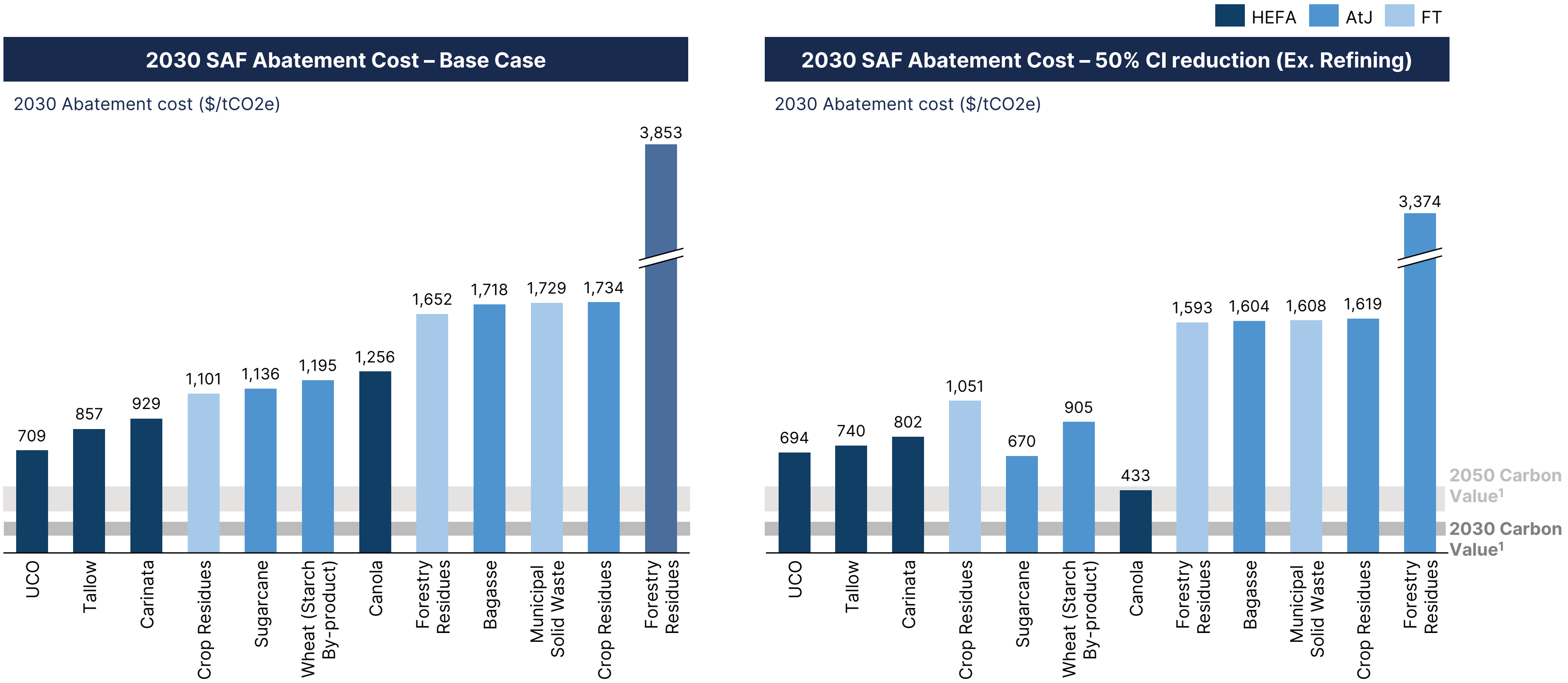
SAF Abatement Cost Curve – Australia (2030)



Notes: (1) Carbon values from Infrastructure Australia, 'Valuing emissions for economic analysis' (2024). Carbon values are to be used for infrastructure cost-benefit analysis. Range reflects low-high cases, with the central case value being 148.(2) Abatement cost and fuel supply estimates are based on analysis in CEFC & Deloitte (2025). Abatement cost ($/tCO₂e) is calculated as (C_SAF – C_Jet) ÷ (CI_Jet – CI_SAF), where C represents fuel price ($/L) and CI represents lifecycle carbon intensity (tCO₂e/L)
Source: Clean Energy Finance Corporation (CEFC) & Deloitte. (2025). Refined ambitions: Exploring Australia's low carbon liquid fuel potential.

SAF Abatement Cost Supply Curve – Australia (2030)

SAF abatement costs could become more competitive with improvements in the feedstock supply chain CI



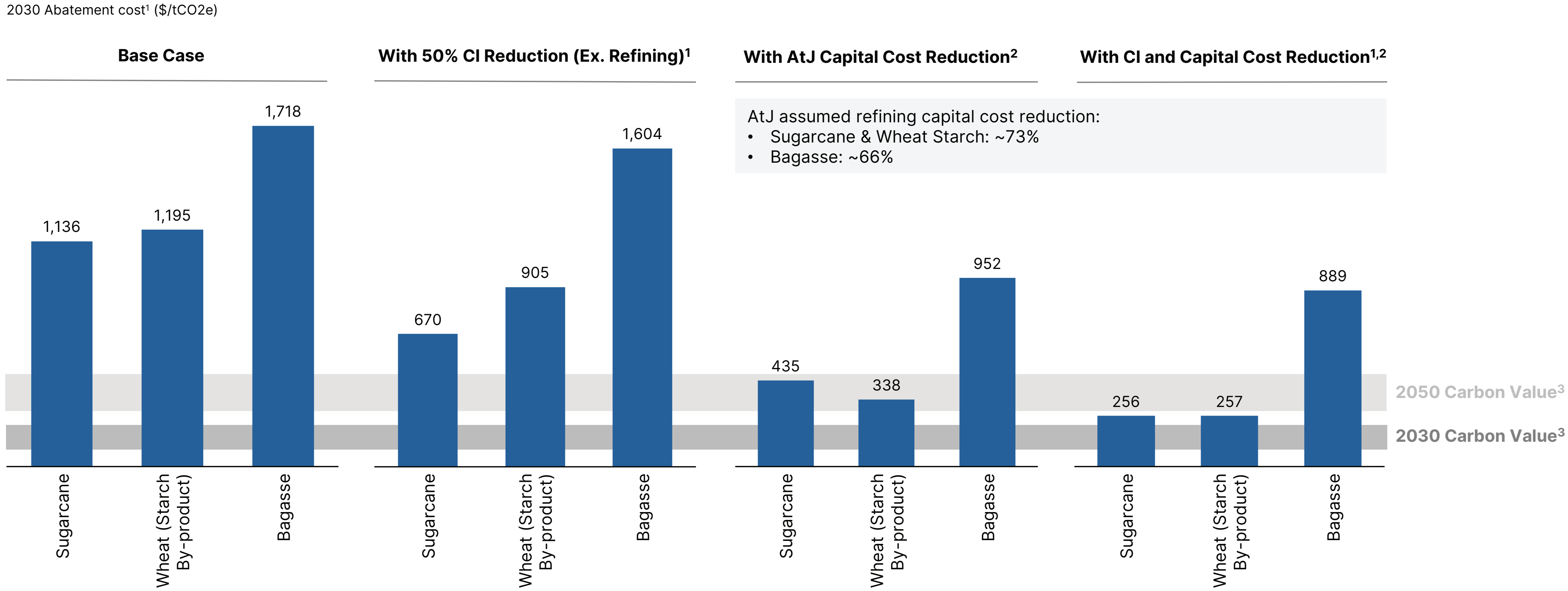
(1) Carbon values are derived from Infrastructure Australia's emissions value ranges (low to high case). 2030: 107-180, central 148. 2050: 287-469, central 377. These are recommended emissions values to be used in cost benefit analyses for infrastructure projects. See Infrastructure Australia, 'Valuing emissions for economic analysis' (2024).

Source: Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential', CEFC / Deloitte (2025); ICAO, CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7 (2025)

SAF Abatement Cost Supply Curve – AtJ Improvements

AtJ SAF abatment costs could benefit from refining capital cost reductions as technology matures

2030 SAF Abatement Cost



Notes: (1) 50% CI reduction excluding the refining step. This captures cultivation and transportation, and ethanol transformation (for Wheat Starch and Sugarcane only). (2) Nth plant capital costs are used instead of pioneer plant costs for the calculation of Wheat Starch, Sugarcane and Bagasse abatement costs. (3) Carbon values are derived from Infrastructure Australia's emissions value ranges (low to high case). 2030: 107-180, central 148. 2050: 287-469, central 377. These are recommended emissions values to be used in cost benefit analyses for infrastructure projects. See Infrastructure Australia, 'Valuing emissions for economic analysis' (2024).
Source: Refined Ambitions: Exploring Australia's Low Carbon Liquid Fuel Potential', CEFC / Deloitte (2025); ICAO, CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7 (2025)

7

SAF feedstock evaluation framework

Purpose, Principles and Considerations of a Feedstock Evaluation Framework

Purpose

A feedstock evaluation framework has been developed to understand feedstock suitability for SAF production and to inform industry development prioritisation

The following slides cover:

- Evaluation framework introduction
- Evaluation of 11 feedstocks and organising into three distinct groups
- Raw scores and ranks for each feedstock

Principles

Feedstocks have been evaluated using specific measures informed by industry sources where possible (e.g. US Department of Energy TRL scores are used to measure technological maturity)

Where no existing industry measurement exists to match the evaluation framework consideration, calculations using industry data have been completed

If this industry data is not available, a points-based quantitative scoring mechanism has been developed

Feedstocks evaluated based on four key considerations

Considerations

Technology Maturity — Noting that feedstock investment must align with commercially viable conversion pathways

Economic Competitiveness — Focusing on both current economics, current abatement cost and scope for CI reduction

SAF Volume Potential — Domestic surplus potential, expansion potential, and existing demand from alternative use-cases

Supply Chain Readiness — Allocating the feedstock based on maturity and where it is on the supply chain readiness scale

Feedstock Evaluation Framework | Questions and Considerations

	Technology Maturity	Economic Competitiveness	SAF Volume Potential	Supply Chain Readiness
Key Question	How **proven** is each **feedstock-technology** pathway for **commercial** SAF **production**?	How **economically competitive** is the feedstock and is there room for future improvement?	Are there **sufficient volumes** of the feedstock to **convert to SAF**, both now and in future?	How much **supply-chain investment** is required to get the feedstock SAF-ready?
Feedstock Evaluation Considerations	**Higher score** for feedstocks with: **Mature refining technologies** already producing SAF commercially	**Higher score** for feedstocks with: **Lowest abatement cost** and ability to improve CI Lower required upfront **capital investment** for the refining technology	**Higher score** for feedstock with: Significant **domestic surplus** Higher **expansion potential** **Lower demand** from alternative use cases	**Higher score** for feedstock with Mature existing supply chains
Evaluation Criteria	**Technology readiness level** Technology readiness level (TRL) score **Current operational facilities** Number of operational plants producing SAF	**Abatement costs (2030)** Abatement costs (\$/tCO_2e) CI improvement potential **CapEx per litre** \$ per plant (nth for HEFA and pioneer for others)	**Total volume availability** Total export volume (SAF million litres per year) **Domestic volume expansion** Qualitative assessment of domestic supplies, expansion potential and alternative demands	**Feedstock supply chain development stage** Pre-production Production Harvest/Collection Aggregation Primary processing Pre-SAF processing SAF Ready

Social license and sustainability

Cross cutting industry development consideration evaluating key issues including

- First Nations cultural heritage, land rights and potential co-governance opportunities
- Maintaining domestic food and feed security
- Managing land use change, biodiversity and water impacts
- Ensuring regional communities share in the economic benefits of new SAF value chains

Feedstock Evaluation Framework | Scoring Methodology

Technology Maturity

Technology (Max: 5)		
Total operational plants (global) Max: 5	10 +	5
	1 – 10	3
	< 0	0

Technology Readiness Level Score (Max: 5)		
TRL score Max: 5	9	5
	7 – 8	4
	5 – 6	3
	3 – 4	2
	1 – 2	1

Economic Competitiveness

Abatement (Max: 5)		
Current abatement (cost per tCO2-e) Max: 3	Low cost ($1–$999)	3
	Med cost ($1–$1.49k)	2
	High cost ($1.5k+)	1
	Not known	0
Potential CI improvement Max: 2	If already low abatement cost, assumed high future CI benefit	2
	High future CI improvement	2
	Limited improvement	1
	Not known	0

Economics (Max: 5)		
CapEx per litre Max: 5	Less than 59c / L	5
	60c – 99c / L	4
	$1 – $9.99 / L	3
	$10 – $14.99 / L	2
	$15+ / L	1

SAF Volume Potential

Domestic availability (Max: 5)		
Total export volume Max: 5	2m+ ML SAF	5
	1.20–1.99m ML SAF	4
	600k–1.19m ML SAF	3
	120–599k ML SAF	2
	1–119k ML SAF	1
	0 ML SAF	0

Domestic expansion (Max 5; scaled from 10)		
Expansion potential Max: 2.5; scaled from 5	High ability to increase production	5
	Medium ability to increase production	3
	Low ability to expand or is a byproduct	1
Domestic surplus Max: 1.5; scaled from 3	70+% total volume exported	3
	<70% total volume exported	2
	0% exported	1
Alternative demand Max: 1; scaled from 2	Low (limited relative demand)	2
	High (moderate to high relative demand)	1

Supply Chain Readiness

Location, Time & Quality (Max: 5)		
Maturity of supply chain Max: 5	Pre-SAF (Converted to SAF blend precursor via approved pathway)	5
	Primary processing (Upgraded or stabilised; conversion-ready)	4
	Aggregation (Consolidated, controlled, transported)	3
	Harvest / collection (Structured collection at scale)	2
	Production (Commercial scale; established non-SAF markets)	1
	Pre-production (Concept/pilot only; no commercial supply chain)	0

Worked example | UCO

Metric	Actual	Score
Technological maturity		**10**
Technology		**5**
Total op. plants	14	5
Readiness score		**5**
TRL Score	9	5
Economic competitiveness		**10**
Abatement		**5**
Current abatement	$709	3
Potential CI improv.	High	2
Economics		**5**
CapEx	$0.56	5
SAF Volume Potential		**4**
Domestic availability		**1**
Domestic avail.	41,394t	1
Domestic expansion		**3**
Expansion potent.	Low	0.5
Domestic surplus	80%	1.5
Alt. demand	Low	0.5
Supply Chain Readiness		**3**
Maturity	Aggreg.	3

TOTAL: 27

Source: Sources outlined on subsequent pages

UCO, Tallow, Canola, and Sugar and Starch Crops are recommended to kick start the industry, given technology maturity, economic competitiveness and supply chain readiness

Feedstock		Technological maturity		Economic competitiveness		SAF Volume Potential		Supply chain readiness	Total
		# plants	Readiness score	Abatement score	Economics	Domestic availability	Domestic expansion	Location, Time & Quality	
		Max 5	Max 5	Max 5	Max 5	Max 5	Max 5	Max 5	Max 35
Tallow	HEFA	5	5	5	5	2	3	3	28
Canola	HEFA	5	4	4	4	4	4	3	28
UCO	HEFA	5	5	5	5	1	3	3	27
Starch crops[1]	AtJ	3	3	4	3	5	4	3	25
Sugar crops	AtJ	3	3	4	3	4	4	3	24
Energy crops	HEFA	5	4	0	0	5	5	0	19
Algae	HEFA	5	4	0	0	0	4	0	13
Perennials	FT	0	2	0	0	5	5	0	12
Crops residue	FT	0	2	3	1	4	3	1	14
Forestry residues	FT	0	2	2	1	4	3	2	14
MSW	FT	0	2	2	2	3	3	2	14

Available feedstocks with a domestic surplus requiring relatively modest supply chain investment

- Feedstocks with the best economics, driven in part by the technological maturity of the refining process. All feedstocks have mature supply chains
- UCO, Tallow and Canola rely on HEFA refining technology, which is most advanced

Mid-term transition feedstocks requiring near-term targeted investment to de-risk scaling

- Crops with limited alternative use cases and high expansion potential
- Energy crops are most appealing given their economics and their use of HEFA technology

Waste feedstocks requiring more substantial supply chain investment and improvement in refining costs

- Feedstocks using less proven FT refining technology and will require significant investment
- MSW and Forestry have some existing supply chain maturity

Legend # Ranked first

Notes: (1) Starch crops will initially use existing wheat starch byproduct capacity; it could then use all theoretical byproducts from current wheat export volume in future. Readiness score derived as a rank from US Department of Energy TRL score for each technology. Abatement cost from CEFC report and ranked in order of lowest cost to highest abatement cost for 2030 ($/tCO2-e); total abatement cost reduced to reflect higher Australian standards (versus global standards). Economics based on $/L from ICAO SAF Rules of Thumb, with lowest $/L ranked highest. Export surplus reflects potential SAF volume for each feedstock and ranked high to low. Use case-competition based on whether feedstock is a food (more competitive), whether there is a strong-non food existing use case (more competitive), percentage of feedstock that is exported (with greater percentage export reflecting lower domestic competition), and whether it would be easy to expand the volume of feedstockSource: US Department of Energy; CEFC report; ICAO TAF 'Rules of Thumb'; Export surplus data derived from ABARES; Ampol; Australian Renderers Association.

Feedstock Evaluation Framework

Category 1 feedstocks have greater technological maturity, economic competitiveness, volume potential and supply chain readiness

	Technology Maturity			Economic Competitiveness			SAF Volume Potential		Supply Chain Readiness
Criteria:	*Technology Type*	*Technology Readiness Level*	*Volumes*	*Abatement Score*		*Capital Cost Per Litre*	*Domestic Availability*	*Domestic Expansion*	*Maturity Stage*
Measurement:	*HEFA, AtJ, FT*	*1-9*	*# plants producing at scale*	*Current abatement cost (AU$/tC02e)*	*Future CI benefit*	*AU$/L distillate*	*Domestic surplus (Million of litres of SAF)*	*Score 1-10*	*Score 0-6*
Tallow	HEFA	9	14	$857	High	$0.56	~200	3.0	3.0
Canola	HEFA	8	14	$1,256	High	$0.71	~1,600	3.5	3.0
UCO	HEFA	9	14	$709	High	$0.56	~50	3.0	3.0
Starch crops	AtJ	6	1	$1,341	High	$1.69	~3,200	3.5	3.0
Sugar crops	AtJ	6	1	$1,136	High	$1.69	~1,600	3.5	3.0
Energy crops	HEFA	8	14	N/A	N/A	N/A	~3,200	4.5	0.0
Algae	HEFA	8	14	N/A	N/A	N/A	N/A	4.0	0.0
Perennials	FT	4	0	N/A	N/A	N/A	~3,200	4.5	0.0
Crops residue	FT	4	0	$1,101	Limited	$17.91	~1,800	2.5	1.0
Forestry residues	FT	4	0	$1,652	Limited	$15.37	~1,200	2.5	2.0
MSW	FT	4	0	$1,729	Limited	$11.42	~900	2.5	2.0

Notes: Sources listed on each subsequent page for each area of consideration. Starch crops will initially use existing wheat starch byproduct capacity; it could then use all theoretical byproducts from current wheat export volume in future.

Technology Maturity

HEFA is the most mature refining technology, already deployed at scale; AtJ is the next most mature, with one commercial plant established; some feedstocks can be processed via multiple pathways

CATEGORY 1

CATEGORY 2

CATEGORY 3

Feedstock	Refining Technology		Technology Readiness		Plants Operational
Tallow Canola UCO Energy Crops Algae	HEFA (Hydro-processed Esters and Fatty Acids)	▪ HEFA converts fats, oils and greases into SAF by using hydrogen to remove oxygen and refine the molecules into hydrocarbons similar to conventional jet fuel.	8 – 9[2]	▪ Technology proven in final form. Tested and validated under full operating conditions; OR ▪ Ready for commercial deployment; OR operating at full commercial scale under real mission conditions, with proven performance over time.	14
Starch Crops Sugar Crops Perennials[1]	AtJ (Alcohol-to-jet)	▪ ATJ converts alcohols such as ethanol into SAF by dehydrating and upgrading them into aviation-grade hydrocarbons.	6	▪ Engineering-scale or pilot plant. ▪ System tested under conditions close to commercial reality. ▪ Scaling factors identified.	1
Crop Residue Forestry Residue MSW	FT (Fischer-Tropsch)	▪ FT produces jet fuel by gasifying solid feedstocks like biomass or waste into syngas and then catalytically converting that gas into liquid hydrocarbons.	4	▪ Components integrated in lab environment. ▪ Low-fidelity prototype. ▪ Early system-level testing under controlled conditions.	0

Notes: (1) Perennials can also be processed by the AtJ and FT pathways. (2) HEFA has a range of 8 – 9 for TRL score per US Department of Energy. Source: U.S. Department of Energy, 'Pathways to Commercial Liftoff: Sustainable Aviation Fuel'; Calumet, Annual Report 2024; Chevron Corporation, Annual Report 2024; China Petroleum & Chemical Corporation (Sinopec), Annual Report 2024 and corporate disclosures; Eni S.p.A., Sustainability and financial disclosures 2024 (2025); International Air Transport Association (IATA), SAF dashboard (2025) and SAF media briefings and regional updates (2025); LanzaJet, Inc., 'Freedom Pines Fuels' launch announcement (2024); Marathon Petroleum Corporation, Investor materials 2024; Neste Corporation, Annual Report 2024 (2025) and Sustainability Report 2024 (2025); Petrobras, Sustainability Report 2024 (2025); Phillips 66, Investor materials 2024; Preem AB, Investor update 2024; TotalEnergies SE, Universal Registration Document 2024 (2025); World Energy, LLC, corporate disclosures and operational updates (2024).

Economic Competitiveness

UCO and Tallow provide the lowest estimated 2030 abatement cost; Canola, Sugar Crops and Starch Crops could achieve significant future CI improvement benefit

Technology maturity | **Economic competitiveness** | SAF volume potential | Supply chain readiness

	Current benefit			Future benefit		Abatement Cost and CI Improvement Potential	CapEx Cost	CapEx Score	Total Score
	Abatement cost (2030)	*Abatement cost (2030)*	*Abatement cost score*	*Potential future CI improvement*	*Score*	*Score*	*$/ litre*	*Score*	*Score*
		Low, med, high	*Max: 3*	*High, limited*	*Max: 2*	*Max: 5*		*Max: 5*	*Max: 10*
Tallow	$857	Low	3	High	2	5	$0.56	5	10
Canola	$1,256	Med	2	High	2	4	$0.71	4	8
UCO	$709	Low	3	High	2	5	$0.56	5	10
Starch crops	$1,341	Med	2	High	2	4	$1.69	3	7
Sugar crops	$1,136	Med	2	High	2	4	$1.69	3	7
Energy crops	$0	N/A	0	N/A	0	0	0	0	0
Algae	$0	N/A	0	N/A	0	0	0	0	0
Perennials	$0	N/A	0	N/A	0	0	0	0	0
Crops residue	$1,101	Med	2	Limited	1	3	$17.91	1	4
Forestry residues	$1,652	High	1	Limited	1	2	$15.37	1	3
MSW	$1,729	High	1	Limited	1	2	$11.42	2	4

Notes: Abatement costs not available for energy crops, perennials and algae, so they have been excluded from this particular component of the analysis.Source: Clean Energy Finance Corporation (CEFC) & Deloitte, 'Refined Ambitions: Exploring Australia's Sustainable Aviation Fuel Opportunity' (2023); International Civil Aviation Organization (ICAO), 'Sustainable Aviation Fuel (SAF) Rules of Thumb'; expert interviews; Commonwealth Scientific and Industrial Research Organisation (CSIRO), 'Opportunities and Priorities for a Low Carbon Liquid Fuel Industry in Australia' (2025).

Domestic Expansion

Energy Crops, Algae and Perennials have the highest domestic expansion score, given their significant expansion potential and relatively lower demand from alternative use cases

Technology maturity	Economic competitiveness	SAF volume potential	Supply chain readiness

	Expansion potential		Excess supply		Alternative demands		Total
	Expansion potential	*Score Max: 5*	*Export surplus / excess supply*	*Score Max: 3*	*Alternative demands*	*Score Max: 2*	*Score Max: 10 (scaled to 5)*
Tallow	Low	1	80%	3	Low	2	6
Canola	Med	3	81%	3	High	1	7
UCO	Low	1	80%	3	Low	2	6
Starch crops	Med	3	77%	3	High	1	7
Sugar crops	Med	3	76%	3	High	1	7
Energy crops	High	5	67%	2	Low	2	9
Algae	High	5	0%	1	Low	2	8
Perennials	High	5	67%	2	Low	2	9
Crops residue	Low	1	67%	2	Low	2	5
Forestry residues	Low	1	67%	2	Low	2	5
MSW	Low	1	67%	2	Low	2	5

Notes: Calculated available feedstock supply by multiplying raw feedstock production volumes by intermediary product yield assumptions and applicable export/surplus percentages, then estimating potential SAF volumes using pathway-specific conversion yields
Source: Expert interviews

Supply Chain Readiness
Feedstocks are assigned a position on the supply chain readiness scale

Technology maturity | Economic competitiveness | SAF volume potential | **Supply chain readiness**

	Pre-production	Production	Harvest/Collection	Aggregation	Primary Processing	Pre-SAF	*SAF Ready*
Score:	0	1	2	3	4	5	
	Resource exists only in concept, pilot volumes, or fragmented supply; no structured commercial supply chain exists.	Feedstock is already produced commercially at scale and has an established market (food, feed, industrial, energy or other uses).	A structured, repeatable system exists to harvest or collect the feedstock at scale and remove it from its point of origin.	Feedstock is stored, consolidated, quality-controlled, and transported through organised supply chains suitable for industrial processing.	Feedstock undergoes initial upgrading or stabilisation (e.g. extraction, rendering, drying, fermentation) to make it conversion-ready.	Feedstock or intermediate is converted into a SAF blend precursor through an approved conversion pathway.	*Feedstock to aviation fuel supply chain is fully commercialised and produces SAF ready for use*

Overall level of maturity:

— **Lower** → **Higher**

Time:

— Greater time to scale → Lower time to scale

Quality:

— Lower and less consistent quality → Higher and more consistent quality

Location:

— More geographical dispersion → Less geographically dispersed

Source: Expert interviews

8

Recommendations

Feedstock industry development could start today with targeted incentives and foundational capabilities in place, however, long term growth will require investment and R&D

	Build a sustainable feedstock supply industry to underpin domestic low-carbon-liquid fuel production		
	Pillar A: Kick-start the industry	**Pillar B: Develop lower CI scalable feedstocks**	**Pillar C: De-risk next generation waste feedstocks**
Objectives	• Ensure domestic demand to underpin investment • Rapidly commercialise HEFA & AtJ feedstocks with established supply chains • Establish the CI reduction pathway	• Build knowledge for informed investment in next generation low CI scalable feedstocks for viable refining technologies (e.g., HEFA, AtJ)	• Reduce 'project-on-project' risk for future feedstock supply chain investment • Monitor commercial readiness for new feedstocks • Develop clear path to attract private investment
Refining	HEFA | AtJ	HEF AtJ	FT | CH | HDCJ | PtL
Feedstocks	Canola | UCO | Tallow | Sugarcane | Wheat starch	Energy Crops | Perennials | Algae	MSW | Ag Residues | Forestry Residues
SAF Volume (ML)	~3,600	~6,500	~3,900
2030|50 Jet Fuel %	~41% | ~27%	~72% | ~48%	~44% | ~29%
Recommendations	A1 Create targeted SAF demand incentives to unlock supply chain investment A2 Incentivise feedstock growers and aggregators to invest to meet early demand targets A3 Develop CI reduction strategy to improve feedstock abatement economics A4 Commission study to identify feasible levers to reduce domestic supply chain development costs	B1 Assess low CI crops and optimise existing feedstocks (oil content, yields) to maximise fuel per hectare B2 Incentivise commercial-scale trials of lower CI crops and establish clear offtake and pricing signals to unlock grower investment B3 Align agriculture and supply chains for next-generation feedstocks	C1 Implement commercial readiness review to determine when to invest in new feedstocks C2 Develop fact-base required to attract private investment to commercialise new feedstocks C3 Directly incentivise R&D/early pilots with potential for at-scale commercialisation

D. Establish national foundational capabilities needed for success

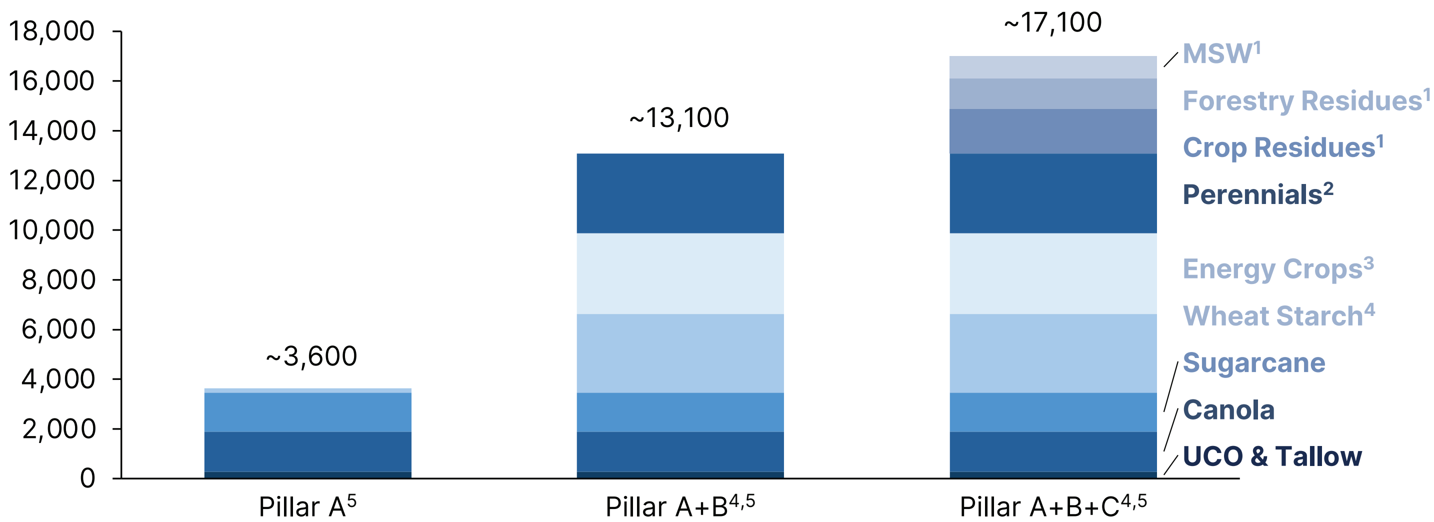
- D1 Develop National Feedstock Strategy with aligned SAF, net zero, and regional economic growth objectives
- D2 Create a National Feedstock Certification Scheme to enable compliance with SAF global markets
- D3 Build social license to develop the SAF industry with Public and Growers, and invest in the required skills and capabilities
- D4 Government led facilitation between SAF, energy and feedstock suppliers to support industry development

~3,600 ML of near-term SAF can be unlocked from readily available feedstocks; scaling beyond this requires development toward ~17,100 ML total potential

Theoretical Potential SAF Production From Feedstock Availability by Pillar

Million litres of SAF

2030 jet fuel demand: ~9,000 ML
2050 jet fuel demand: ~13,500 ML



	Pillar A[5]	Pillar A+B[4,5]	Pillar A+B+C[4,5]
Million tonnes	**~3**	**~11**	**~14**
2030 demand %	**~41%**	**~72%**	**~44%**
2050 demand %	**~27%**	**~48%**	**~29%**

Feedstocks by Pillar

The potential SAF volumes attributed to each pillar consist of supply from the following feedstocks

1. **Pillar A:**
   - UCO & Tallow
   - Canola
   - Sugarcane (including Bagasse)
   - Wheat Starch (existing gluten byproduct only)

2. **Pillar B:**
   - All Pillar A Feedstocks
   - Wheat Starch (all theoretical byproduct)
   - Energy Crops
   - Perennials

3. **Pillar C:**
   - All Pillar B Feedstocks
   - Crop Residues
   - Forestry Residues
   - Municipal Solid Waste (MSW)

Notes: (1) Assumes 67% of potentially collectable MSW, Forestry Residues and Crop Residues are usable for SAF production – benchmarked to percentage of forestry residues deemed 'low quality'. (2) Perennials volume is based on CSIRO estimates of land area for environmental planting. It assumes 50% of this land can be planted with perennials. (3) Energy Crops areas estimates are from recent research on the potential of Pongamia. (4) Wheat Starch Pillar A includes only current capacity for Wheat Starch byproduct, whereas Pillars B & C include all theoretical export Wheat Starch capacity. (5) Pillars are reflective of this report's recommendations and categorisations. Algae SAF production could also be included in Pillars B&C but is excluded in this graph.
Source: ABARES, 'Future opportunities for using forest and sawmill residues in Australia'; CSIRO, 'Australia's Carbon Sequestration Potential' (2022); AgriFutures Australia, 'New research to explore potential of pongamia as renewable fuel'.

Pillar A Feedstocks: What is required?

	Abatement Cost	Potential Supply		Supply Chain Readiness		
	$/tCO2	Surplus Volume (ML)	% FY30 demand (~9,000ML)	Maturity	Capital required[1]	What is required to unlock the path to sustainable supply?
UCO	$709	~50	~1%	Aggregation	• Pre-treatment required; primary processing typically occurs within HEFA plant	• Redirect export flows via long-term offtake contracts
Tallow	$859	~250	~3%	Aggregation		• Ensure rendering capacity and segregation scale with demand • Provide domestic price signal
Canola	$1,256	~1,600	~18%	Aggregation	• Primary processing occurs within HEFA plant • Additional crushing capacity may be required	• Expand domestic crush capacity • Confirm Australian cultivation adjustments and ILUC offset ambition to reduce Canola CI
Sugar crops	$1,136	~1,600 (~1000 from sugar cane and molasses, ~600 from bagasse)	~17%	Aggregation	• **Ethanol**: $148m for a 100ML p.a sugarcane (molasses) derived bioethanol plant[2] • **3% 2030 SAF target**: ~$660m • **5% 2030 SAF target**: ~$1.1bn	• Expand fermentation capacity • Integrate supply contracts across growers, mills and fuel producers
Starch crops	$1,147	~200 (up to ~3,200 if all by-products are included)	~2%	Aggregation	• **Ethanol**: $147m for a 100ML p.a wheat starch derived bioethanol plant[2] • **3% 2030 SAF target**: ~$660m • **5% 2030 SAF target**: ~$1.1bn	• Expand fermentation capacity • Integrate supply contracts across growers, mills and fuel producers

Notes: (1) Capital required to meet 3-5% of 2030 Total Jet Fuel Demand (~9,000ML). (2) Ethanol for AtJ pathway, capital cost estimated using AECOM (2016) for a 100ML bioethanol facility.Source: International Civil Aviation Organization (ICAO), 'Sustainable Aviation Fuel (SAF) Rules of Thumb'; Boeing, 'Australia Aviation Outlook' (2025), Boeing Cascade; AECOM, 'Efficient Costs of New Entrant Ethanol Producers: Final Report Prepared for the Independent Pricing and Regulatory Tribunal of New South Wales (IPART)' (2016), p. 39.; Sunshine Sugar / NSW industry (2022), Reference Notes for New Cane Growers in NSW; Australian Sugar Milling Council (2022), Queensland Raw Sugar Cost of Production Report (BDO analysis, 2018–2020).

Pillar B Feedstocks: What is required?

	Abatement Cost	Potential Supply		Supply Chain Readiness		
	$\$/tCO_2$	Surplus Volume (ML)	% FY30 demand (~9,000ML)	Maturity	Capital required[1]	What is required to unlock the path to sustainable supply?
Energy Crops	929 (Carinata)	~3,250	~36%	Pre-production	• **Production (Carinata)**: ~ 1000 $/ha[6] • **Production (Pongamia):**~ 7,500-11,000 $/ha[7] • **Pre-processing:** ~$500m crush plant for 1.0 Mt p.a capacity[2] • **3% 2030 SAF target**: ~$400m • **5% 2030 SAF target**: ~$700m	• Scale grower programs and diversify seed supply • Validate meal use and resolve antinutritional factors • Invest in agronomy to lift yields • Expand local crushing and align carbon incentives
Perennials	-	~3,250	~36%	Pre-production	• **Production:** ~ 7,900-9,600 $/ha[5] • **Ethanol**: ~$530m for a ~140ML p.a Switchgrass derived plant (660 Kt of feedstock input)[3] • Cost driven by difficulty of enzymatic pretreatment (accounts for ~72% of TCI above)[3] • **3% 2030 SAF target**: ~$4.6-8.3bn • **5% 2030 SAF target**: ~$7.8-13.8bn	• Promote perennial grass growth on marginal cropland • Leverage existing logistics networks for grass aggregation, storage and transportation • Support further research and development into lignocellulosic bioethanol production
Algae	-	Trials only	-	Pre-production	• **Cultivation Capex:** Open-pond algae farm capex ≥$350,000/ha[4] • **3% 2030 SAF target**: ~$2.6-8.0bn • **5% 2030 SAF target**: ~$4.4-13.3bn	• Validate supply chain and standardise logistics and certification prior to scale-up • Scale photobioreactors and unlock co-product value to improve economics

Notes: (1) Capital required to meet 3-5% of 2030 Total Jet Fuel Demand (~9,000ML). (2) Indicative costs using Canola crush plant costs from Cargill (US$350m). (3) Total capital investment (TCI) of ~$509m CAD for a 660Kt feedstock input Switchgrass bioethanol plant. (4) NREL Cultivation capex greater than US$250,000/ha. Yields taken as ranging from 9.9-30t SAF / ha. (5) When all categories of costs including annual overheads, machinery, fixed asset depreciation and labour are included the range varies from $7922 to $9666 /ha in a mature orchard for almonds production (6) In the southeastern US, carinata production costs are reported at about 300 USD/acre, which is roughly 740 USD/ha per season (7) Analyses note pongamia establishment costs similar to citrus (around 2,000–3,000 USD/acre, i.e. roughly 5,000–7,500 USD/ha), with relatively low annual inputs thereafter
Source: Cargill, 2021. "Cargill unveils plans for new canola processing facility in Regina."; Van Herwaarden, A., et al. (2022). "The performance and feasibility of carinata in Australia." Agronomy Australia. Olughu et al, 2023, "Technoeconomic analysis of a fungal pretreatment-based cellulosic ethanol production"; Davis, R., et al. (2016). Process design and economics for the production of algal biomass in open pond systems. National Renewable Energy Laboratory (NREL); Klein, B., & Davis, R. (2024). Algal biomass production via open pond algae farm cultivation: 2022 state of technology. National Renewable Energy Laboratory; Wright, D. (2021, January 29). Progress of carinata research in the Panhandle; Schenk, T. (2014, September 2). Pongamia: A new opportunity in agriculture; Horticulture Innovation Australia, Economics of Almond Production in Southern Australia

Pillar C Feedstocks: What is required?

	Abatement Cost	Potential Supply		Supply Chain Readiness		
	$/tCO2	Surplus Volume (ML)	% FY30 demand (~9,000ML)	Maturity	Capital required[1]	What is required to unlock the path to sustainable suppy?
MSW	1,729	~900	~10%	Harvest / Collection	• **Pre-processing**: ~$200-350 million per 350 kt/yr hub[2] • **3% 2030 SAF target**: ~$0.9-1.7bn • **5% 2030 SAF target**: ~$1.5-2.8bn	• Develop large MSW hubs to sort, clean and densify waste into consistent SAF-ready feed. • Secure long-term MSW supply contracts and logistics so hubs run at stable high load
Agricultural residues	1,101 (FT) 1,734 (AtJ)	~1,800	~18%	Production	• **Pre-processing**: ~$8.3m for 80Kt depot for herbaceous biomass[3] • **Ethanol**: $292m for a 100ML p.a Cane Trash derived plant[4] • **3% 2030 SAF target**: ~$1.5bn • **5% 2030 SAF target**: ~$2.5bn	• Develop efficient aggregation and transportation networks for bulky residues • Support further research and development into lignocellulosic bioethanol production to reduce capital cost
Forestry Residues	1,652 (FT) 3,853 (AtJ)	~1,200	~14%	Harvest / Collection	• **Pre-processing**: ~$6.4m for 80Kt depot for woody biomass[3] • **Ethanol**: $287m for a 100ML p.a Forest Residues derived plant[4] • **3% 2030 SAF target**: ~$1.4bn • **5% 2030 SAF target**: ~$2.4bn	• Develop efficient aggregation and transportation networks for bulky residues • Support further research and development into lignocellulosic bioethanol production to reduce capital cost

Notes: (1) Capital required to meet 3-5% of 2030 Total Jet Fuel Demand (~9,000ML). (2) Order-of-magnitude estimate based on scaling Australian MRF/recycling plant costs (e.g. the East Rockingham waste-to-energy project at A$511m for 300 kt/yr MSW and new Hume recycling facility cost reporting) and international MSW-to-fuel studies indicating that front-end sorting and pre-processing typically account for roughly one-third of total waste-to-fuel plant capital expenditure; figures are indicative only and not project-specific. Combines advanced sorting, shredding, drying and RDF/pelletising infrastructure. (3) Costs converted from USD using 1AUD = 0.7USD. Costs displayed for 10 modular pellet plants for both herbaceous and woody biomass facilities. From Jacobson et al (2014), 'Techno-economic analysis of a biomass depot'.
Source: AECOM, 'Efficient Costs of New Entrant Ethanol Producers' (2016); Region Media, 'DA shows the real cost of new Hume recycling plant' (10 February 2026); Thompson, D., et al., 'Municipal solid waste preprocessing and decontamination for biofuels and bioproducts' (2023).

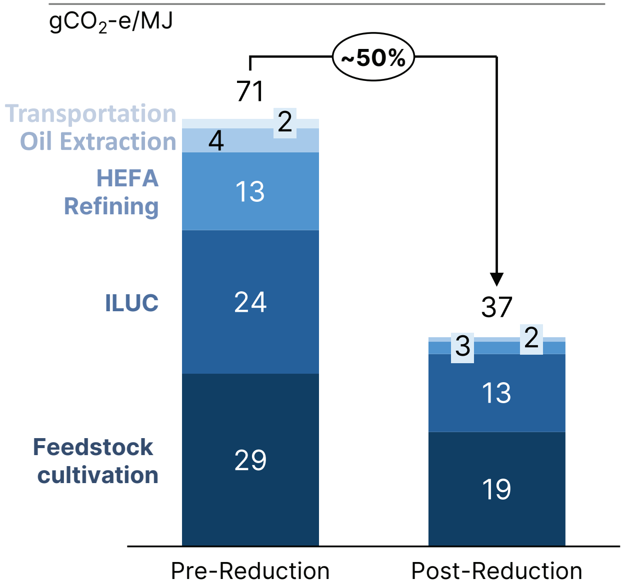
Prioritising high-impact ILUC and refining levers materially lowers CI and cost, with Canola achieving a ~66% abatement cost reduction from ~51% lower CI

Carbon Intensity Reduction Opportunities

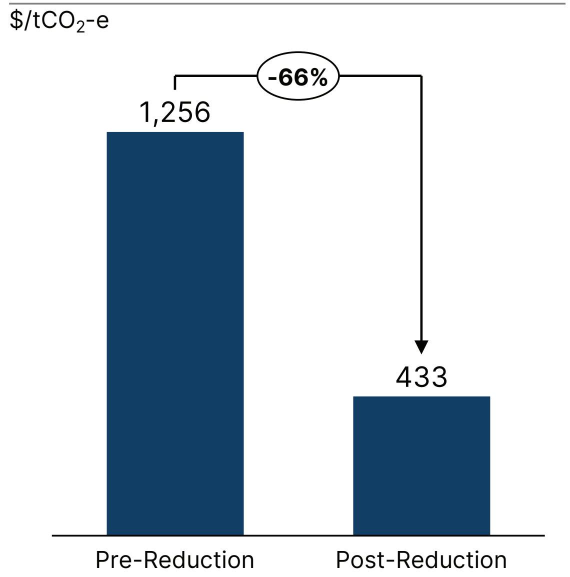
Feedstock Cultivation	• Improve farming practices and increase yields • Enforce zero-deforestation and sustainable residue removal
ILUC	• Implement ILUC[1] mitigation strategy • Strengthen land use governance • Reduce land pressure through yield improvement
Oil Extraction & Conversion	• Electrify and switch to renewable power • Improve heat integration and process efficiency • Use low-carbon hydrogen
Transportation	• Optimise biomass collection and routing • Co-locate plants near feedstock • Shift to lower-carbon transport modes

Carbon Intensity – Canola Oil Example

Carbon Intensity Potential Reduction[2]



Cost of Abatement Potential Reduction



Example of levers
- ILUC offset ambition reduces lifecycle carbon intensity by lowering indirect land use change impact
- Australian cultivation adjustments reduce carbon intensity by applying local data and farming practices
- Cultivation and crushing improvements reduce upstream emissions through better agronomic practices and renewable-powered, efficient extraction

Notes: (1) ILUC = indirect land use change emissions. (2) A 50% reduction was applied to non-SAF processing stages, neither cultivation. Cultivation reduction assumptions were based on CSIRO estimates for Australia
Source: Commonwealth Scientific and Industrial Research Organisation (CSIRO), 'Opportunities and Priorities for a Low Carbon Liquid Fuel Industry in Australia' (2025); Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024); International Civil Aviation Organization (ICAO), 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); International Civil Aviation Organization (ICAO), 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

9
Case studies

GrainCorp

Singapore's legally binding SAF mandate with clear targets and cost-management mechanisms underpin domestic SAF production capacity

Overview of Singapore's SAF Mandate

SAF Target	Government mandate for all departing flights to use at least 1% SAF from 2026, increasing to 3-5% by 2030
Passenger SAF Levy	Airlines will be charged a per-passenger SAF levy based on distance travelled ranging from S$1.00-10.40 (AU$1.12-11.65)[1] starting from October 1, 2026
Cargo SAF Levy	Cargo aircraft operators will be charged a per-kilogram SAF levy based on distance travelled ranging from S$0.01-0.15 (AU$0.01-0.17)[1] starting from October 1, 2026
State-led SAF Procurement	The Singapore Sustainable Aviation Fuel Company (SAFCo), a public agency, will centralise SAF procurement using SAF levy revenue, securing supply and reducing cost
Aviation Emissions Target	The Singapore Sustainable Air Hub Blueprint targets aviation emissions reduction targets of 20% by 2030, and net zero aviation emissions by 2050[2]

Implications for SAF Feedstock Suppliers

1 Clear Demand Signal

Mandated SAF use targets create a visible and predictable baseline of demand, justifying capacity investments and allowing for long-term offtake contracts

2 Price Certainty

SAF levies create price certainty for SAF refiners and feedstock suppliers, reducing exposure to volatile jet fuel spot pricing and making investment more viable

3 Streamlined Logistics and Procurement

Centralised procurement through SAFCo reduces sales risk and allows for scalable contracts and access to aggregated demand for individual producers

4 Policy Stability and Direction

Clear long-term targets encourage future development of the SAF industry in Singapore, drawing regional and global investment

Note: (1) SGD to AUD exchange rate of S$1.00 to AU$1.12 used (as of 17 Feb 2026). Premium cabin passengers will be charged 4x the regular amount for each distance categorisation. (2) Emissions reduction target is with reference to 2019 baseline levels.
Source: Civil Aviation Authority of Singapore (CAAS), 'New Sustainable Aviation Fuel Levy to Apply From 1 April 2026 for Flights Departing From 1 October 2026' (2025); SAFCo; Civil Aviation Authority of Singapore (CAAS), 'Singapore Sustainable Air Hub Blueprint' (2024)

The Northern Territory Government used a market based competitive processes to support efficient development of the Northern Gas Pipeline

Northern Territory Gas Pipeline Development

Context	▪ In 2014 the Northern Territory (NT) Government sought opportunities to grow its gas industry through providing access to the East Coast gas network ▪ This connection would facilitate new gas sales from existing and new fields which were historically constrained by domestic NT demand and LNG net-back economics ▪ Estimated infrastructure development cost were significant ~A$0.8-1.3bn ▪ Funding the full development cost was not an NT Government priority
Finding the best option	▪ The NT Government launch a multi-round competitive reverse auction process to determine the economic and technical feasibility of the infrastructure development ▪ Auction documents set out non-negotiable policy and development objectives, including two route options, while deliberately leaving other dimensions open for bidders to propose the most competitive solutions ▪ Auction participants were assessed across multiple dimensions
Outcomes	▪ Jemena, an Australian gas and electricity utility, won the process and delivered the Northern Gas Pipeline, a 622 km transmission line linking Tennant Creek (NT) to Mount Isa (Qld) ▪ The NT Government was able to meet all its objectives

Implications for SAF Feedstocks

1. **Government commitment support private sector actions**

   Decisive government action is critical to attract in private investment, especially in sectors with high upfront capital and unproven economics

2. **Market based competitive processes can reveal the best and most efficient types of support**

   A well-designed market based competitive process tests feasibility, pricing, risk and delivery capability before committing to any structure or financial support

Source: AEMC; Australian Financial Review “NT opens tender process for gas pipeline link”, 13 November 2014

10. SAF feedstock deep dives

a. Oilseeds

b. Sugar crops

c. Starch crops

d. Used cooking oil (UCO)

e. Tallow and animal fats

f. Crop residues

g. Forestry residues

h. Municipal solid waste

i. Energy crops

j. Perennials

k. Algae

GrainCorp

Introduction to the feedstock deep dives

GrainCorp completed an analytical review of key SAF feedstocks and refining pathways using publicly available data to inform the paper's fact base.

This section profiles Australia's most relevant SAF feedstocks, drawing on domestic and international data, case studies, and techno-economic analysis.

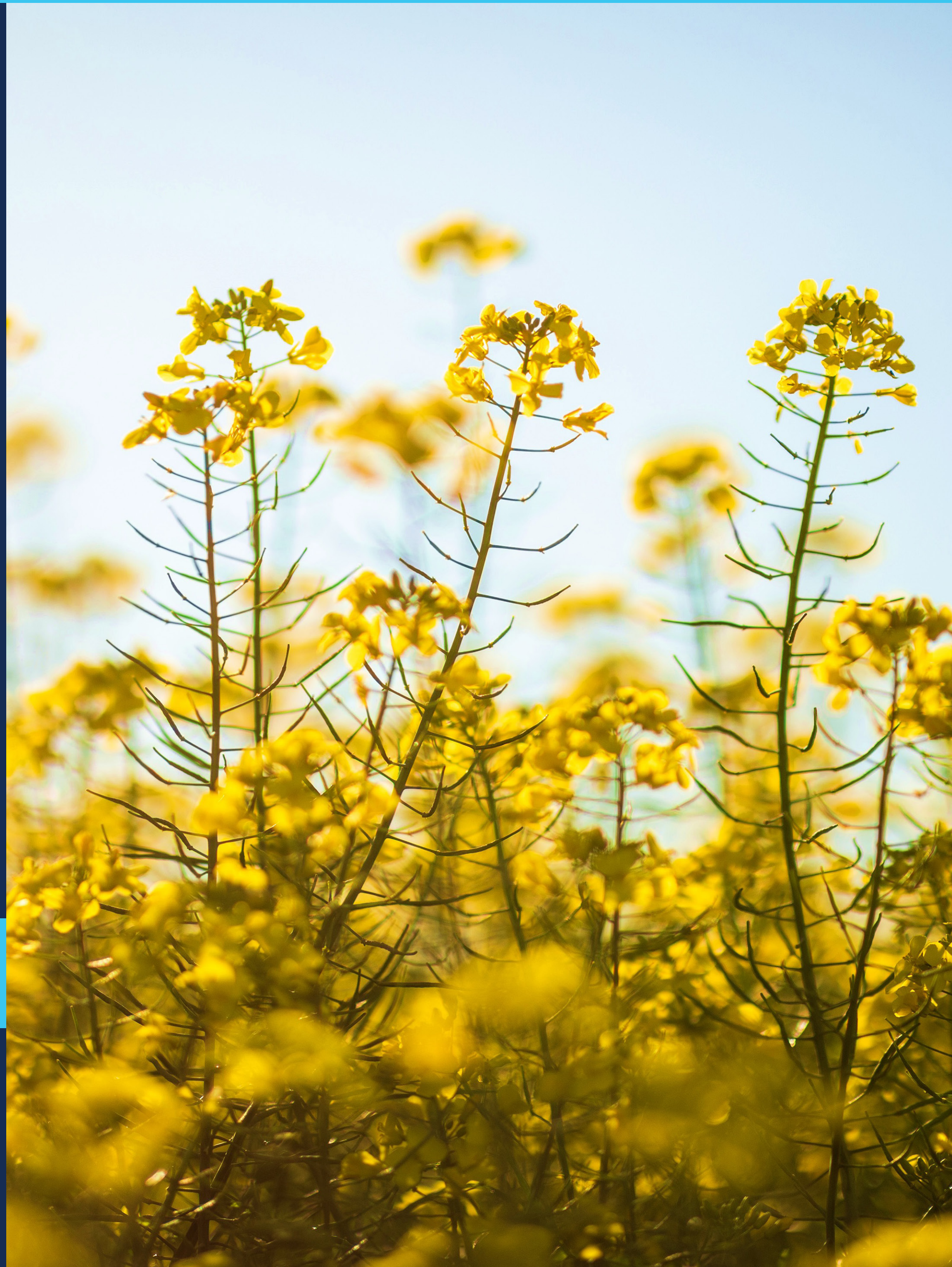
Each deep dive is designed to provide a quick overview of the feedstocks. The slides cover

- An overview of the technical process, the pathway viability and expected SAF volumes per unit of production
- The carbon intensity (CI) for producing SAF and potential CI reduction opportunities
- An overview of economic competitiveness versus fossil jet fuel and other potential SAF feedstocks
- An overview of Australia's opportunity and ability achieve production scale

Further work is being completed to review and validate information

10
SAF feedstock deep dives

a. Oilseeds



Canola Oil Summary

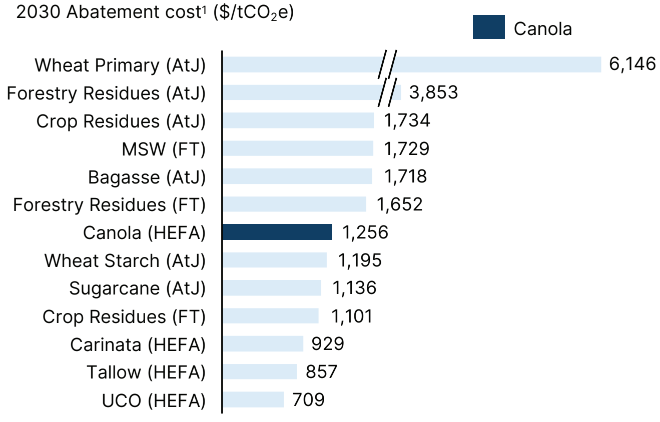
Canola oil offers scalable domestic SAF potential, underpinned by established agricultural supply chains and mid-range abatement economics

Executive Summary

Technical viability	• Canola oil is a technically proven SAF feedstock via the HEFA pathway, leveraging established crushing, refining and export infrastructure • SAF yields depend on oil allocation: full diversion of canola oil delivers ~24–28% SAF from total seed mass, versus ~14–17% when using the portion of oil typically allocated to fuel markets[4]
Emission reduction potential	• Under default CORSIA values, canola-based SAF delivers ~20% lifecycle carbon intensity reduction versus fossil-derived Jet A-1 (~71.3 gCO_2e/MJ vs ~89 gCO_2e/MJ) • CI performance is influenced by cultivation inputs and ILUC factors, with Australian-specific adjustments reducing lifecycle CI to ~37.7 gCO_2e/MJ (~58% reduction versus ~89 gCO_2e/MJ
Economic competitiveness	• Canola-based SAF sits in the mid-range of Australia's abatement cost curve (~A$1,256/$tCO_2e$), reflecting moderate emissions reduction and crop-linked feedstock costs • At around 1.0-1.5x the cost of fossil jet fuel, Canola benefits from established crushing infrastructure and strong co-product revenues that improve overall project economics
Australia's opportunity	• Australia produces ~6.3 MT of canola annually, with ~80% exported to international markets • Redirecting export volumes could create meaningful SAF supply for domestic SAF production
Australia's scale potential	• Full diversion of Australian canola production could supply ~19–28% of 2030 domestic jet fuel demand • Redirecting current export volumes alone could supply ~14–23% of 2030 jet demand • Redirecting domestic industrial canola volumes could deliver ~11–17% of 2030 demand

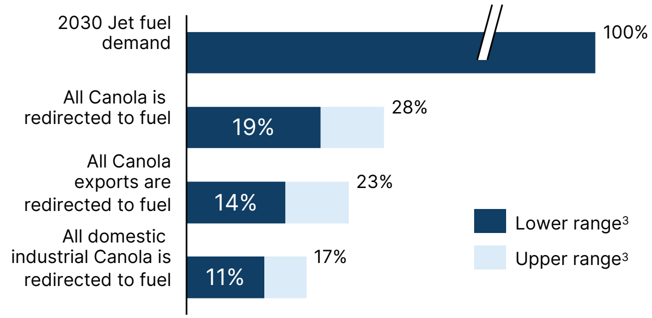
2030 SAF Abatement Cost Comparison - Australia

2030 Abatement cost[1] ($/$tCO_2e$)



2030 Jet Fuel Volume Potential vs. 2030 demand[2]

Percent of 2030 Australian jet fuel demand[2]



Notes: (1) Abatement cost assumes conservative cost reductions; refer to 'Abatement cost curve position' slide for detailed assumptions. (2) Percent of 2030 Australian jet fuel demand based on projected domestic demand scenario outlined in 'Canola Oil volume and potential implication.', all volumes are Australian. (3) Volume ranges calculated based on variation in oil allocation, food vs. fuel diversion assumptions, and SAF yield factors. (4) For yields information please refer to 'Canola Oil SAF yields'

Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024); International Civil Aviation Organization (ICAO), 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); International Civil Aviation Organization (ICAO), 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025)

Canola Oil value chain

Canola is a versatile oilseed feedstock supplying food, feed and renewable fuels through established processing pathways

Fuel pathway

Production Pathway

Production

Canola is grown as a broadacre rotation crop alongside other crops like wheat and barley

Collection & Aggregation

Harvested canola is collected, stored, graded, and traded through bulk handlers and merchants, consolidating volumes

Cleaning and Conditioning

Seed is cleaned and conditioned to optimise oil extraction

Crushing

Canola seed is mechanically and/or solvent-crushed to separate crude vegetable oil from protein-rich canola meal.

Refining, bleaching, and deodorising

Crude canola oil is purified through refining, bleaching, and deodorising to remove impurities, colour, and odour, producing food-grade or industrial-grade oil

End Use Applications

Food

Refined canola oil is used as an edible oil in household cooking and food manufacturing due to its neutral flavour and favourable nutritional profile

Fuel

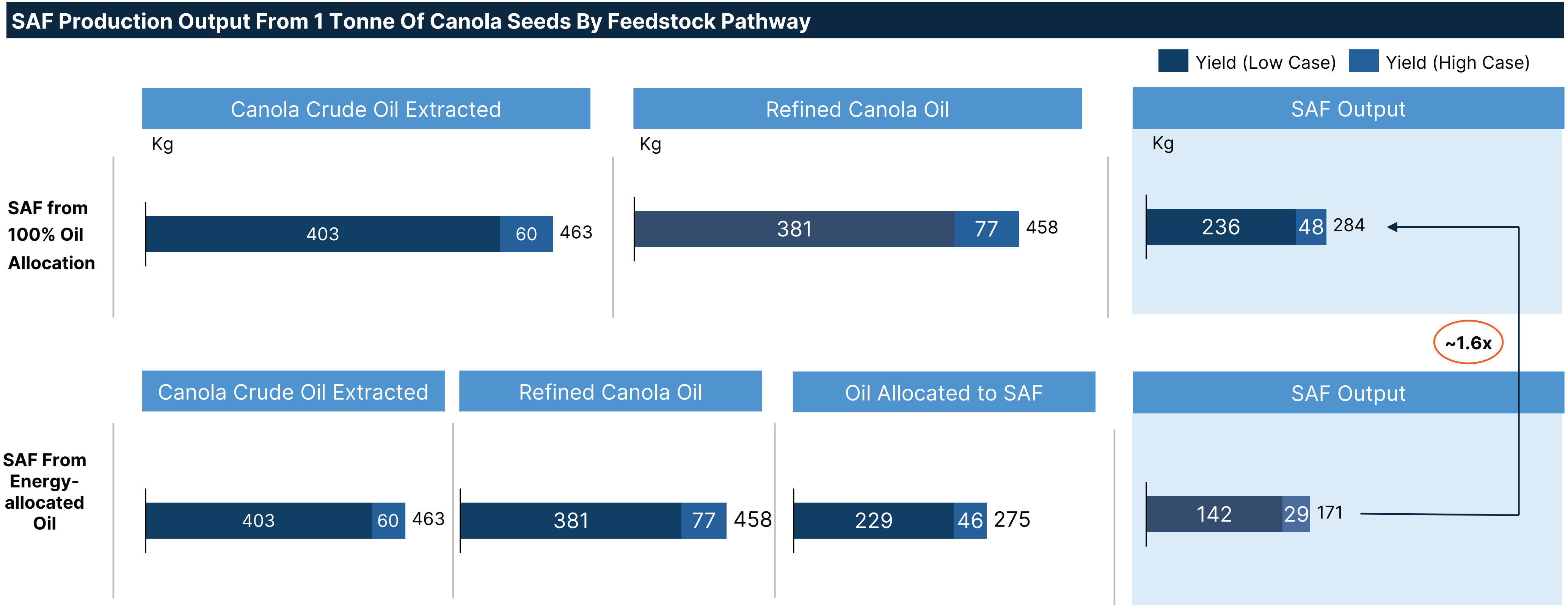
Refined or semi-refined canola oil is used as a feedstock for renewable diesel and sustainable aviation fuel

Feed

Canola meal/oil, the co-product of crushing, is sold into livestock feed markets as a high-protein ingredient for ruminant and monogastric diets.

Canola Oil SAF yields

Maximising canola allocation to SAF increases output by ~1.6x versus the current food/fuel split



Notes: (1) Results reflect the yield calculations presented in the 'Canola Oil SAF Yields' slide

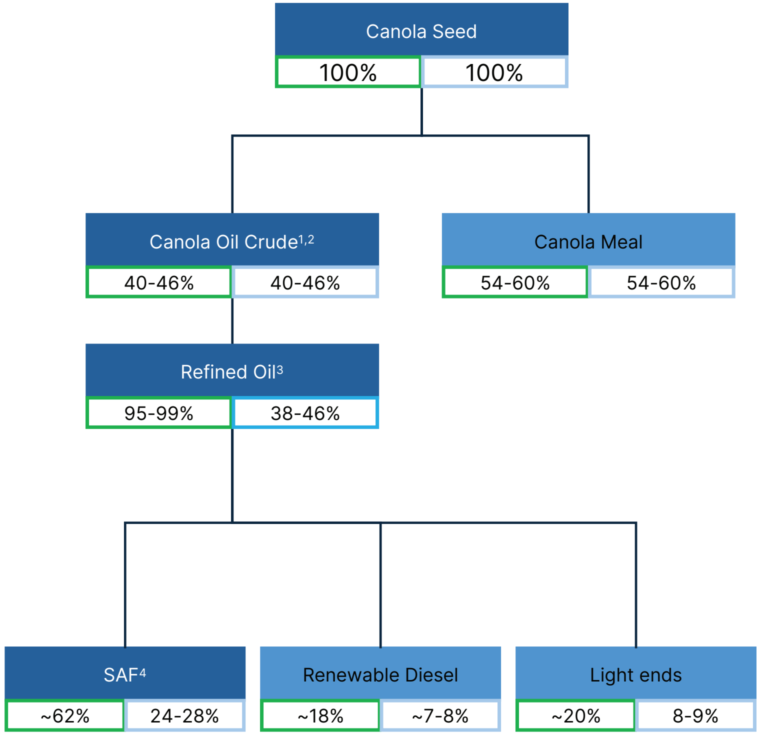
Canola Oil SAF yields

SAF yield depends on oil allocation: converting 100% of canola oil to SAF delivers ~24–28% yield from total seed mass, vs. ~14–17% when using the portion of oil typically allocated to fuels

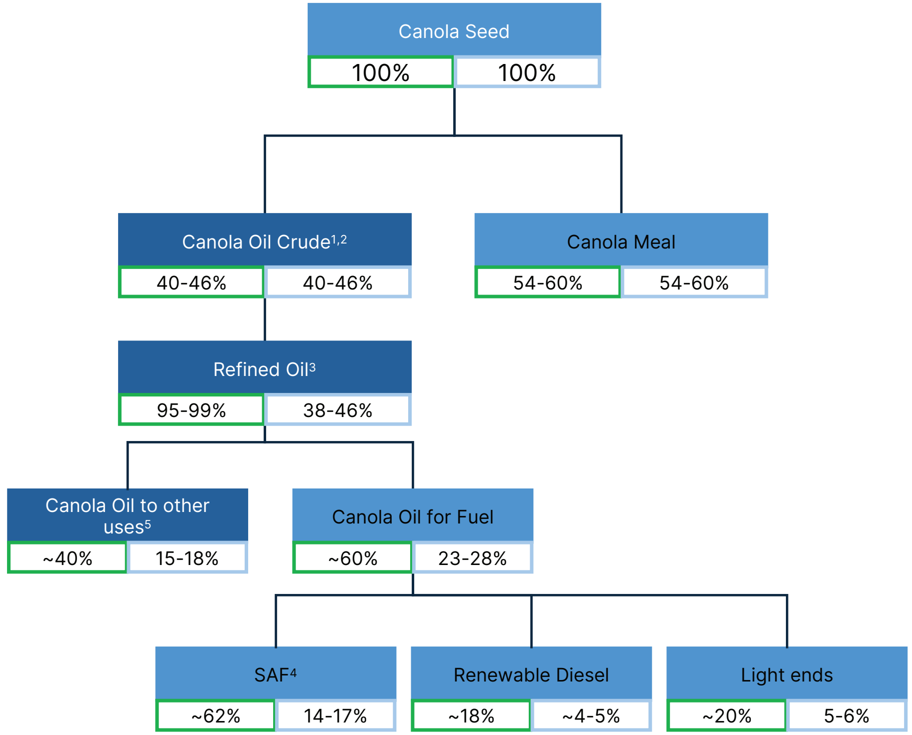
XX% Stage weight conversion   XX% Cumulative weight conversion

Primary product   Secondary products

SAF from 100% Oil Allocation



SAF From Energy-allocated Oil

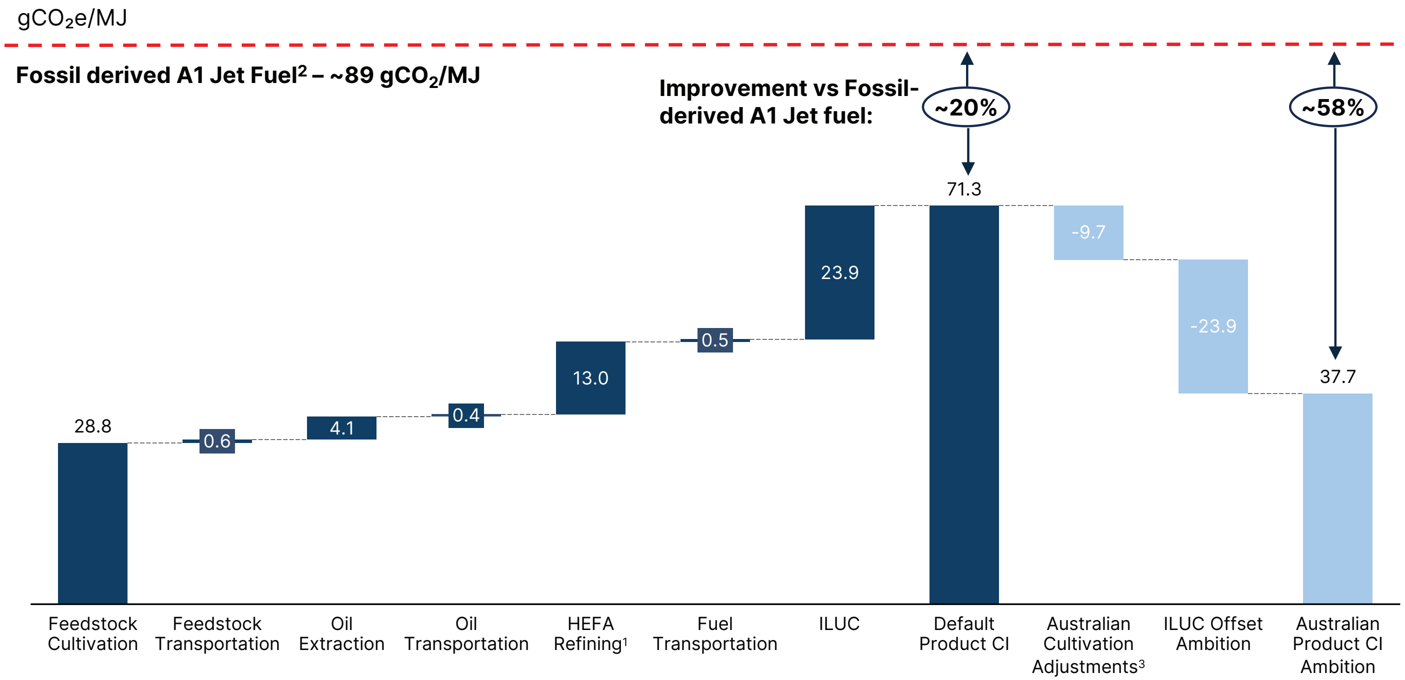


Notes: (1,2) Extractable canola oil per tonne of seed is estimated by multiplying seed oil content (42–47 wt%) by extraction efficiency (96–98%), resulting in ~40–46% recovery of seed mass.(3) Refined oil yield reflects standard industrial refining recovery rates.(4) Energy allocation (~60%) reflects the historical share of canola oil directed to energy markets (biofuel/renewable diesel). (5) Product distribution shares reflect observed HEFA outputs and are not fixed structural demand assumptions.
Source: Department of Primary Industries NSW (DPI), 'Quality of Australian Canola' (2024); DPI, 'Variability of Quality Traits in Canola Seed, Oil and Meal – A Review' (2014); Gavankar & Gómez, 'Techno-Economic Analysis of Civilian Sustainable Aviation Fuel' (2025); Australian Oilseeds Federation, 'Australian Canola and the EU Biodiesel Market' (2024).

Canola Oilseed carbon intensity

SAF derived from Canola Oilseed delivers a ~20% carbon intensity reduction versus fossil jet fuel using default CORSIA values, albeit with potential to reduce CI further with Australian adjustments

Canola Oilseed Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers primarily target cultivation and oil extraction, key upstream drivers of Canola CI

1 Cultivation Practice Improvements

- **Further increases in zero or reduced tillage:** Minimises soil disruption, erosion and increases water retention, decreasing cultivation emissions
- **Improved crop rotation:** Improves soil health and reduces incidences of pests and diseases through crop rotation with cereals and legumes
- **Optimising crop residue management:** Ensures even emergence and consistent soil temperatures when crop residue achieves a uniform spread

2 Crushing Plant Emission Reductions

- **Renewable-powered oil extraction:** Using renewable energy in crushing plant steps such as seed cooking and pressing can reduce emissions during heat-intensive stages
- **Process energy efficiency:** Upgrading manufacturing infrastructure can enhance efficiency and reduce the energy intensity of crushing

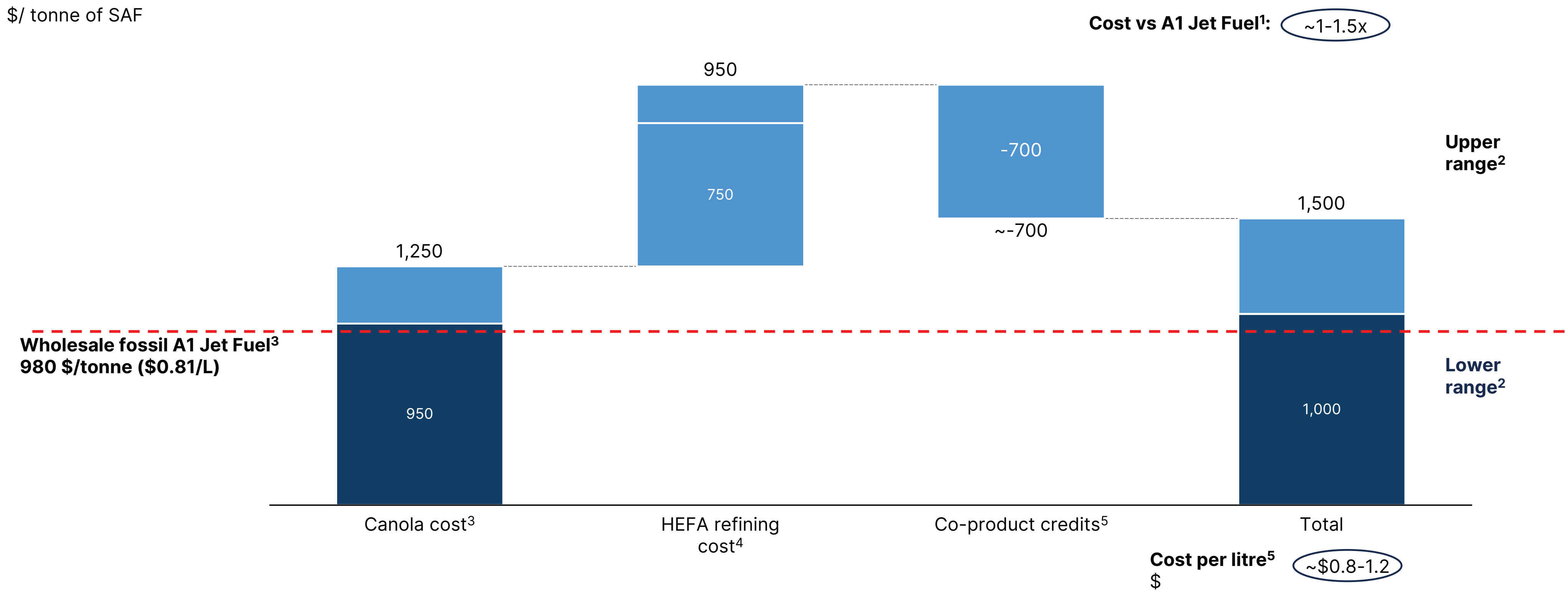
Notes: (1) Add 5.7 gCO_2e/MJ if hydrogen used is produced from coal; add 4.7 gCO_2e/MJ if process heat is produced from coal. (2) CI score calculated under a standalone conversion design. Standard fossil fuel-derived value from CORSIA used as baseline (~89 gCO_2e/MJ). (3) Australian cultivation adjustments based on CSIRO (2023) and Australian Oilseeds Federation (2022). CI of Australian canola cultivation derived using RED LCA methodology, which differs from CORSIA's approach

Source: International Civil Aviation Organization (ICAO), 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – Version 7' (2025); Department of Primary Industries NSW, 'Variability of Quality Traits in Canola: A Review'; Commonwealth Scientific and Industrial Research Organisation (CSIRO), 'Opportunities and Priorities for a Low Carbon Liquid Fuel Industry in Australia' (2025); Australian Oilseeds Federation (2022).

Canola SAF cost

Canola-based SAF remains ~0.8-1.2x more expensive than fossil jet fuel, at around ~ $1.05 $/L versus ~$0.81 $/L for fossil jet fuel

Cost of Production

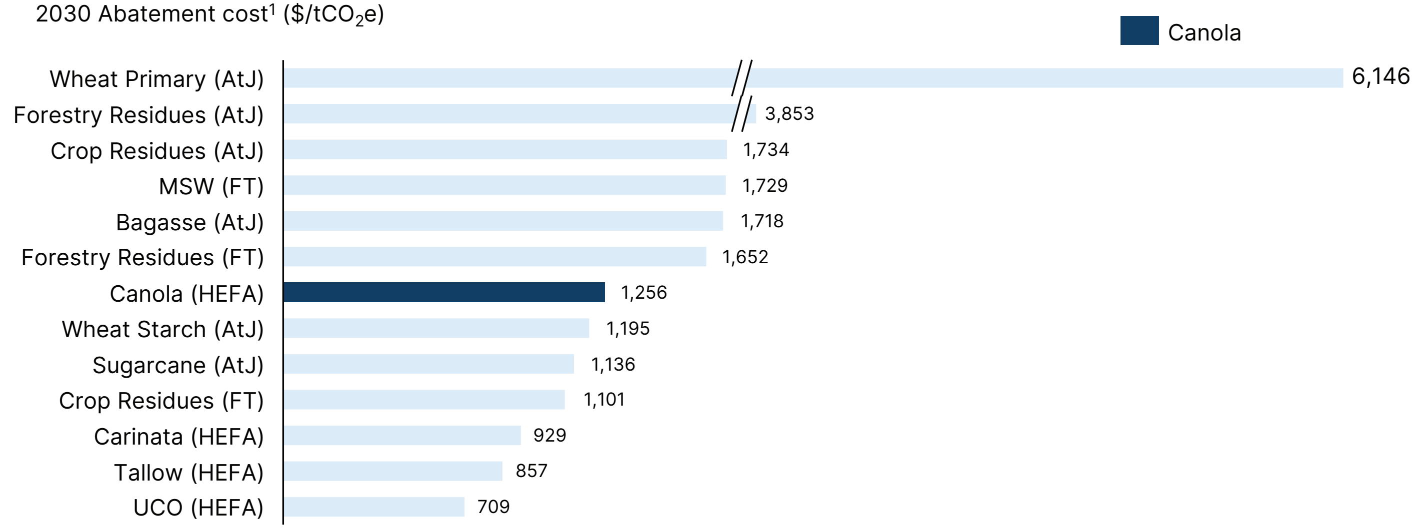


Notes: (1) Conventional jet fuel price of 685 USD/t for Asia & Oceania (~980 $/t) based on IATA/S&P Global Platts Jet Fuel Price Index (30 January 2026).(2) Upper and lower ranges reflect uncertainty in Canola prices and HEFA capital and operating costs; range reflects trailing 12-month volatility. (3) Canola commodity prices taken from trailing 12 months figures. (4) HEFA refining cost reflects standalone conversion estimates. (5) Co-product credits include sale of by-products (renewable diesel); renewable diesel reference price range $2/L, taken as 2x fossil diesel (Australian Institute of Petroleum, 2024).
Source: ATA & S&P Global Platts, Jet Fuel Price Index (2026); Grainwise, 'Canola' (2026); Bioenergy Australia, Bioenergy Market Report (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb'.

Abatement cost curve position

Australian Canola Oil SAF occupies a mid-range position on the abatement cost curve, offering scalable supply with moderate emissions reduction.

SAF Abatement Costs - Australia



$1,256
Canola Oil SAF
$/tCO2e

~1.0-1.5x
Costs
vs. fossil jet

~20%
GHG Reduction
vs. fossil jet

SAF – Abatement cost drivers

- Moderate lifecycle GHG reduction versus fossil jet, driven by agricultural inputs and hydrogen use in the HEFA refining process
- Feedstock pricing linked to crop markets linked to oilseed markets and export parity dynamics

Competitive Context

Scalable domestic feedstock, but higher CI than waste-based pathways

Competes with food and biodiesel markets, pricing tied to global oilseeds

Requires policy and CI incentives to compete with waste-based SAF

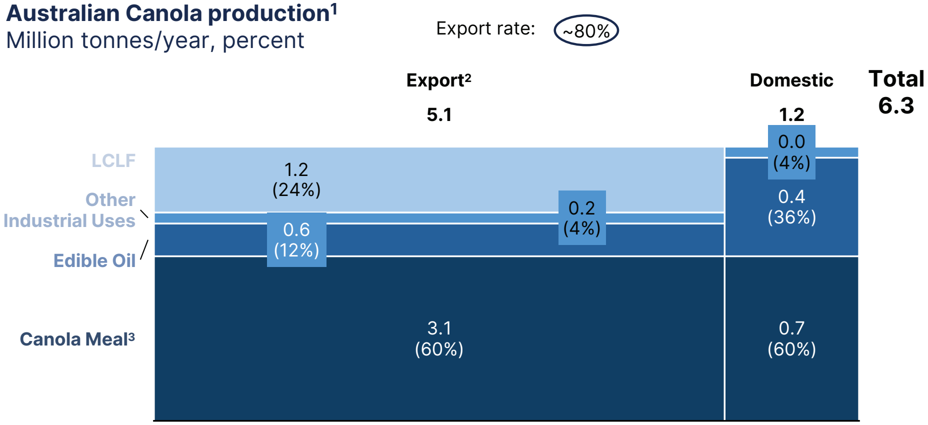
Note: (1) Abatement cost is calculated as the SAF–fossil jet price differential divided by emissions reduction per tonne of fuel, where emissions reduction equals (CI_fossil − CI_SAF) × 43,000 MJ/t ÷ 1,000,000, based on CORSIA default CI values. (2) assumes conservative cost reductions.
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024).

Canola supply potential

Australia has significantly increased Canola production over the last 5 years – averaging ~6.3Mtpa; ~80% is exported to international markets

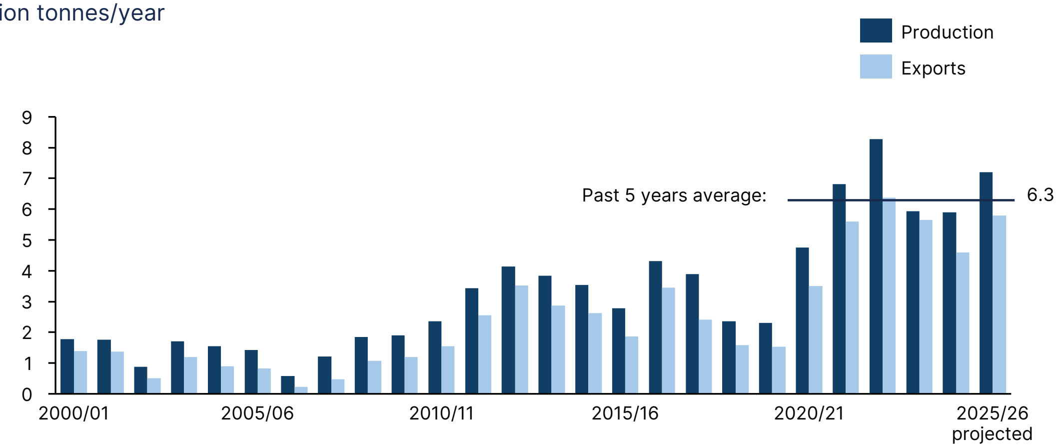
Canola Overview

Australian Canola production[1]
Million tonnes/year, percent



Domestic Production

Australian Canola Seed production and export volume[4]
Million tonnes/year



Current uses

Food-grade oil
Extracted oil is used for cooking and food product manufacturing, valued for its high smoke point and low saturated fat content

Livestock meal
Canola meal is a valuable, protein-rich feed for livestock

Biofuels
Processed into various low carbon liquid fuels, such as biodiesel and SAF

Industry challenges

Soil acidity sensitivity
Canola is particularly sensitive to acidic soils due to its high sensitivity to toxic levels of aluminium and manganese

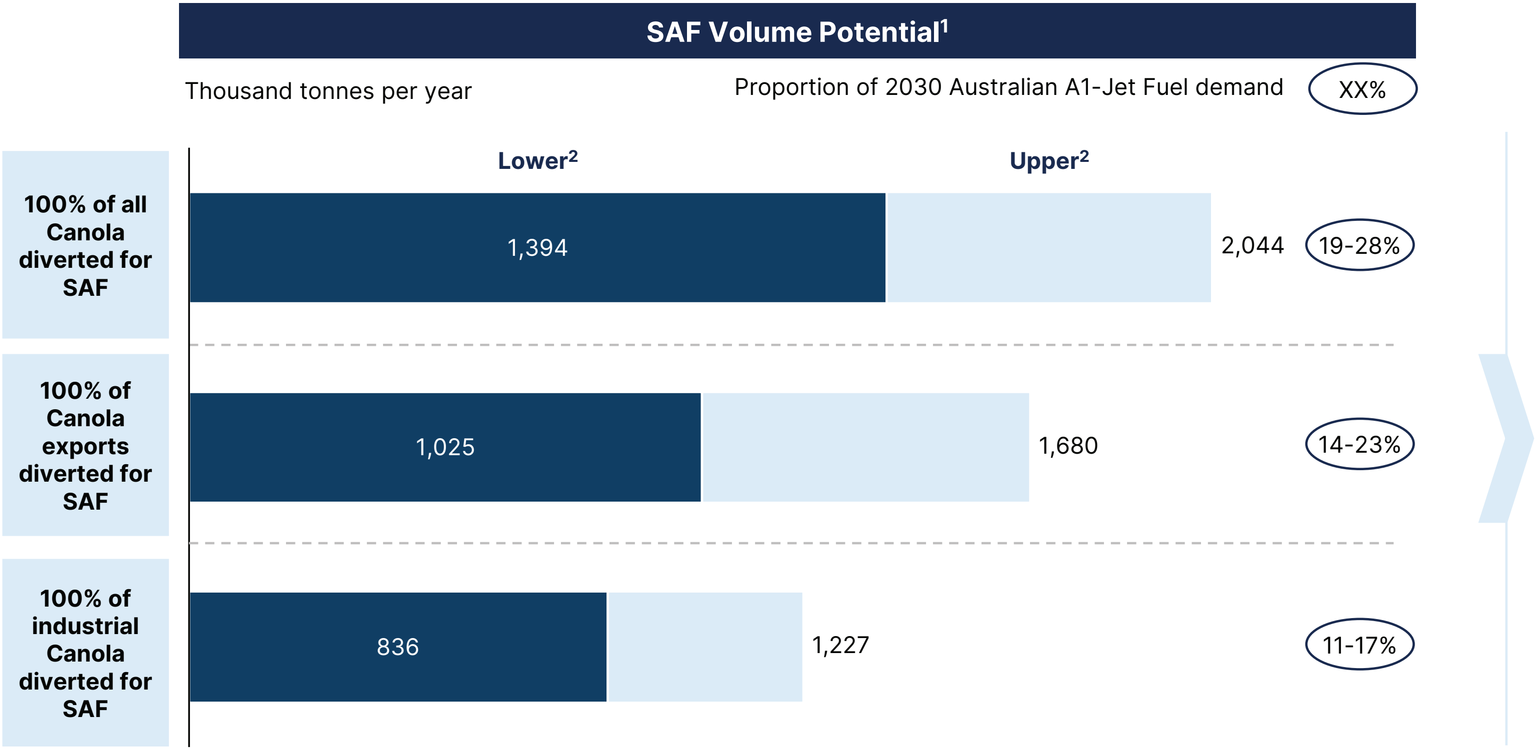
Disease and pests
Blackleg disease requires management through crop rotation and resistance breeding

Climate change
Hotter and drier growing seasons in temperate Australia threaten future crop yields

Notes: (1) Production of ~6.3 million tonnes reflects average of past five years (ABARES data). (2) Export shares extrapolated based on use breakdown in export destinations. (3) Canola meal assumed to represent ~60% of seed mass in both export and domestic allocations. (4) Production and export data sourced from ABARES crop data and December 2025 Australian Crop Report; projections based on composite estimates from Australian Crop Report and Australian Grain 'Domestic and Global Oilseeds Outlook.'
Source: Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), Australian Crop Report (2025); ABARES, Crop Data Portal; Australian Grain, Domestic and Global Oilseeds Outlook (2025); CSIRO, Future Canola.

Canola volume potential and implications

If 100% of supply is diverted, Canola could supply ~19-28% of domestic jet fuel demand, with supply potential remaining at ~14-23% when using exported volumes



Insights

- If 100% of all Australian Canola production is diverted into SAF production, Canola could theoretically supply up to ~19-28% of Australia's 2030 jet fuel demand
- Assuming an export rate of ~74-82%, diverting all Canola exports into domestic SAF production would still yield supply of ~14-23% of 2030 jet fuel demand
- Assuming a non-food use Canola rate of ~60%, with a 100% diversion rate of non-food use Canola into SAF production, non-food Canola could supply up to ~11-17% of 2030 jet fuel demand

Notes: (1) Potential volume is calculated through Canola production volume, export percentage, non food oil %, product yield percentage and SAF yield from Canola oil. It assumes 100% of all available feedstock in that category is diverted to produce SAF. See 'Canola SAF yields' slide for more detailed methodology and sources. (2) Ranges are calculated based on source differences in Canola volume, export percentage, food oil percentage and variation in product yield percentages and SAF yield.
Source: International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb'; ABARES, production data; ABARES, Australian Crop Report (2025).

SAF vs other uses

Export markets, global edible oil demand and biofuel policy anchor canola pricing, shaping its allocation and competitiveness for SAF

Current Market Uses

Road Fuels

Food

Edible cooking oil

Food manufacturing

Global export trade

↓ -4.2% from 2023

Consumption of fats and oils per capita[1]

20.4 grams/day

(2024)

Biofuels

Policy-driven demand

- Biodiesel
- Renewable diesel

Australian Canola Oil Export[2]

70-80 percent

(2023)

Emerging uses

Lubricants

Oleochemicals

Bioplastics

EU Share of canola oil[3]

40 percent food
60 percent renewable fuels

(2023)

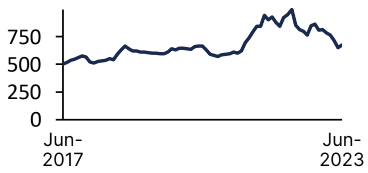
Investment and Economic Challenges

1 **Global edible oil markets anchor canola seed pricing**

Food demand and export parity link Australian pricing to global oilseed markets

Historical seed price volatility reflects tight global stock cycles

Canola seed historical price[4]
$/tonne



2 **Established food and export channels absorb canola supply[3]**

Australia produced ~6.3 MMT of canola per year, reinforcing scale and consistency of supply

Canola exports exceeded ~5.1 MMT, representing 80% of export volume

Strong edible oil demand and established export trade flows absorb significant volumes, leaving SAF to compete at the margin against prevailing export parity prices

3 **Capital follows established food and trade economics[5]**

National crushing capacity is ~1.2 MMT, and projected to increase to ~1.6MMT, with stable annual crush volumes around 800,000 MT, reflecting consistent domestic demand

Record canola oil exports in recent years were driven by global renewable fuel demand

Without aviation-specific incentives, capital and feedstock favour food and export markets over SAF

Notes: (1) Per capita fats and oils consumption based on Australian Bureau of Statistics (ABS) 2024 data; reflects −4.2% change from 2023. (2) Australian canola oil export share (70–80%) based on ABARES agricultural outlook data (2023). (3) EU allocation of canola oil (~40% food, ~60% renewable fuels) based on Australian Oilseeds Federation industry factsheets (2023). (4) Historical canola seed prices based on NSW DPI oilseed price series (2017–2023).(5) Crushing capacity and capital allocation insights based on NSW DPI industry publications and ABARES production statistics.
Source: Australian Bureau of Statistics (ABS), Apparent Consumption of Selected Foodstuffs (2024); ABARES, Agricultural Outlook (2025); Australian Oilseeds Federation, Industry Factsheets (2023); NSW Department of Primary Industries (DPI), Oilseed Publications (2024); USDA/FAS via UkrAgroConsult, ‘Canola continues rise in Australia,’ (2025).

Strategic opportunities

Australia's Canola Oilseed supply could potentially support the domestic SAF industry; unlocking supply requires leveraging scale and local abatement economic benefits

Feedstock Market

Scalable Feedstock Base

Unlike waste-based feedstocks, Canola can be grown at scale, and its production can be expanded through agronomic and logistical improvements

Crop Rotation & Soil Health

Canola serves as a vital break crop in wheat-dominated rotations, helping reduce weed as well as pest pressures and improving soil health. Additionally, this safeguards long-term Canola volumes.

Infrastructure & Processing

Processing Incentives Through Co-product Market Strength

Overall Canola crush economics is supported by the value of co-products such as Canola meal, lowering the breakeven point and incentivizing infrastructure and processing investment.

Abatement Economics

Opportunities to Lower CI With Australian-Specific Factors

Under default CORSIA values, canola SAF reduces CI by ~20%[1] versus fossil jet. With Australian adjustments and ILUC offset ambition, total CI reduction can reach ~58%.

Policy and Direction

Regional Economic Development

Expanding crush capacity and refining infrastructure in regional areas can support job creation, regional manufacturing and supply chain resilience.

Policy Alignment with Agriculture & Decarbonisation Goals

Canola-based SAF provides a pathway to decarbonise aviation while supporting Australian farmers, aligning with both productivity and climate targets

Notes: (1) Default CORSIA CI values for canola-based SAF can be adjusted using Australian-specific cultivation emissions factors, with studies indicating potential lifecycle CI reductions of ~20% under local conditions.(2) Infrastructure and regional development benefits are qualitative assessments based on domestic crushing capacity and co-product market dynamics.
Source: CSIRO, Greenhouse Gas Emissions from the Cultivation of Canola Oilseed in Australia (2023).

Structural and execution challenges

While Australia's Canola Oilseed system possesses several key strengths for SAF, infrastructure gaps and a crowded feedstock market could act as constraints to long-term SAF viability

Feedstock Market

1 High Feedstock Cost Relative to Waste Oils

Canola can be more expensive than UCO and tallow. Limited availability of biofuel-optimised varieties (higher oil content, lower nitrogen requirement) constrains cost and CI improvements.

2 Export Competition

Established export markets set the price for canola seed. Local SAF refiners must match export-parity pricing (FOB plus freight equivalent) to secure supply

3 Global Price Volatility

Oilseeds, such as canola, are traded on global commodity markets and are subject to significant price volatility driven by exogenous factors such as drought and geopolitical events

4 Hydrogen Access and Cost in Canola Regions

Green hydrogen production in Australia is still nascent, with around 15 small-scale facilities nationwide, the majority located in canola-growing states (WA, VIC, NSW and SA)

Abatement Economics

5 ILUC Penalty in CORSIA

The ILUC penalty increases the lifecycle CI of Canola-based SAF, reducing its attractiveness in global markets without domestic policy offsets

Infrastructure & Processing

6 Refining Integration Complexity

Canola requires co-location or logistics coordination between farming, crushing, pretreatment and refining - a challenge in a nation-wide value chain

7 Crushing Infrastructure Deficit

Less than one-third[1] of Canola production is currently crushed domestically, limiting oil availability for local SAF production

Notes: (1) Domestic crushing capacity estimates based on NSW Department of Primary Industries (2023) oilseed publications and Australian Oilseeds Industry production statistics. (2) Hydrogen infrastructure references reflect current distribution of green hydrogen facilities in Australia (Grattan Institute, 2025). (3) ILUC treatment consistent with CORSIA default methodology.
Source: NSW Department of Primary Industries (DPI), Oilseeds Publications (2023); Australian Oilseeds Industry, Industry Facts & Figures; Grattan Institute, What's Hampering Hydrogen (2025); ICAO, CORSIA Methodology.

Infrastructure and processing gaps

To supply 3-5% of 2030 domestic fuel demand with Canola SAF, HEFA infrastructure investment is required, in addition to a potential increase in domestic crushing capacity

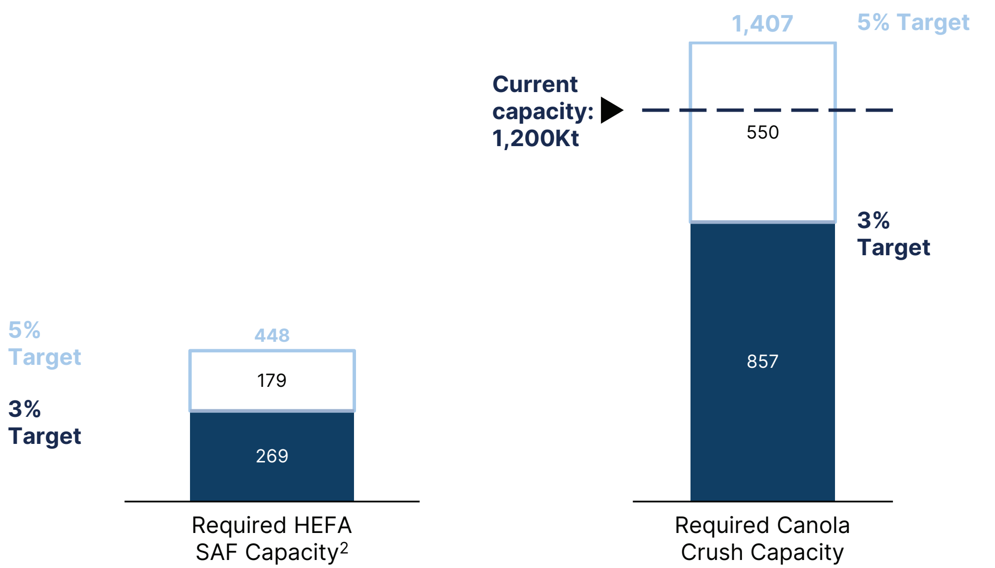
HEFA (ML) and Crush (kt) Capacity Required for 3–5%

Meeting the 3–5% 2030 Target Requires 269–448 ML of HEFA Capacity[1]

Million litres per year

Supplying This Output Requires 857–1,407 kt of Domestic Canola Crush[3]

Thousand Tonnes per year



Planned HEFA Developments in Australia

AMPOL, GrainCorp & IFM, Lytton Refinery – Brisbane, Qld

Description: Proposed large HEFA facility producing SAF and RD
Feedstocks: Waste oils (e.g. UCO), tallow and canola oil
Planned capacity: 750ML of LCLF per year, a mix of SAF (~90%) and RD (~10%)
Development status: Pre-FEED stage completed late 2025, co-funded by ARENA

Jet Zero Australia & Apeiron Bioenergy, Project Mandala – Gladstone, Qld

Description: Proposed large HEFA facility producing SAF and renewable diesel (RD)
Feedstocks: Waste oils and non-edible and excess crop oils (e.g. Canola)
Planned capacity: 402ML of LCLF per year (308,000 tonnes), a mix of SAF and RD
Development status: Pre-FEED stage. Feasibility study due for completion by 2026

APAC Regional HEFA Refineries

Neste, Tuas Refinery, Singapore

- HEFA facility using waste and crop oils (e.g. Canola) completed in April 2023
- Capacity: ~1,200ML per year, supplied to airlines such as Singapore Airlines

SK Energy, Ulsan Refinery, South Korea

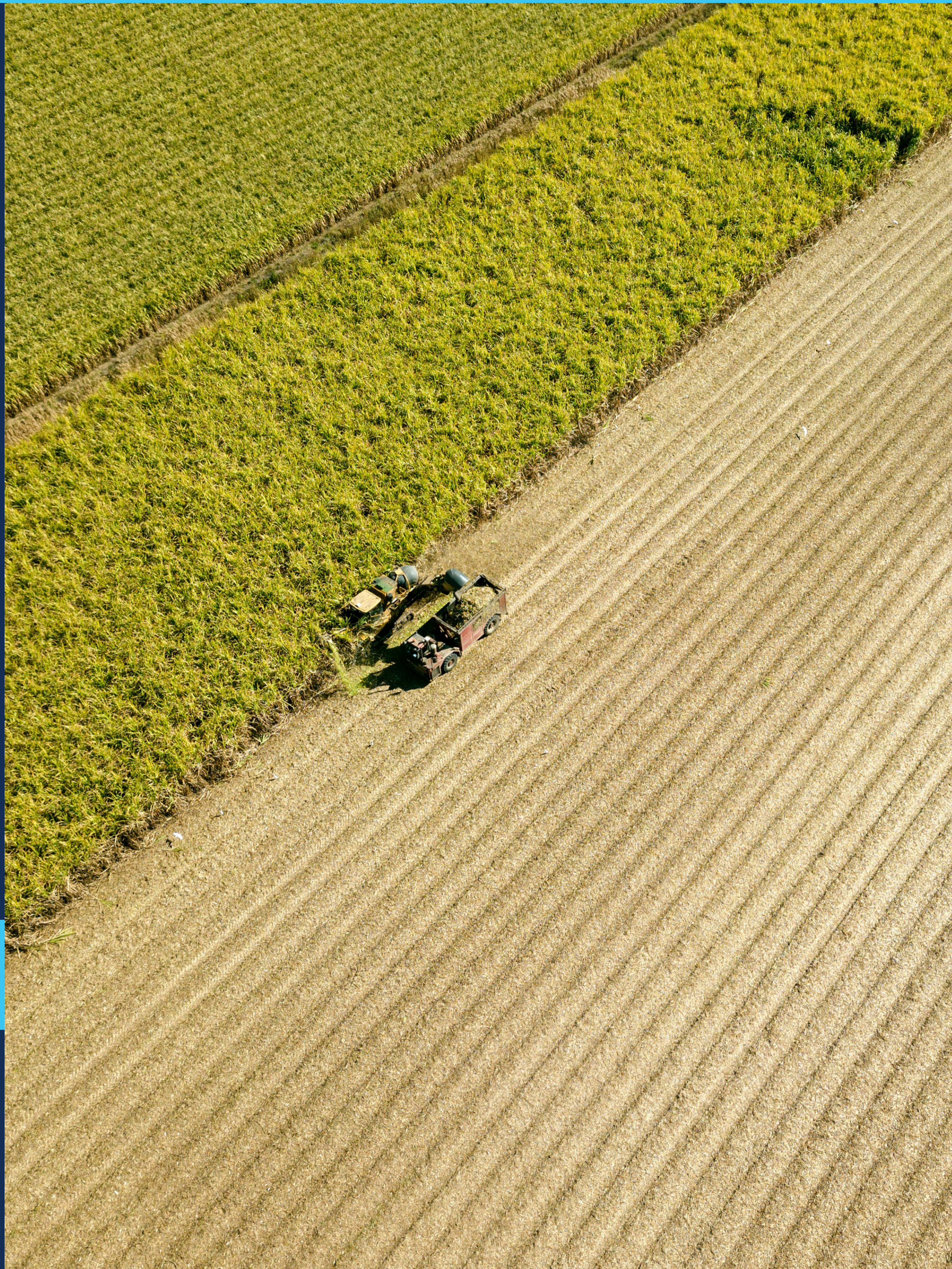
- HEFA facility using waste oils completed in September 2024
- Capacity: ~120ML per year (~80% SAF), supplied to airlines such as Korean Air and Cathay Pacific

Notes: (1) Required/target capacity refers to 3–5% of Australia's 2030 jet fuel demand (~9,000 ML), in line with Singapore's proposed 2030 targets. (2) Refined canola oil yield and SAF conversion assumptions derived from 'Canola SAF volume potential and implications' calculations (~1 kg refined canola oil → ~0.62 kg SAF). (3)~2.9-3.5kg of Canola Oilseed is required to produce 1L of SAF. (4) APAC reference facilities included as benchmarks for regional scale and commissioning timelines.
Source: Jet Zero Australia, Project Mandala (2025); Manufacturing Monthly (2025); ARENA, Ampol Brisbane Renewable Fuels Pre-FEED Study; Argus Media (2024); Neste, Singapore Refinery Overview; World Grain, Australian Canola Production.

10

SAF feedstock deep dives

b. Sugar crops



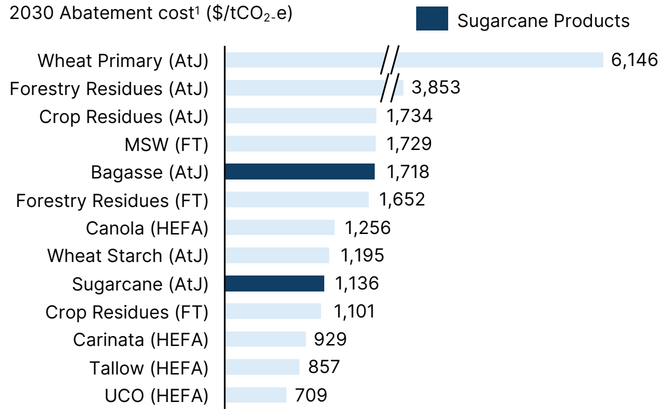
Sugarcane Summary

Sugarcane is a technically viable SAF feedstock via the ATJ pathway, sitting mid-range on Australia's abatement cost curve and leveraging existing sugar milling infrastructure

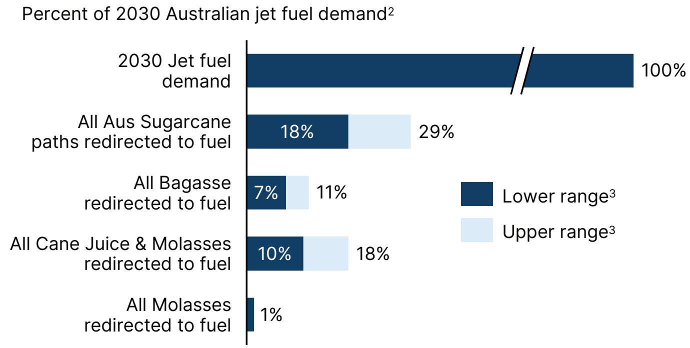
Executive Summary

Technical viability	Sugarcane is a technically proven SAF feedstock via the ATJ pathway, leveraging mature sugar-to-ethanol conversion processes. Bagasse can also be converted via Fischer-Tropsch gasification as an alternative pathway[5] Australia has established sugar milling and ethanol capability, providing a credible platform for early SAF deployment[4]
Emission reduction potential	Sugarcane-derived SAF delivers ~40% CI reduction (~53 vs ~89 gCO_2e/MJ), while Bagasse-based SAF delivers ~55% reduction (~40 vs ~89 gCO_2e/MJ) CI is driven primarily by cultivation, upgrading and ILUC; Bagasse pathways show zero ILUC in the default case
Economic competitiveness	The most cost-efficient Sugarcane pathways remain ~2.8-3.8x the cost of fossil jet fuel, with Bagasse being up to ~4.9-5.2x more expensive Secondary-product sugarcane routes are higher than the primary route due to the combination of higher production costs not fully offsetting lower CI
Australia's opportunity	Australia produces ~32 Mt of Sugarcane p.a., which could theoretically enable ~0.8–1.3 Mt of SAF (or ~1.3-2.1 Mt if including Bagasse) This is equivalent to ~10–18% of Australia's projected 2030 jet fuel demand, under a 100% diversion scenario (or ~18-29% if including Bagasse)
Australia's scale potential	In practice, scale-up may be constrained by: – Limited downstream ethanol capacity (~360 ML p.a., with ~60 ML being sugar-based) – The absence of commercial-scale ATJ refining

2030 SAF Abatement Costs - Australia



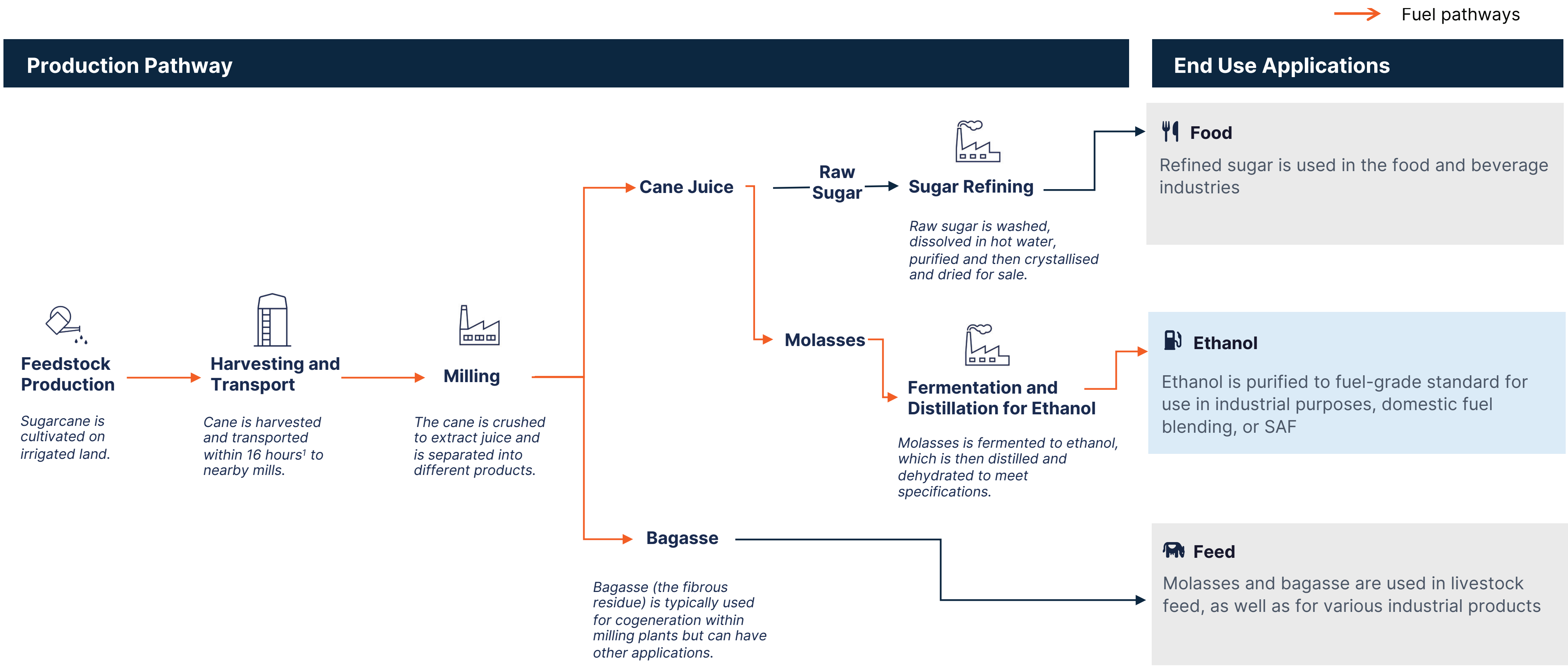
2030 Jet Fuel Volume Potential vs 2030 Demand



Notes: (1) Assumes conservative cost reductions. (2) For percent of 2030 Australian jet fuel demand refer to the slide 'Sugarcane volume and potential implication'. (3) Ranges are calculated based on annual differences in sugarcane harvest volume, variation in product yield percentages, ethanol yield and ATJ SAF conversion efficiency. (4) For yields information please refer to 'Sugarcane SAF yields'. (5) Fischer-Tropsch (FT-SPK) via bagasse gasification is an ASTM-certified pathway with high GHG reduction potential, but comprehensive Australian cost and yield data remain limited. Pathway included for completeness pending further industry development.
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024); ABARES, agricultural production statistics.

Sugarcane value chain

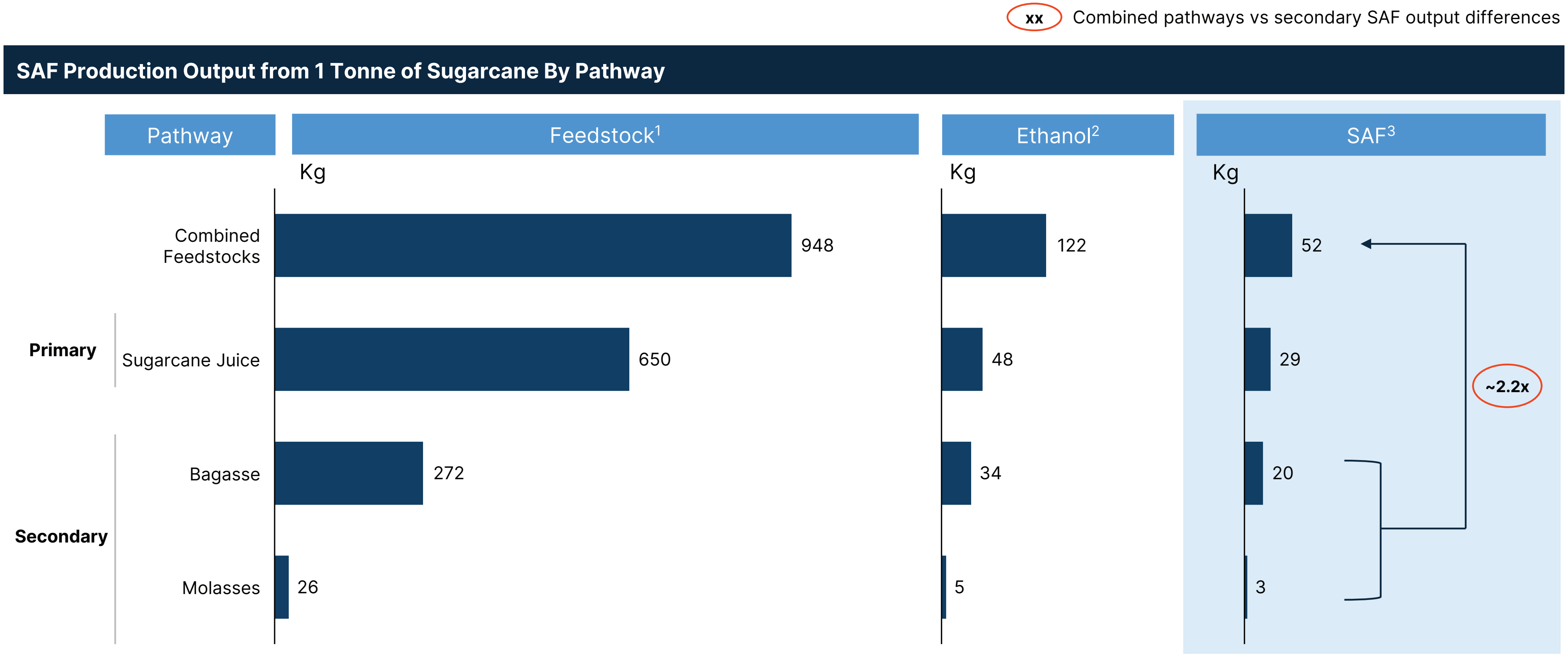
Sugarcane is a technically proven SAF feedstock with multiple primary and by-product conversion pathways using the Alcohol-to-Jet process



Notes: (1) This is required to minimise sucrose deterioration and juice evaporation.
Source: Canegrowers, 'Learn About Sugarcane' (2026).

Sugarcane SAF yields

SAF yields vary materially by pathway, with combined Sugarcane pathways yielding ~2.2× higher output than current secondary routes alone



Notes: (1) Feedstock mass distribution based on typical sugarcane composition ranges (juice, bagasse and molasses fractions). (2) Ethanol yields derived from fermentation conversion efficiencies for sucrose and lignocellulosic pathways.(3) SAF output calculated using ethanol-to-jet (ATJ) conversion efficiency assumptions. (4) The ~24x differential refers to combined feedstock pathways (72 kg SAF) relative to molasses-only secondary route (3 kg SAF).
Source: Australian Government Office of the Gene Technology Regulator (2011); Zabed et al. (2014); Lifecycles (2021); Sugar Research Australia (2019); International Civil Aviation Organization (2025).

Sugarcane SAF yields

Total SAF yields from Sugarcane can reach ~5% by weight compared to the standard Molasses secondary route of ~0.3%

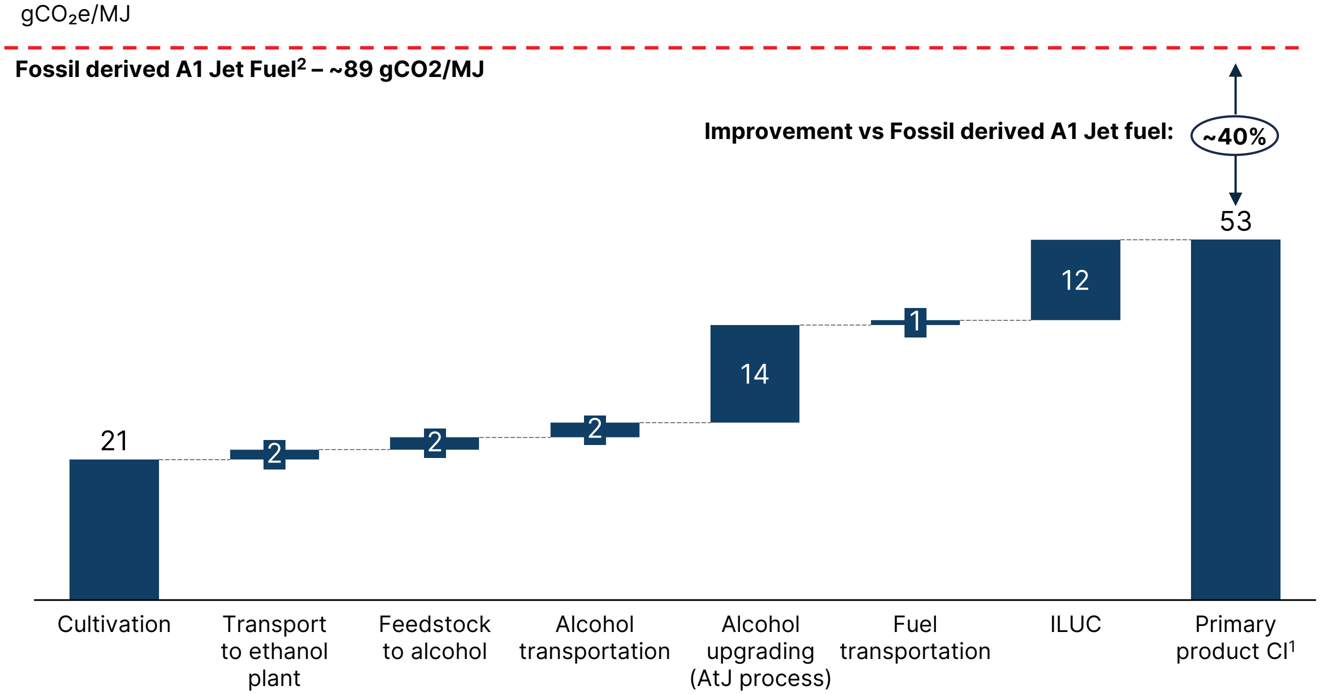
Notes: (1) The by-products of distillation not converted to ethanol are carbon dioxide and a slurry known as vinasse. Vinasse can be used as an organic fertiliser, but due to high mineral content must be managed carefully to prevent environmental damage.(2) Total SAF yield (~7%) and molasses-only yield (~0.3%) are derived from cumulative stage conversion assumptions combining cane composition, ethanol fermentation efficiency and ATJ product yield distribution.

Source: Australian Government Office of the Gene Technology Regulator, 'The Biology of Sugarcane' (2011); Santos et al., 'Sugarcane Biorefinery, Technology and Perspectives, Chapter 2 – By-products of the Sugarcane Industry' (2020); International Civil Aviation Organization, 'SAF Rules of Thumb' (2025); Beltyukov, 'The Most Viable Route to Greener Skies' (2026); Lifecycles, 'Life Cycle of Ethanol Production from Bagasse Using MicroBioGen Yeast Strains' (2021); Bulderiek et al., 'Direct Alcohol vs Alcohol-to-Jet SPK Utilisation in Commercial Aviation' (2022).

Sugarcane carbon intensity

SAF derived from Sugarcane Juice or Molasses delivers a ~40% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Sugarcane Juice and Molasses Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers primarily target cultivation and ILUC emissions, which drive a large proportion of Sugarcane-to-SAF lifecycle CI

1 Feedstock Cultivation

- **Switch to renewable-powered irrigation:** Replace diesel or grid-powered pumps with solar or renewable-powered systems
- **Adopt low-emission fertilisers:** Use enhanced efficiency fertilisers or bio-based inputs to reduce N_2O emissions
- **Optimise nitrogen application:** Apply fertilisers using precision ag tools or variable rate technology to reduce overuse
- **Improve soil carbon sequestration:** Use cover cropping, trash blanketing, and reduced tillage to enhance soil organic carbon
- **Deploy higher-yielding, drought-tolerant varieties:** Reduces land-use emissions per tonne of cane produced
- **Reduce diesel use in harvesting machinery:** Transition to electric or more efficient equipment where feasible

2 Supply Chain Improvements

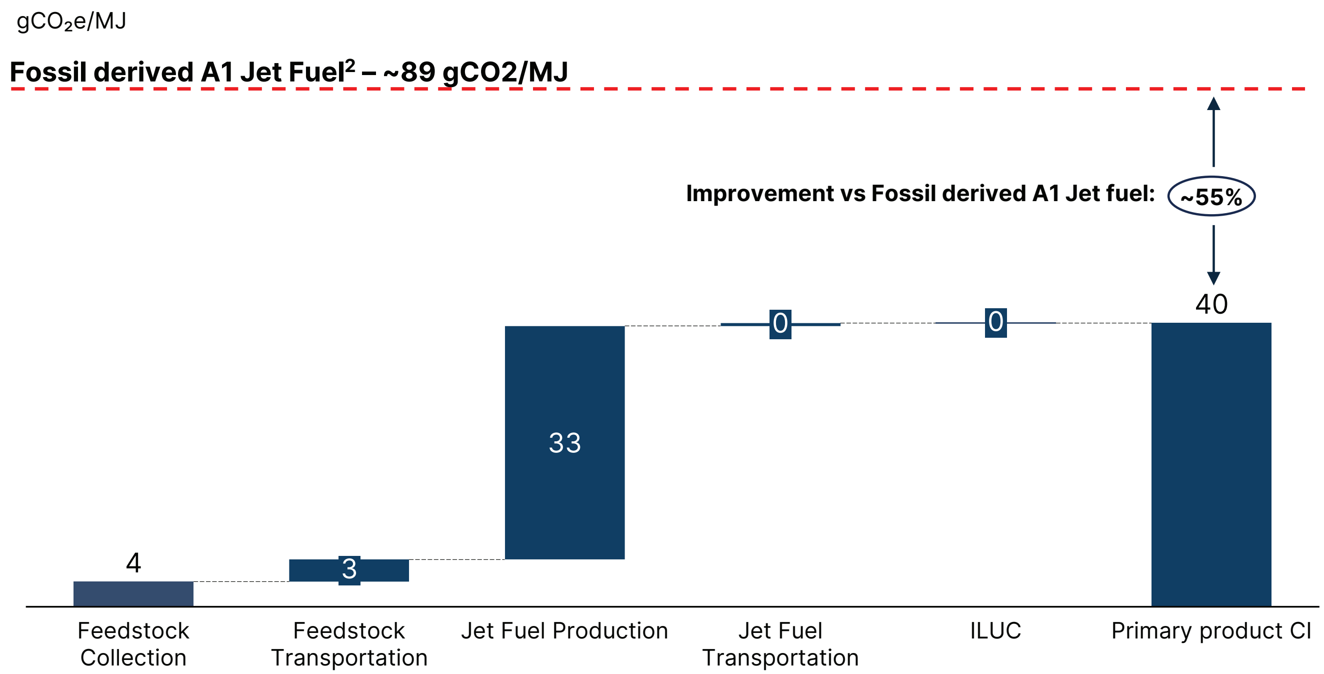
- **Shorten cane-to-mill interval:** Reduces degradation and need for reprocessing, lowering energy use
- **Improve land use governance:** Ensure zero-deforestation, low-ILUC sourcing policies are in place

Notes: (1) Subtract 20.3 gCO2e/MJ for an integrated conversion design (ethanol and ATJ refining in the same plant). Subtract 19.0 g CO2e/MJ if using the isobutanol conversion process in place of ethanol. CI score calculated under a standalone conversion design (2) Standard fossil fuel derived value from CORSIA. (3) Australian cultivation may yield lower cultivation CI values, but no national specific values have been recognised thus far.
Source: International Civil Aviation Organization (ICAO), CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025 (2025); International Civil Aviation Organization (ICAO), CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – Version 7 (2025).

Bagasse carbon intensity

Bagasse-based SAF delivers a large ~55% carbon intensity reduction versus fossil jet fuel

Bagasse Carbon Intensity Build Up[1]



CI Reduction Levers

These levers primarily target logistical efficiencies that can be adopted to reduce overall process CI

1 Feedstock Logistics and Densification

- **Improve logistics efficiency:** Implementing bulk aggregation points or pelletisation, reducing emissions associated with feedstock collection and haulage
- **Locating biorefineries close to residue-producing regions:** Further minimises emissions from transport

2 Pre-Treatment Efficiency

- **Adopting solar drying techniques:** Using solar or low-grade waste heat from adjacent industrial processes reduces CI and operating costs for the carbon-intensive drying phase necessary for high-moisture feedstocks such as Sugarcane bagasse
- **Improve land use governance:** Ensure zero-deforestation, low-ILUC sourcing policies are in place

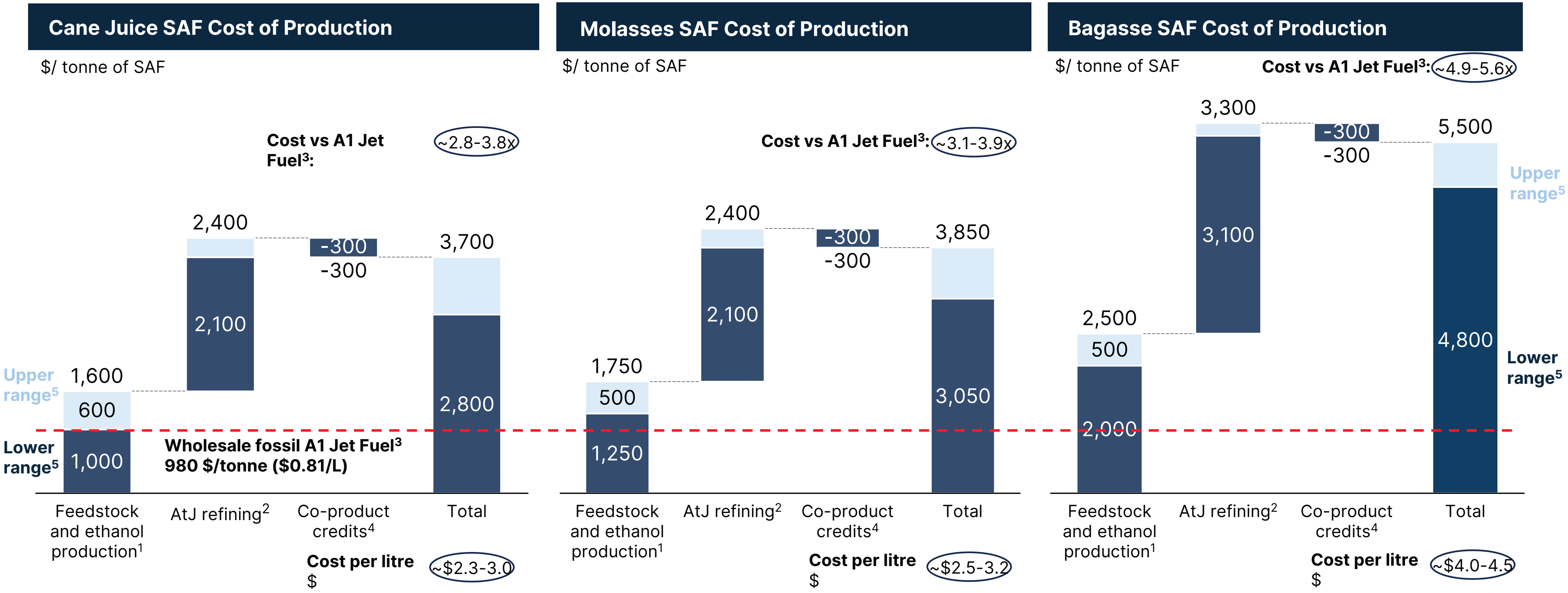
3 Land Use Benefits

- **Unlock soil and carbon sequestration benefits:** Transforming crop residues into biochar – a stable carbon form – can create negative emissions and maintain soil health, preventing ILUC concerns

Notes: (1) CORSIA default numbers for agricultural residue, used as per CORSIA guidance for cane trash. Add 13.6 gCO2e/MJ if process heat is produced from coal. Subtract 10.4 gCO2e/MJ if using the isobutanol conversion process in place of ethanol. CI score calculated under a standalone conversion design. Standard fossil fuel derived value from CORSIA.
Source: International Civil Aviation Organization (ICAO), CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025 (2025); International Civil Aviation Organization (ICAO), CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – Version 7 (2025); International Civil Aviation Organization (ICAO), SAF Rules of Thumb (2025).

Sugarcane SAF cost

The most cost-efficient Sugarcane pathways remain ~2.8-3.8x the cost of fossil jet fuel, with Bagasse being up to ~4.9-5.6x more expensive



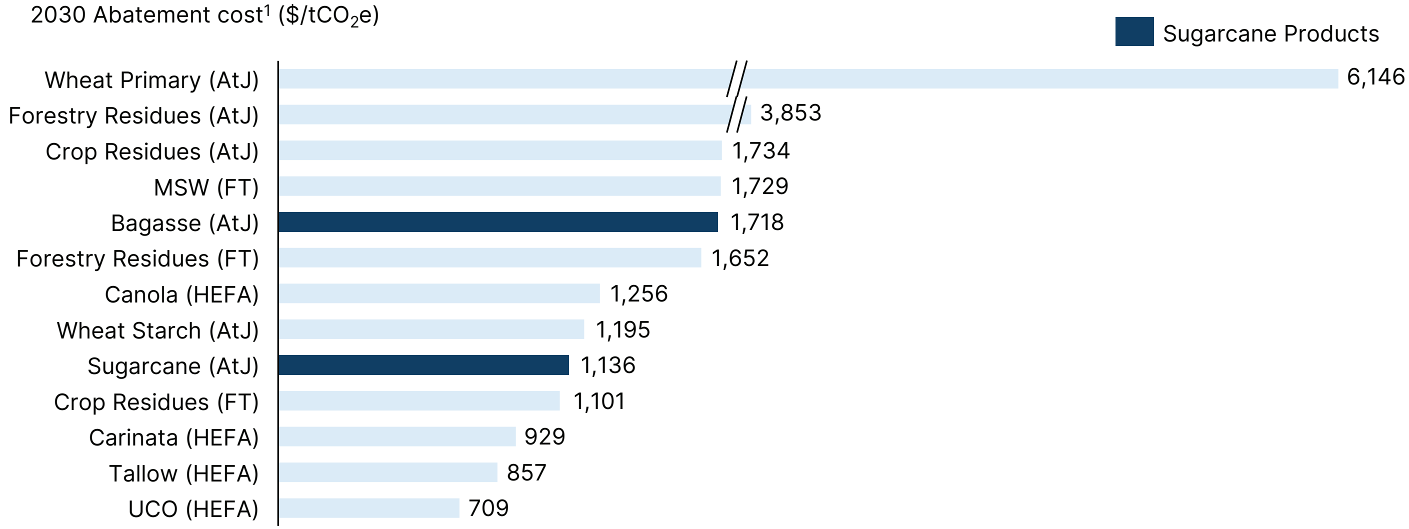
Notes: (1) Feedstock and ethanol production is inclusive of feedstock cost, direct costs, maintenance, indirect costs, return on RAB + depreciation and co-product credits. (2) AtJ refining is based on pioneer facility costs from the ICAO SAF rules of thumb, in addition to opex costs from CEFC. (3) Conventional wholesale jet-fuel price of 686 USD/t for Asia & Oceania (≈980 $/t) is taken from the IATA/S&P Global Platts Jet Fuel Price Index for 30 January 2026. SAF multiple of A1 jet fuel is taken from the midpoint of the lower and upper ranges. (4) Co-product credits from the AtJ refining process include naphtha and LPG. (5) Upper and lower ranges capture uncertainty in SAF yield percentages and AtJ refining capex.

Source: AECOM, Efficient Costs of New Entrant Ethanol Producers (2016); Jet Zero Australia, Submission to the Commonwealth Government Aviation Green Paper (2023); International Civil Aviation Organization (ICAO), SAF Rules of Thumb (2025); Santos et al., Integrated 1st and 2nd Generation Sugarcane Biorefinery for Jet Fuel Production in Brazil: Techno-economic and Greenhouse Gas Emissions (2018); Clean Energy Finance Corporation (CEFC), Refined Ambitions – Appendices (2024).

Abatement cost curve position

Sugarcane-based SAF sits mid-range when compared with other feedstocks' abatement costs in Australia, with bagasse-based pathways at the upper end due to more costly processing and capital intensity

SAF Abatement Costs - Australia



$1,100-1,800
Sugarcane abatement costs SAF
$/tCO2e

~2.8-5.6x
Costs
vs. fossil jet

40-55%
GHG Reduction
vs. fossil jet

SAF – Abatement cost drivers

- Mid-range abatement costs driven by relatively low feedstock CI and bagasse-supported process energy
- Pathway optionality (Sugarcane Juice, Molasses, Bagasse) enables optimisation across cost and emissions, but does not achieve lowest-cost abatement

Competitive Context

Lower abatement cost than crop-based FT pathways; higher cost than waste-lipid HEFA routes

Exposure to sugar and ethanol market dynamics, which influence feedstock pricing, margins, and scalable volumes based on mill economics

Notes: (1) Assumes conservative cost reductions.
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024).

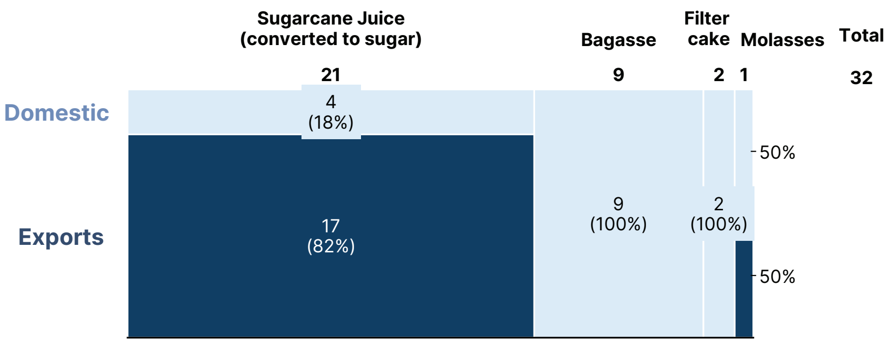
Sugarcane supply potential

Australia produces ~32 million tonnes of sugarcane annually, with most output currently sold to export markets

Sugarcane Overview

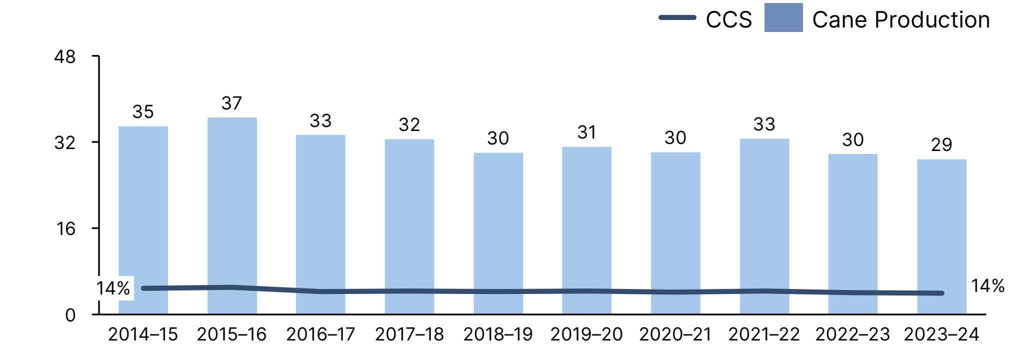
Cane production[1]
Million tonnes/year, percent

Export rate: ~82%



Domestic Production

Cane production and commercial cane sugar (CCS) by season[1]
Million tonnes, percent



Current uses

Sugar	Bagasse	Molasses	Ethanol
Export and domestic use in food and beverage manufacturing, and retail	Mainly utilised for generating electricity at mills, bagasse is also used as livestock feed and to produce fibrous items	Livestock feed; yeast, ethanol production and rum production; pharmaceuticals; industrial uses as a binding agent	Primarily for domestic E10 fuel blending, current capacity is ~60ML/year[2]

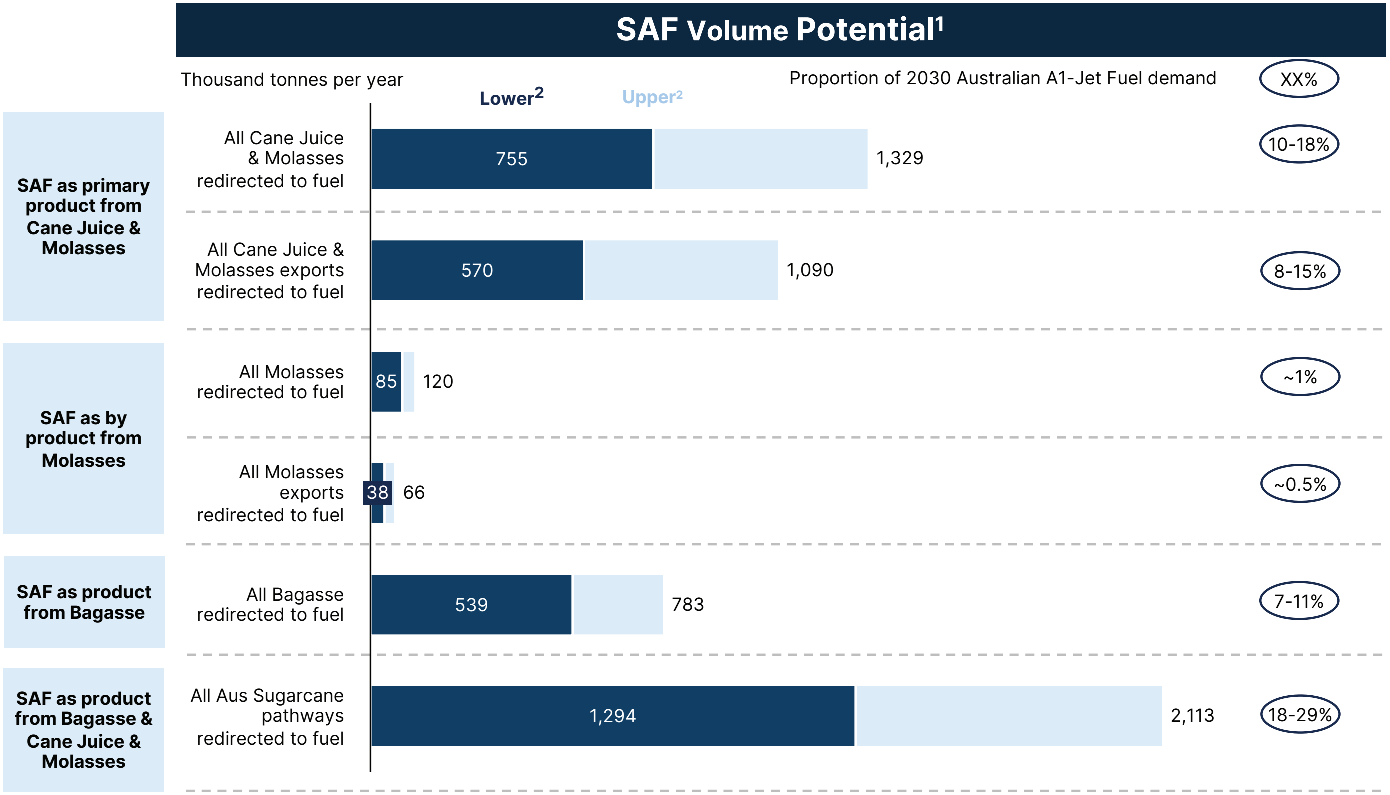
Industry challenges

Weather volatility	Shrinking and ageing grower base	Ageing infrastructure
More frequent floods, droughts and cyclones disrupt yields and reliability	Fewer farmers, ageing workforce and weak succession reduce supply	Old mills increase costs, downtime, and capital required for modernisation
>6 Mt lost from Cyclone Yasi	**>60,000 ha reduction in harvested area since mid-2000s**	**>70% of mills are over 100 years old**

Notes: (1) Cane production, CCS figures and export volumes are 10-year averages based on ABARES data from 2014-15 to 2023-24. (2) Ethanol production figure refers to current installed capacity of ~60 ML/year from sugarcane, primarily used for domestic E10 fuel blending. National ethanol capacity is ~360ML/year, with the rest coming from starch-based sources.
Source: Sugar Nutrition Resource Centre, 'Where does sugar come from?' (2016); Business Queensland, 'Queensland biofuels mandates' (2024); Sugar Research Australia (SRA), 'Final report: Industry priorities for value add & diversification opportunities in the sugar industry' (2019); Grain Central, 'Australia's ethanol plants underutilised by 60pc' (2025); CSIRO/Boeing, 'Sustainable Aviation Fuel Roadmap' (2023); Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). (2015–2024). Agricultural commodities reports; Canegrowers Australia – Industry facts and figures (2023–24).

Sugarcane volume potential and implications

With current production levels, under a 100% diversion scenario, Sugarcane could supply ~18-29% of Australia's 2030 jet fuel demand with 7-11% from Bagasse, a by-product of the milling process



Insights

- If 100% of all Australian production is diverted, Sugarcane could theoretically supply ~18–29% of Australia's 2030 jet fuel demand
- Utilising all export Cane Juice and Molasses could provide 8-15% of 2030 jet fuel demand
- Bagasse holds a high supply potential, theoretically capable of supplying ~7-11% of Australia's 2030 jet fuel demand if 100% utilised

Notes: (1) potential volume is calculated through cane production volume, product yield percentage, export percentage, ethanol yield and SAF yield from ethanol. It assumes 100% of all available feedstock in that category is diverted to produce SAF. (2) Ranges are calculated based on annual differences in sugarcane harvest volume and variation in product yield percentages, ethanol yield and SAF yield.
Source: ABARES, 'Agricultural Commodities and Trade Data' (2023); Australian Government Office of the Gene Technology Regulator, 'The Biology of the Sugarcane' (2011); Australian Cane Farmers Association (ACFA), 'Sugar Milling' (2020); Zabed et al., 'Bioethanol Production from Fermentable Sugar Juice' (2014); Sugar Research Australia, 'Industry Priorities for Value Add & Diversification Opportunities in the Sugar Industry' (2019); Lifecycles, 'Life Cycle of Ethanol Production from Bagasse using MicroBioGen Yeast Strains' (2021); ICAO, 'SAF Rules of Thumb' (2025); AECOM, 'Efficient Costs of New Entrant Ethanol Producers' (2016).

SAF vs other uses

Food competition does not appear to be a constraint in Australia; system structure and capital allocation are the primary determinants of fuel scale-up

Current Market Uses

Food & Beverage Industry

Beverages
Soft drinks, juices, cordial, rum (alcohol from molasses)

Bakery products
Bread, pastries, cakes

Confectionary
Chocolates, sweets

Preserved food
Jams, canned foods

Retail
Supermarket sugar and molasses

AU global sugar production share[1]
~2 percent
(2024)

Largest sugar producer markets[2]
Brazil (~23 percent)
India (~19 percent)
EU (~8 percent)[1]
(2024)

AU sugar exported
~82 percent
(10-year average)

Investment and Economic Challenges

1 Limited global impact and strong export orientation
- Australia accounts for ~2% of global sugar production and is a price taker
- Changes in Australian output are unlikely to materially affect global sugar prices
- ~80% of AU sugar is exported; domestic consumption represents a small share
- Fuel production could draw from export volumes rather than domestic food supply

2 Existing cane footprint and limited land substitution
- Sugarcane volume is already established; fuel would not necessarily require expansion of crop acreage
- Cane-growing regions are agro-climatically specialised and not easily substitutable with other food crops
- Indirect land-use change risk is therefore limited in the Australian context

3 Installed capacity limits rapid reallocation to fuel
- Production flexibility depends on installed capacity: in Brazil, diversified sugar–ethanol mills allow output to shift with price signals
- Australia's milling base is smaller and primarily configured for sugar export, limiting current reallocation ability
- Fuel expansion would require new or repurposed capacity, implying additional capital

Notes: (1) the EU is the leading producer of beet sugar.
Source: U.S. Department of Agriculture (USDA), 'Sugar: World Markets and Trade' (2024); International Sugar Organization (ISO), 'ISO Sugar Yearbook 2024' (2024); Agraria.pe, 'Producción mundial de azúcar ascendió a 186 millones de toneladas' (2024); Vesper Energy, 'Understanding future Brazilian sugar production levels with Vesper's new sugar-ethanol parity widget' (2023).

Strategic opportunities

Australia's sugar supply creates a strong SAF opportunity; unlocking scale depends on expanding processing and conversion capacity in an economic manner

Feedstock Market

Large and Consistent National Supply

Australia produces ~32 million tonnes of Sugarcane annually, providing a scalable and reliable domestic feedstock pool.

Export Market Potential

~80% of sugar produced in Australia in exported, and ~50% of molasses. This allows for some supply to potentially be diverted without impacting domestic food and beverage supply.

Abatement Economics

Geographic Concentration Benefits

With ~95% of Sugarcane grown in Queensland, this allows the feedstock to SAF pathway to be concentrated, leading to lower transportation costs and carbon intensity.

Strong Co-Product Value Streams

Sugarcane processing yields valuable co-products such as molasses, bagasse and filter cake, which can add economic value and improve project viability.

Infrastructure & Processing

Established Ethanol Infrastructure

Facilities like Wilmar Sugar's Sarina plant already produce Sugarcane-based ethanol, creating a technical and operational foundation for SAF production.

Potential for Refining Process Integration

SAF facilities can be co-located with ethanol distilleries and sugar mills to share utilities, realise capital benefits and reduce carbon intensity.

Technology

Technology and Economic Development Alignment

Technological development associated with SAF from sugarcane supports regional job creation, economic diversification, and greater energy independence

First-mover Advantage in AtJ

Development of cane juice and bagasse for primary use in SAF can position Australia as a world leader in AtJ technology, specifically lignocellulosic pathways.

Source: ABARES, 'Agricultural Commodities and Trade Data' (2023).

Structural and execution challenges

While sugar can support early SAF volumes and regional development, it cannot underpin long-term aviation decarbonisation without assistance from other feedstocks

Feedstock Market

1 High and Volatile Feedstock Costs

Sugar attracts global commodity pricing and ethanol/SAF production could become uneconomical in high price years. Molasses prices are less volatile, but production potential is limited

Infrastructure & Processing

2 Scale and Infrastructure Gaps

Australia lacks co-located sugar – ethanol and ethanol – SAF refining capacity and will need to invest in integrated or modular supply chains

3 Hydrogen Access and Cost in Cane Regions

Green hydrogen production is currently limited in Australia, further so in cane growing regions, with 2 of Australia's 15 green hydrogen facilities in the state

Abatement Economics

4 Modest Carbon Intensity Benefits (Default Values)

CORSIA default CI for Sugarcane-to-SAF is ~52.9 gCO_2e/MJ - a ~40% reduction vs fossil jet

5 Sustainability Certification Complexity

Tracing and verifying the sustainability credentials of Sugarcane (e.g., fertiliser use, land-use history) adds transaction and verification costs

6 Policy Uncertainty

Without clear, long-term government incentives for low-CI SAF feedstocks, investment risks remain elevated

Technology

7 Enzyme and Energy Requirements for Bagasse Fermentation

Bagasse conversion requires more processing than standard Sugarcane, raising both operational complexity and emissions

Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); Grattan Institute, 'What's Hampering Hydrogen' (2025).

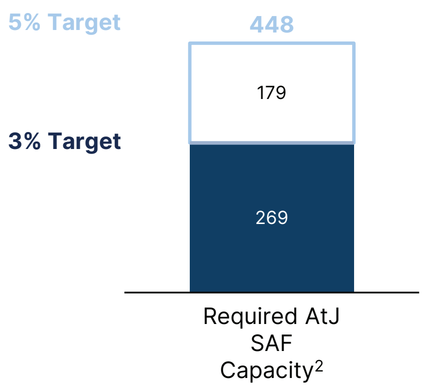
Infrastructure and processing gaps

To supply 3-5% of 2030 domestic fuel demand with Sugarcane SAF, AtJ infrastructure investment is required, in addition to an increase in domestic bioethanol capacity

AtJ (ML) and Bioethanol (ML) Capacity Required for 3–5%

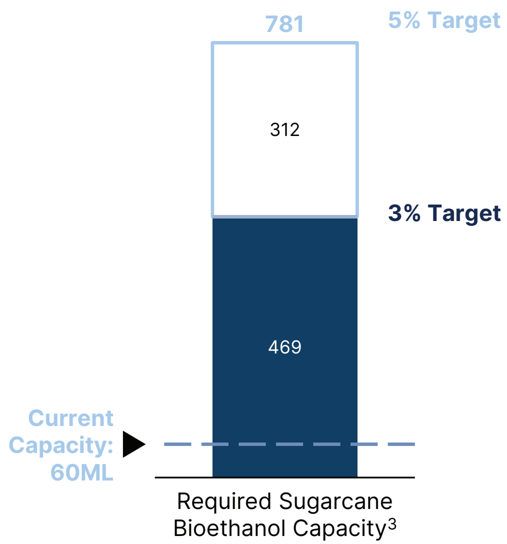
Meeting the 3–5% 2030 Target Requires 269–448 ML of AtJ Capacity[1]

Million litres per year



Supplying This Requires 469–781 ML of Upstream Bioethanol Capacity (vs ~60 ML Current)

Million litres per year



Planned AtJ Developments

Jet Zero Australia, Project Ulysses – Townsville, Qld

Description: Proposed large alcohol-to-jet facility producing SAF and renewable diesel

Feedstocks: Bioethanol (currently proposed to be from Wheat Starch)

Planned capacity: 113ML of LCLF per year (92,000 tonnes), of which ~90% will be SAF and ~10% renewable diesel

Development status: Front-End Engineering Design (FEED) stage, with $36.8 million committed, including $9 million funded by ARENA. FEED stage due for completion in January 2026, enabling a Class II cost estimate and further progression of commercial agreements

Construction status: Planned to commence construction in early 2026. Estimated to cost $600 million +

Operational date: Planned to commence operations in early 2028

Ethanol development focus: Future focus should be on building integrated ethanol and SAF facilities, limiting transportation cost and carbon intensity (~38% reduction compared to standalone conversion for Sugarcane[3])

Notes: (1) Capacity calculation based of ethanol density of 0.789kg/L and SAF density of 0.825kg/L. This assumes 100% of ethanol capacity is diverted for SAF production use. (2) Required/target capacity refers to 3–5% of Australia's 2030 jet fuel demand (~9,000 ML), in line with Singapore's proposed 2030 targets. (3) According to CORSIA default values. ~1.7L of ethanol is required to produce 1L of SAF.
Source: ARENA, 'Jet Zero Australia – FEED Study for Project Ulysses ATJ SAF Plant' (2026); International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); CSIRO & Boeing, 'Sustainable Aviation Fuel Roadmap' (2023); AECOM, 'Efficient Costs of New Entrant Ethanol Producers' (2016).

Case study | Gevo Inc: Corn to SAF via AtJ

Overview

Gevo is a US-based renewable fuels company that has pioneered the use of **starch-based ethanol (primarily corn)** to produce Sustainable Aviation Fuel via the **Alcohol-to-Jet (AtJ)** pathway.

Their flagship **Net-Zero 1 (NZ1) project in Lake Preston**, South Dakota, aims to produce **~60 million gallons/year of SAF** and other fuels.

The site was chosen due to its proximity to its **primary feedstock field corn** (with its starches fermented into ethanol), **high-protein feed demand** and **rail transportation.**

Feedstock Sourcing, Preparation and Logistics

- **Sourcing:** From regional growers near its facilities in Minnesota and South Dakota. Gevo emphasises sustainability in procurement, and works with farmers to reduce carbon intensity via low-emission farming practices (e.g., precision agriculture, reduced tillage, and low-carbon fertilisers).
- **Co-products:** The corn oil (~34 million pounds) and protein fractions (~695,000 tonnes) are separated and sold as co-products (animal feed and biodiesel feedstock).
- **Processing:** After corn is delivered to the site, it undergoes dry milling to extract starch **(an agricultural residue)**, which is then fermented into ethanol. The ethanol is dehydrated and shipped to AtJ conversion sites. Gevo's process includes integration of renewable electricity (e.g., wind power), renewable natural gas (potentially from dairy / beef cow manure) and green hydrogen to reduce lifecycle emissions.
- **Logistics:** Feedstock aggregation is relatively straightforward due to the maturity of the grain supply chain in the U.S. Midwest. Logistics are supported by rail and trucking infrastructure

Feedstock Challenges and Opportunities

Challenges

- **Ensuring low-carbon corn supply at scale:** Traditional row crop farming can have high carbon intensity due to fertiliser use and soil emissions. Maintaining a low CI score under CORSIA and other regulatory schemes requires extensive traceability and cooperation from growers.
- **Exposure to corn price volatility:** Impacts ethanol margins and overall SAF competitiveness.
- **Ensuring consistent quality and moisture content during storage and transport**

Opportunities

- **At the farm:** Leveraged precision farming data and partnerships with growers to reduce emissions from land use and fertiliser application. Potential to expand corn supply by incorporating regenerative agriculture practices.
- **Existing Infrastructure:** Gevo has develop technology that works with and leverages existing ethanol infrastructure. Potential to expand ethanol supply via existing infrastructure across the Midwest.
- **Co-products:** Monetising feedstock-related co-products, including distillers' grains and corn oil, to improve overall project economics.

Key Feedstock Lessons

- **Farmer engagement is critical to achieving low-CI feedstock.** Transparent incentives and traceability systems are needed.
- **Existing ethanol infrastructure offers a head start in scaling AtJ SAF, but the upstream carbon footprint must be actively managed.**
- **Diversification of co-products is essential** to offset high corn prices and maintain economic resilience.
- **Policy alignment (e.g., 45Z tax credits, LCFS) makes sustainable feedstock procurement financially viable.**

Note:

- *Gevo Inc has put this project on hold due to legislation changes in South Dakota, which prohibited use of eminent domain specifically for carbon dioxide pipelines.*
- *Gevo Inc received a ~$1.46bn conditional loan guarantee from the US Department of Energy, which required Gevo's project hitting certain carbon reduction thresholds. The CCS pipeline was a core component to achieving this but has now been paused due to the above changes.*
- *Gevo is exploring a smaller-scale SAF facility in North Dakota*

Source: Gevo Inc, 'Sustainable Aviation Fuel' (2022); Gevo Inc, 'Introducing Gevo's ATJ-60 Project: A Source of Homegrown Energy' (2026); Gevo Inc, 'SAF: Our Cost-Competitive Synthetic Aviation Fuel' (2026); Gevo Inc, 'Gevo and Future Energy Global Sign SAF Scope 1 and Scope 3' (2025); Precision Risk Management, 'Gevo Receives $1.5 Billion Loan Guaranteed To Build' (2024); Renewables Now, 'Gevo wins USD-1.46bn DOE loan guarantee for S Dakota SAF project' (2024); USA Farmers.gov, 'Ready for Takeoff: How Gevo's Farm-To-Flight Program Is Working' (2024); Bleecker Street Research, 'Gevo (Fuel Me Once... analysis)' (2024); Air Transport Action Group, 'Gevo joins the Air Transport Action Group' (2023); S&P Global, 'Gevo North Dakota SAF plant gains from delayed South Dakota project; CCS outlook cloudy' (2025); SDPB, 'Gevo CEO: No pipeline, no plant' (2025).

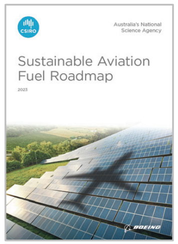
Case study | CSIRO / Boeing Sustainable Aviation Fuel Roadmap - Sugar Crops

Sugar Crops

Fundamentally carbohydrates are sugar molecules, ranging from simple sucrose found in sugarcane to complex longer-chain starches in maize and sorghum. Fermentation of these sugars can produce ethanol, an alcohol intermediate suited for upgrading to SAF.

The cultivation of sugar provides additional biomass resources. As well as residues from sugarcane harvesting on farms, sugarcane bagasse is a fibrous by-product from milling. In most cases, this is combusted to produce steam and electricity, but could be liberated for conversion into fuels.

CSIRO / Boeing SAF Roadmap 2023



Current Availability

- Sugarcane residues, such as bagasse or cane pulp, are identified as a promising feedstock, although no current commercial-scale SAF supply exists.
- CSIRO highlights that crop residues like sugarcane pulp must be collected to contribute meaningfully to biomass feedstock supply.

Australia will need to grow new crops and collect crop residues such as sugar cane pulp, to create enough biomass to fuel the industry

CSIRO / Boeing SAF Roadmap 2023

Growth Potential and Challenges

Challenges

- **Infrastructure gap:** There is currently no commercial-scale processing of sugarcane residues into SAF.
- **Feedstock logistics and collection:** Residues must be efficiently collected and transported, requiring coordinated supply chain planning.
- **Policy and demand incentives:** Without clear government policy or mandates, sugar waste will likely remain tied to non-SAF uses.
- **Competition with established industrial uses:** Residues may be directed to co-generation or livestock feed unless redirected through policy.

Opportunities

- **Bagasse from sugar mills represents a large untapped biomass pool,** with potential for conversion via Alcohol-to-Jet (AtJ) or Fischer–Tropsch (FT) pathways.

Our industry has long advocated for policies that support the use of domestic, sustainable feedstocks... With readily available biomass from sugar manufacturing, Australia is uniquely positioned to develop a domestic low carbon liquid fuel capability

Australian Sugar Manufacturers, CEO Ash Salardini.

Key Statistics

Data Point	Note
Sugarcane pulp (bagasse)	Identified as a high-potential second-generation feedstock
Commercial SAF production from sugar in Australia	None to date. Feasibility under consideration
Timeframe for development	Recommended focus: 2025–2035 - scale-up of residue supply chains
Conversion pathways	Alcohol-to-Jet (AtJ) and Gasification and FT synthesis
Carbon intensity (CI) consideration	Dependent on residue logistics and fermentation efficiency (not quantified)
SAF yield from sugar	Not quantified in the report, but discussed under ethanol pathways in general

Source: CSIRO & Boeing, 'Sustainable Aviation Fuel Roadmap' (2023).

10
SAF feedstock deep dives

c. Starch crops

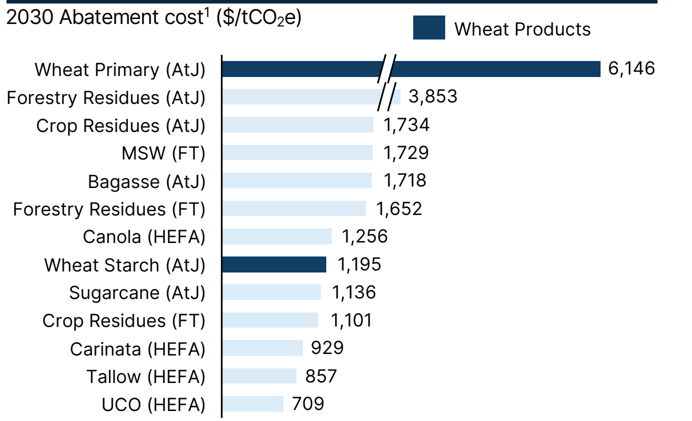
GrainCorp

Wheat Summary

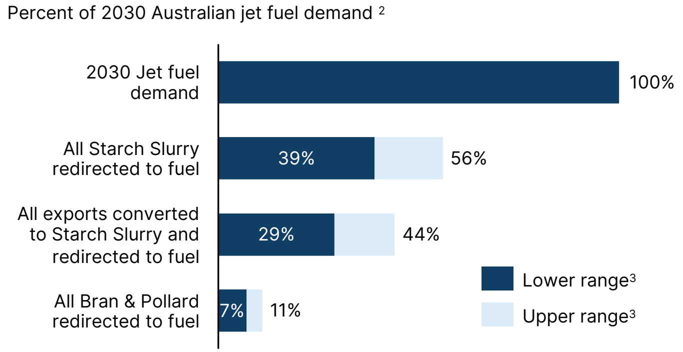
Wheat Starch Slurry (byproduct stream) can enable SAF deployment in Australia at moderate scale, with ~50% CI reduction potential and ~2944% jet demand coverage under full redirection scenarios

Executive Summary	
Technical viability	• Wheat starch slurry generated from wet-milling can represent ~34-36% of the grain stream and can be converted to ethanol, yielding ~98–105 kg SAF per tonne via the AtJ pathway[4] • Conversion of Bran & Pollard to ethanol remains at pilot stage, limiting near-term scalability beyond Starch Slurry streams
Emission reduction potential	• Wheat starch slurry–derived SAF delivers ~50% lifecycle carbon intensity reduction versus fossil-derived Jet A-1 (~44 gCO_2e/MJ vs ~89 gCO_2e/MJ) under by-product allocation assumptions • Default by-product allocation assumptions materially influence results, with CI outcomes ~5x higher than primary wheat-to-SAF pathways (~50% vs ~10% reduction versus the ~89 gCO_2e/MJ fossil baseline)
Economic competitiveness	• By-product routes (starch slurry and bran & pollard) lowers feedstock costs by ~6% (1,600 vs 1,700 $/t) versus primary-product pathway • Total production costs from wheat starch slurry remain ~3.0-3.8x fossil jet, requiring policy support, mandates, or premium offtake to close the gap
Australia's opportunity	• Redirecting all potential wheat starch slurry to SAF could supply ~39–56% of 2030 domestic jet fuel demand (~1.5–2.2 Mt per year equivalent) • If bran & pollard conversion reaches commercial scale, total by-product contribution could increase by ~7-11% of projected 2030 demand
Australia's scale potential	• Current ethanol infrastructure capacity is constrained, with Manildra's Shoalhaven facility (Nowra, NSW) possessing capacity for ~300 ML/year of bioethanol (~142 Kt SAF equivalent)

2030 SAF Abatement Cost Curve - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand

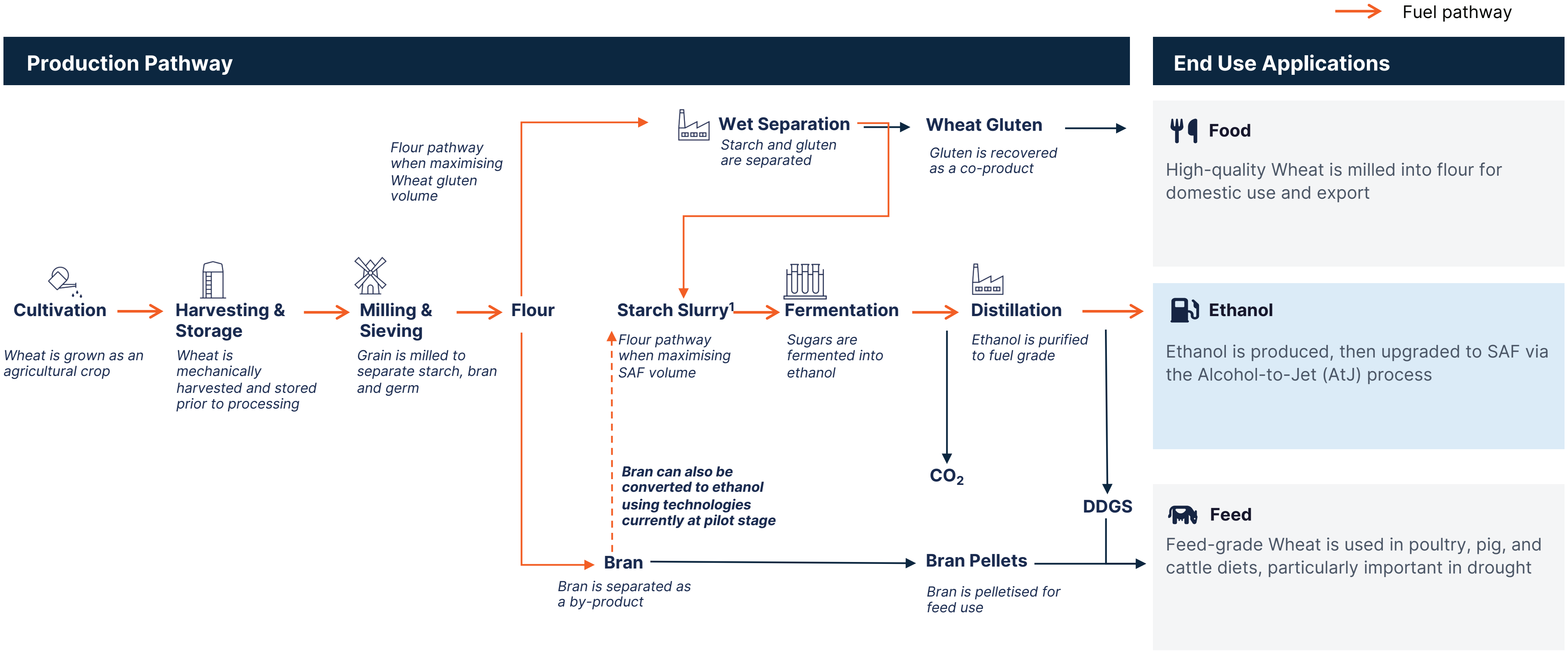


Notes(1) Assumes conservative cost reductions; for detailed abatement cost methodology refer to the slide 'Abatement cost curve position.'(2) Percent of 2030 Australian jet fuel demand aligns with the slide 'Wheat volume and potential implication.' (3) Volume ranges are calculated based on annual variation in Australian wheat harvest volumes and variation in product yield percentages, ethanol yield and SAF yield assumptions. (4) For yields information please refer to 'Wheat SAF yields'

Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025); Manildra Group, 'Transport Fuels'.

Wheat value chain

Wheat is a technically proven SAF feedstock via the AtJ pathway, leveraging established wheat-to-ethanol processes

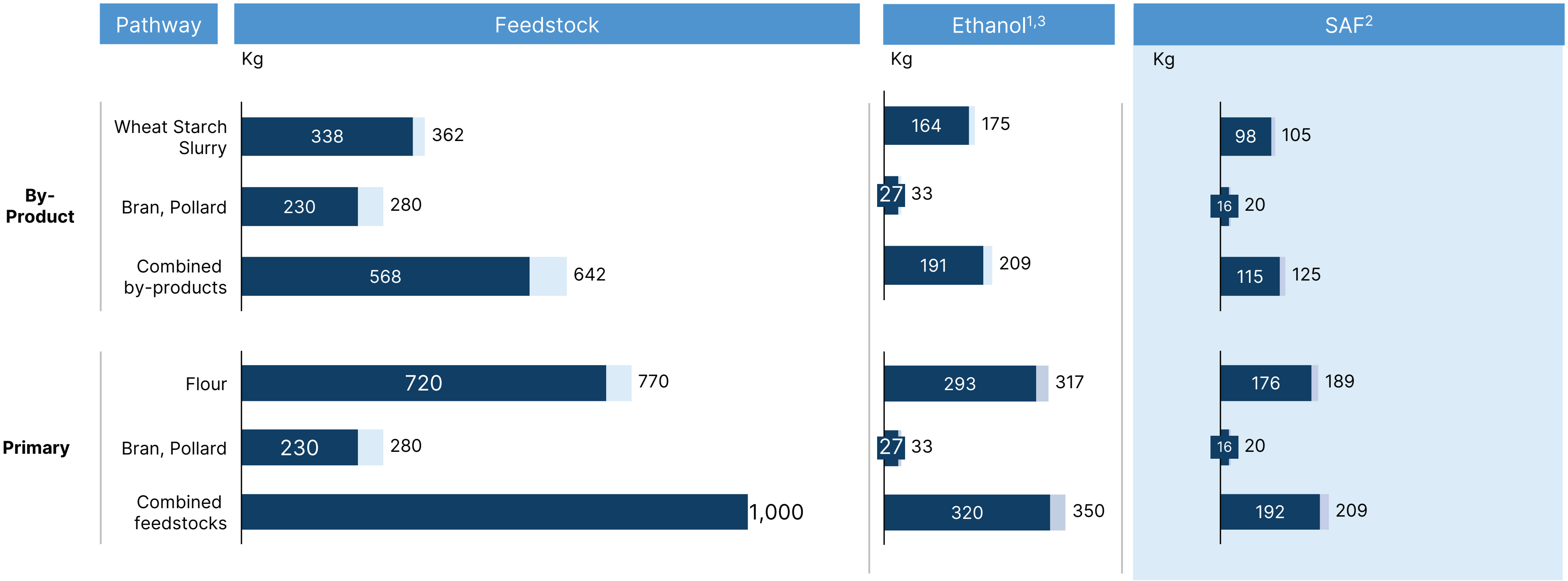


Note: (1) Starch slurry can be directed to food, industrial, or fermentation pathways depending on market allocation (e.g., bakery/noodles, paper/adhesives, or ethanol production).

Wheat SAF yields

Wheat Starch Slurry yields ~98–105 kg SAF per tonne of raw Wheat input, with combined by-product streams delivering ~115–125 kg SAF per tonne of grain processed

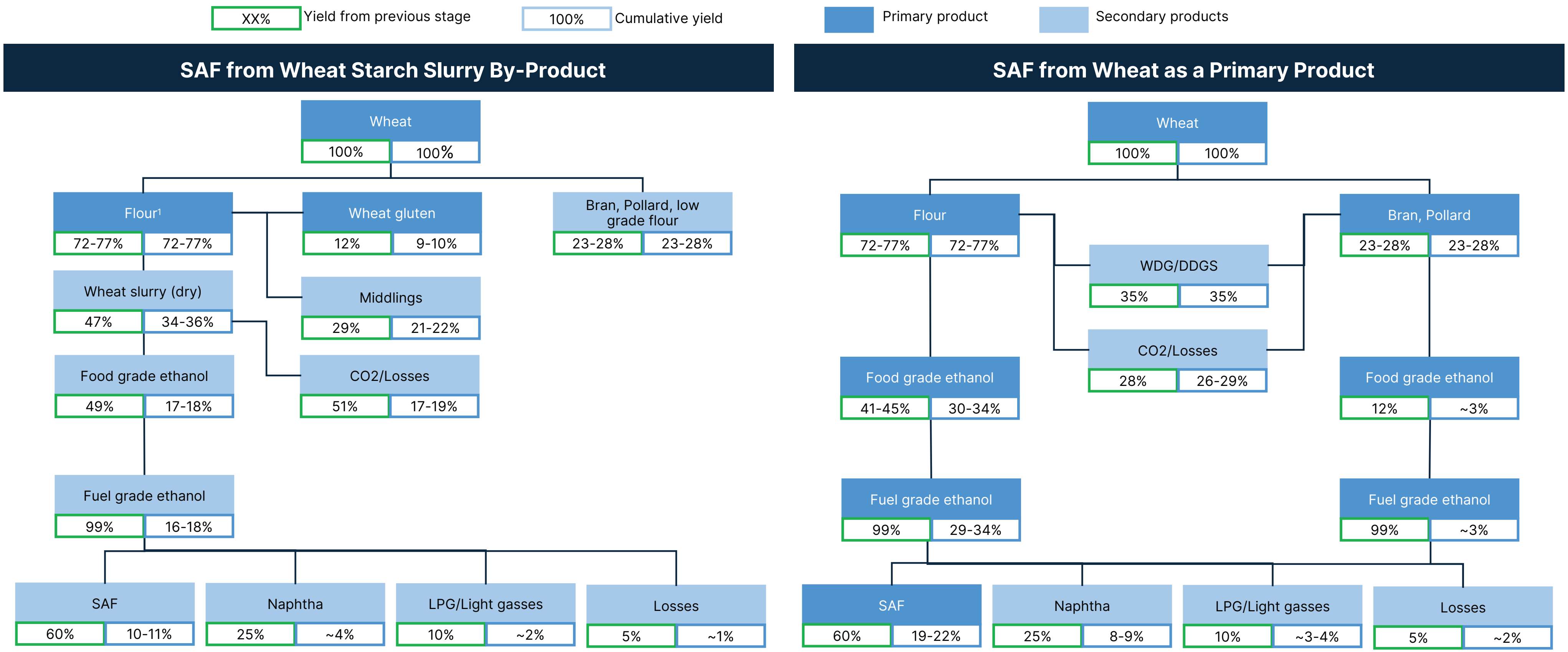
SAF Production Output from 1 Tonne of Wheat by Feedstock Pathway



Notes: Wheat content and wheat-to-flour conversion per Source 72–77% Wheat→flour documentation; Benchmark ethanol yield of 435 L/t wheat (range 410–480 L/t) and associated calculation methodology; Wheat starch slurry to ethanol yield (~2.8 gal ethanol per bushel equivalent, ~380–400 L/t wheat equivalent); DDGS yield of ~0.30–0.35 t per tonne of wheat; 60% SAF yield from food-grade ethanol in ATJ process.
Source: Farmpe, 'HGCA+RR61 Wheat for Alcohol' (2022); ScienceDirect, 'Development of Novel Wheat Biorefining: Effect of Gluten Extraction from Wheat on Bioethanol Production' (S09601481200180X); ARB, 'LCFS Fuel Pathways: B0099 Report'; Farmdoc Daily, 'CO_2 Production by the US Ethanol Industry and the Potential Value of Sequestration' (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025).

Wheat SAF yields

Wheat Starch Slurry SAF yields reach ~10-11% by weight, while using Wheat as a primary product can theoretically yield ~19-22% SAF by weight



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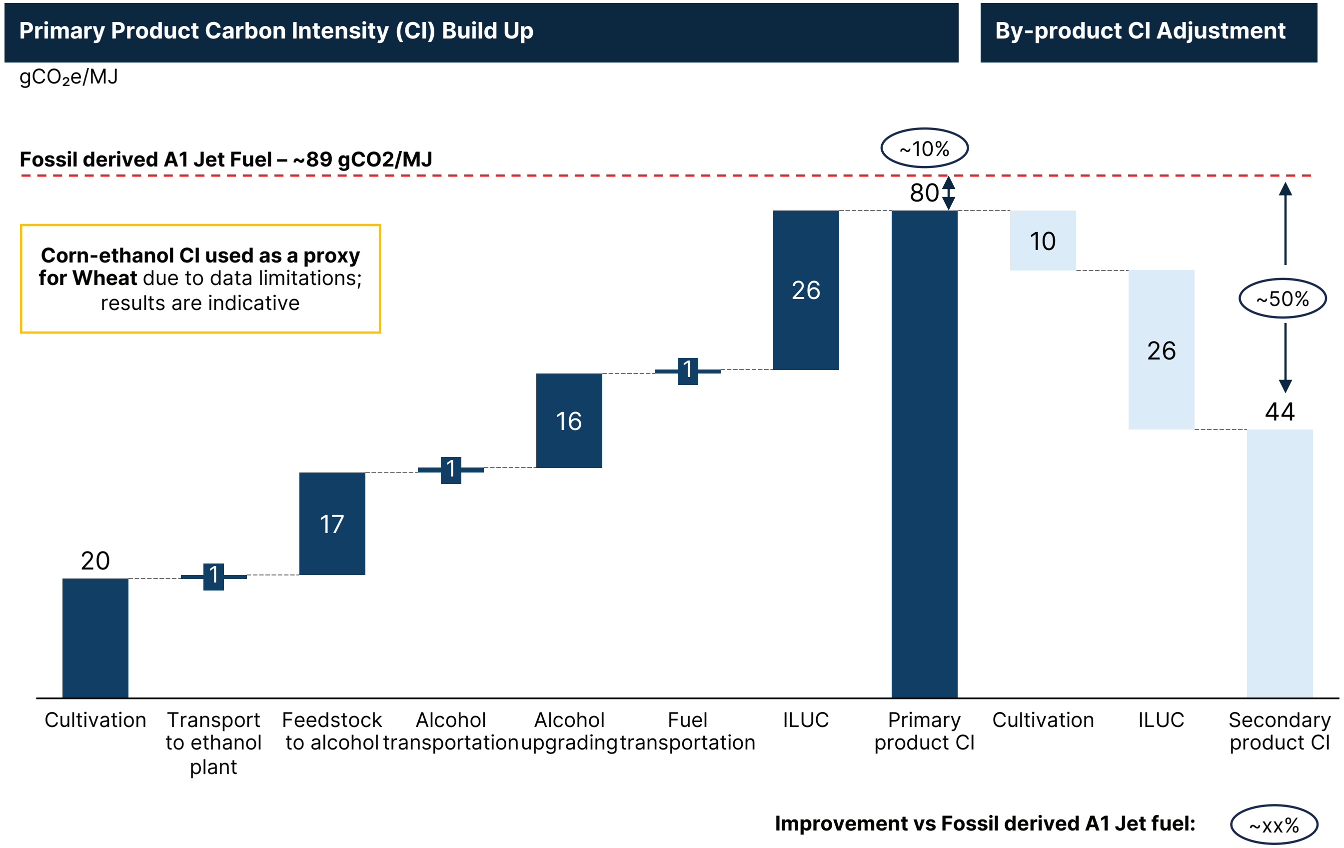
Wheat carbon intensity

SAF produced from Wheat Starch Slurry can deliver ~50% CI reduction vs fossil jet, driven by co-product allocation and lower feedstock burden.



Primary CI Reduction Levers

Levers primarily target cultivation and transport emissions, which account for the majority of wheat-to-SAF lifecycle CI

1 Feedstock Cultivation

- **Low-emission fertilisers:** Use enhanced efficiency fertilisers or nitrification inhibitors to reduce N_2O emissions
- **Reduced fertiliser rates:** Precision nutrient management aligned to crop demand
- **Minimum or zero tillage:** Conserves soil carbon and reduces diesel use
- **Cover cropping / rotational legumes:** Improves soil health and reduces need for synthetic Nitrogen
- **Carbon farming practices:** Participate in carbon sequestration programs to offset cultivation emissions
- **Rainfed production:** Avoid emissions from irrigation pumping in dryland systems (already standard in much of Australia)

2 Feedstock Transport

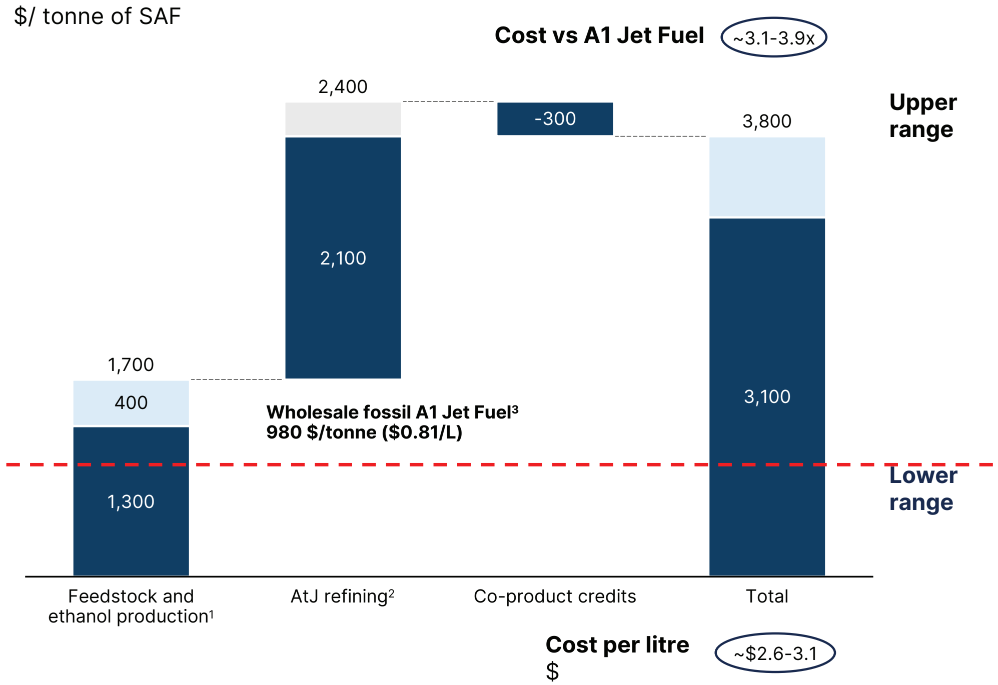
- **Shorter supply chains:** Co-locate ethanol facilities near major wheat-growing regions to reduce transport emissions
- **Efficient freight logistics:** Use of B-double trucks or rail instead of small or inefficient road freight

Note: Corn-ethanol CI used as a proxy for Wheat due to limited public data. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); International Civil Aviation Organisation (ICAO), 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

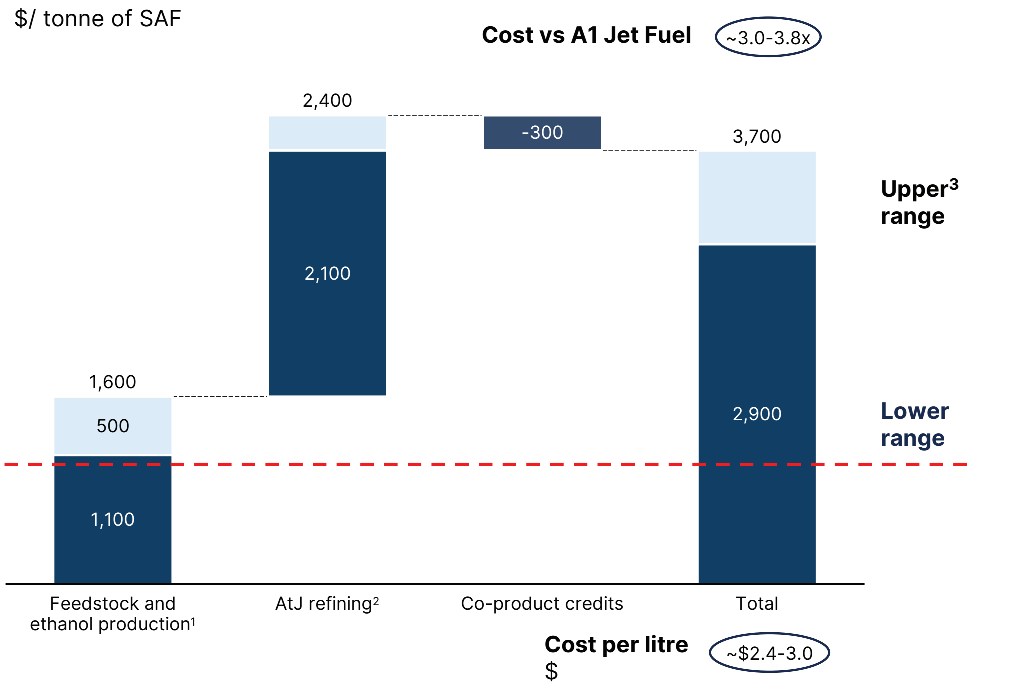
Wheat SAF cost

Wheat Starch-based SAF remains ~3.1–3.9x more expensive than fossil jet fuel, at around 2.6–3.1 $/L versus ~0.8 $/L, with a small cost advantage for integrated Starch and Gluten facilities

Cost of Production from Wheat Starch Slurry (Standalone)



Cost of Production from Integrated Wheat Starch / Gluten Facility



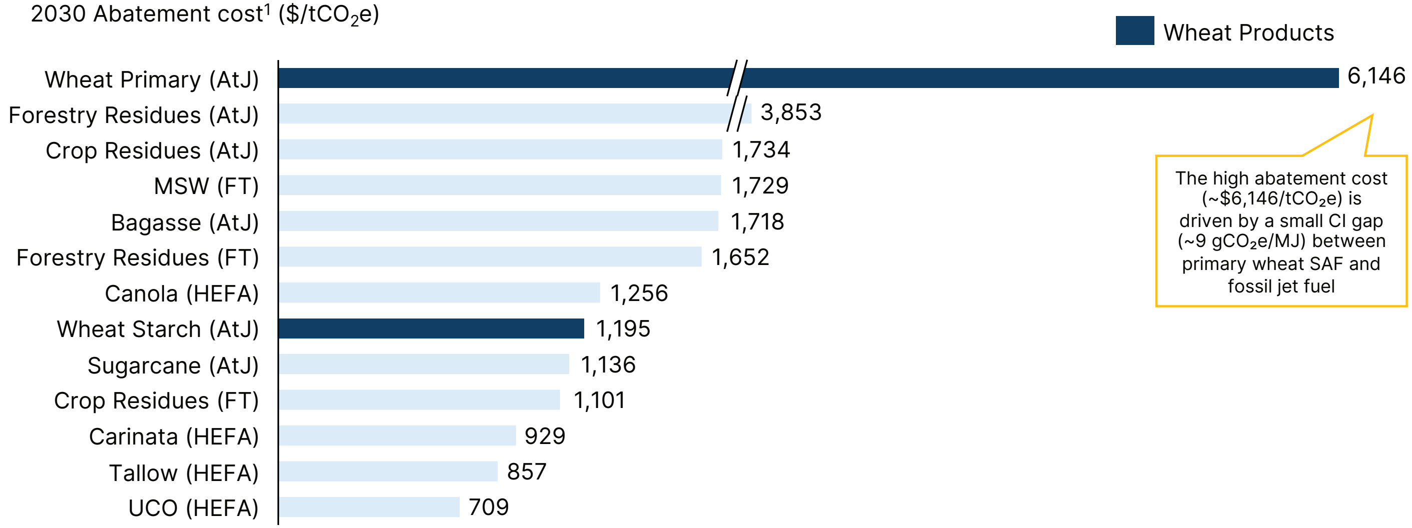
Notes: (1) A conventional jet-fuel price of 686 USD/t for Asia & Oceania (≈980 $/t) is taken from the IATA/S&P Global Platts Jet Fuel Price Index for 30 January 2026. (2) Ethanol cost assumptions are based on AECOM (2016, IPART), which estimates $0.69/L for standalone Wheat/starch ethanol and $0.64/L for integrated gluten–ethanol facilities in NSW; integrated by-product pathways therefore retain a structural cost advantage when converted to SAF via AtJ Co-product credits from the AtJ refining process include naphtha and LPG. (3) Upper and lower ranges capture uncertainty in SAF yield percentages and AtJ refining capex.
Source: ABARES, commodity statistics Excel files (wheat prices 2000 and 2025 Q1); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb'; Clean Energy Finance Corporation (CEFC), 'Refined Ambitions – Appendices'; AECOM, 'Efficient Costs of New Entrant Ethanol Producers – Final Report to IPART'; IATA & S&P Global Platts, 'Jet Fuel Price Index – 30 January 2026'.

Abatement cost curve position

Australian Wheat by-product SAF (Starch Slurry) sits mid-curve, with abatement costs driven by CI allocation and AtJ upgrading intensity

SAF Abatement Costs - Australia

2030 Abatement cost[1] ($/t$CO_2$e)



$1,195
Wheat Starch SAF
$/tCO2e

~3.0-3.8x
Wheat Starch Costs
vs. fossil jet

~50%
GHG Reduction
vs. fossil jet

SAF – Abatement cost drivers

- Wheat starch–derived SAF delivers ~50% CI reduction vs fossil jet
- CI depends on allocation across starch, gluten and feed co-products
- AtJ upgrading requires hydrogen and process energy, increasing costs

Competitive Context

Wheat starch (AtJ) abatement cost is $1,195/t$CO_2$e, positioning it mid-curve

Higher cost than waste- and residue-based pathways (e.g., UCO, tallow)

Lower cost and stronger CI performance than primary wheat-to-SAF routes

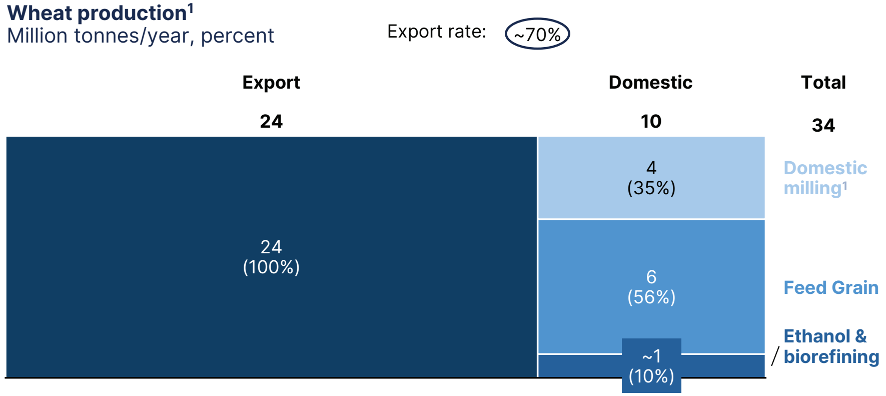
Note: (1) Abatement cost is calculated as the SAF–fossil jet price differential divided by emissions reduction per tonne of fuel, where emissions reduction equals (CI_fossil − CI_SAF) × 43,000 MJ/t ÷ 1,000,000, based on CORSIA default CI values and corn-ethanol as a proxy for wheat. Assumes conservative cost reductions.
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024).

Wheat supply potential

Australia produces ~34 Mt of Wheat annually with ~70% exported as raw Wheat

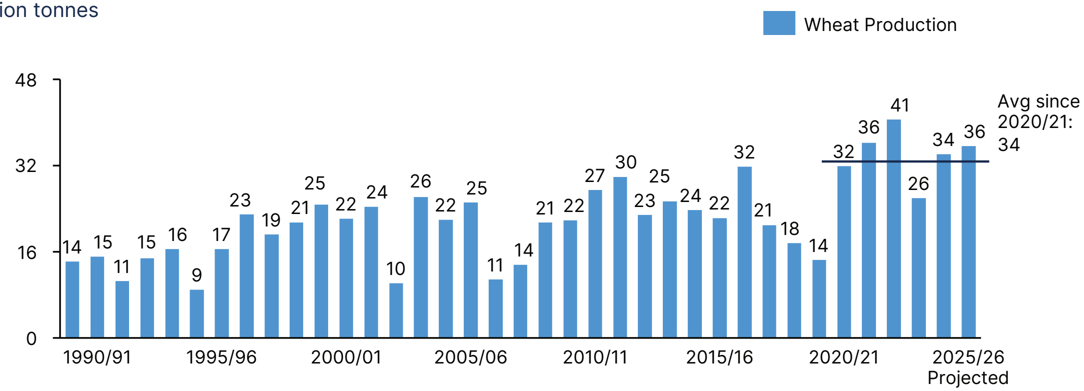
Wheat Overview

Wheat production[1]
Million tonnes/year, percent



Domestic Production

Wheat production
Million tonnes



Current uses

Food
Flour for bread, pasta, baked goods, noodles, alcoholic beverages

Feed
Major livestock input, particularly in drought years or during low-price periods

Industrial
Wheat starch used in paper, textiles, fermentation, and ethanol production

Biofuels
Limited use in ethanol production (~355-370L/tonne); mostly domestic, feed-grade, or off-spec grain

Industry challenges

Weather volatility
More frequent droughts and heatwaves cutting yields; some regions report Wheat harvests down by up to 50% in bad drought years

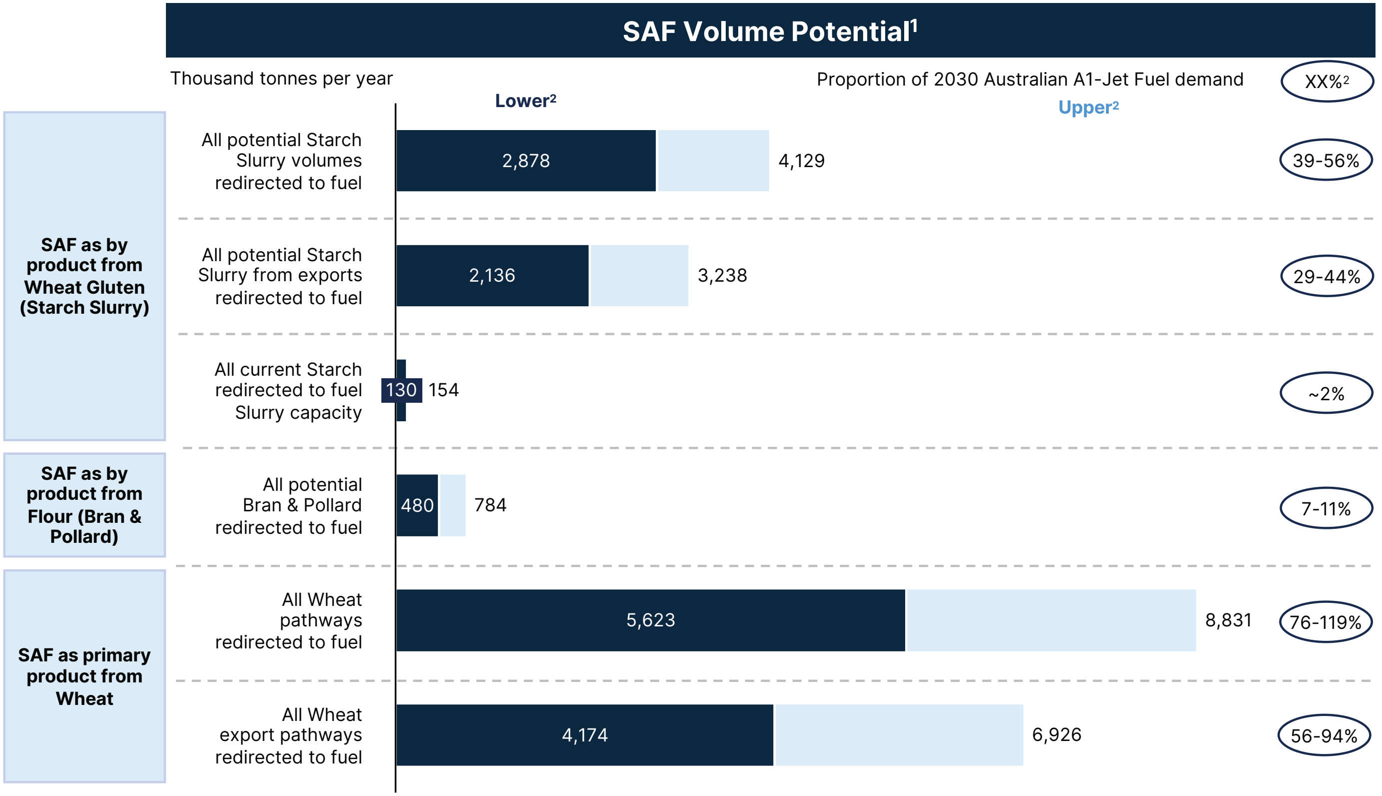
Shrinking and ageing grower base
Average broadacre farmer now in the mid-50s to 60s, with a growing share of farmers aged 55+ and fewer young entrants

Ageing infrastructure
Old mills increase costs, downtime, and capital required for modernisation

Notes: (1) Average production refers to the rolling average of the past five seasons (2020–21 to 2024–25), based on ABARES Australian Crop Report data.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 'Australian Crop Report – December 2025' (2025); Australian Bureau of Statistics (ABS), 'Agricultural Census 2015–16' (2016); ABC Rural, 'Who's farming Australia?' (2017); CBH Group, 'Storage and handling network investment'; United States Department of Agriculture (USDA), 'Grain and Feed Update – Canberra, Australia' (AS2023-0001).

Wheat volume potential and implications

If fully redirected from export volumes, Wheat Starch Slurry could supply ~29-44% of 2030 domestic jet fuel demand, while current Starch Slurry capacity could supply ~2% of 2030 jet fuel demand



Insights

- Redirecting all Wheat production into Starch Slurry processing could supply ~39-56% of 2030 domestic jet demand; converting all exported Wheat volumes into Starch Slurry could supply ~29-44%
- Redirecting all Bran & Pollard by-product streams could supply ~7-11% of 2030 jet fuel demand
- Australia's Starch-to-ethanol capacity is concentrated at Manildra[3] (Nowra), with ~300 ML/year capacity for bioethanol, equating to ~130-154 Kt of SAF, or ~2% of 2030 jet fuel demand

Notes: (1) Potential volume is calculated through Wheat production volume, product yield percentage, export percentage, ethanol yield and SAF yield from ethanol. It assumes 100% of all available feedstock in that category is diverted to produce SAF. (2) Ranges are calculated based on annual differences in Wheat harvest volume, export percentages and variation in product yield percentages, ethanol yield and SAF yield. (3) Manildra's Shoalhaven Starches facility at Nowra in New South Wales dominates the market, with a maximum annual ethanol capacity of 300 million litres.
Source: Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 'Australian Crop Report – December 2025' (2025); Grain Central, 'Australia's ethanol plants underutilised by 60pc' (2025); Farmpe, 'HGCA+RR61 Wheat for alcohol' (2022); Zhang et al., 'Development of novel wheat biorefining: Effect of gluten extraction from wheat on bioethanol production' (2020); California Air Resources Board (ARB), 'LCFS Fuel Pathways: B0099 Report' (2019); Farmdoc Daily, 'CO_2 production by the US ethanol industry and the potential value of sequestration' (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025).

Strategic opportunities

Australia's wheat system offers a credible SAF opportunity at limited scale, with broader deployment constrained by processing economics and feedstock competition

Feedstock Market

Large and Consistent National Supply

Australia produces ~34 million tonnes of Wheat annually, providing a scalable and reliable domestic feedstock pool.

Use of Off-Spec or Surplus Grain

In high-yield years, downgraded Wheat may be available at lower prices, but diversion to fuel depends on wet-milling capacity and demand for co-products that underpin mill economics

Widespread Geographic Applicability

Unlike Sugarcane, Wheat is grown in all mainland states, enabling SAF feedstock development across inland and coastal regions.

Abatement Economics

Potential for On-Farm Carbon Abatement

Adoption of low-emission cropping practices could reduce lifecycle CI, improving eligibility for international SAF markets and crediting schemes.

Strong Co-Product Value Streams

Wheat ethanol production generates valuable co-products (e.g. DDGS for livestock), helping offset SAF production costs and reduce carbon intensity.

Energy Security And Economic Outcomes Alignment

SAF development from Wheat supports regional job creation, economic diversification, and greater energy independence.

Technology & Development

Complementary to Grain Industry Trends

Trends in the Wheat industry have seen an increase in investment in grain traceability, sustainability, and low-CI agriculture aligns with SAF market requirements.

Infrastructure & Processing

Established Ethanol Infrastructure

Facilities like Manildra already produce Wheat and starch-based ethanol, creating a technical and operational foundation for SAF production.

Source: Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 'Australian Crop Report December 2025' (2025).

Structural and execution challenges

While Australia's wheat system provides by-product streams for SAF, scalability remains constrained by co-product markets, ethanol integration, and upgrading intensity

Feedstock Market

1 Co-product Market Dependence

Wheat starch diversion depends on sustained demand for gluten and feed co-products that underpin wet-milling economics

2 Exposure to Grain Price Cycles

Even by-product pathways remain linked to global wheat pricing and milling margins in tight years

Abatement Economics

3 Sustainability Certification Complexity

Sustainability verification (e.g., fertiliser use, land-use history) adds compliance cost and complexity

4 Policy Uncertainty

Abatement cost (~$1,100/t$CO_2$e) requires mandates or credit support to compete with lower-cost waste-based pathways

Technology & Development

5 Upgrading Intensity

Starch-to-ethanol conversion and AtJ upgrading require hydrogen and process energy, increasing cost intensity

6 Bran & Pollard Conversion Not Yet Commercial

Additional by-product upside depends on pilot-stage technologies reaching commercial scale

Infrastructure & Processing

7 Concentrated Ethanol Capacity

Ethanol production is concentrated (e.g., ~300 ML/year at Nowra), limiting distributed SAF scale without additional AtJ investment

Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025).

Fuel vs other uses

Wet-milling infrastructure and co-product markets are structurally aligned to food and industrial starch uses, making fuel diversion dependent on market allocation

Current Market Uses

Food & Beverage Industry

Flour and bakery products
Bread, cakes, noodles, pasta

Processed foods
Biscuits, wheat-based snacks

Retail
Supermarket flour and mixes

Feed & Livestock

Animal feed
Poultry, pork, cattle livestock diet

Total Australian Wheat flour exports[1]

$16.7m

(2024)

Largest export markets from Australia[1]

New Zealand ($4.28m)
Papa Guinea ($2.6m)
Thailand ($2.32m)

(2024)

Global significance[2]

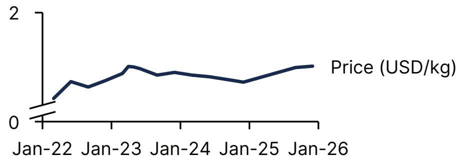
Australia is the 46th largest exporter of Wheat Flour (out of 169)

Investment and Economic Challenges

1 Flour Wheat price volatility anchors food returns

- Global Wheat flour prices are volatile, with frequent spikes above USD 0.5–1.5/kilo
- Strong industrial starch margins anchor wet-milling allocation, limiting diversion to fuel

Worldwide average Wheat flour price[3]
USD/kg



2 Feedstock diversion from food and exports

- Australia produces ~34 Mt of Wheat p.a., with the majority ultimately used in food, flour and feed markets in Australia and key export destinations
- Scaling starch-to-SAF requires reallocation within wet-milling output, not simply utilisation of surplus grain

3 Structural reliance on gluten markets

- Wheat-to-fuel pathways rely on selling vital wheat gluten as a high-value co-product, requiring sustained market absorption at scale
- Domestic gluten demand and wet-milling capacity are limited, increasing reliance on exports and additional capital investment

Notes: (1) Export values and destination rankings reflect 2024 bilateral wheat flour trade data; (2) Global flour price series reflects reported average wheat flour prices (USD/kg) across major markets for 2022–2026; (3) Price volatility reference corresponds to observed global wheat flour price spikes above USD 0.5–1.5/kg range during recent commodity cycles.
Source: OECD, 'Wheat flours – Trade by reporter: Australia' (2024); Global Product Prices, 'Flour prices worldwide' (2024).

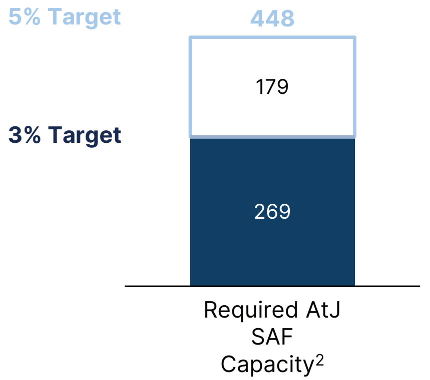
Infrastructure and processing gaps

To supply 3-5% of 2030 domestic fuel demand with Wheat Starch SAF, AtJ infrastructure investment is required, in addition to an increase in domestic bioethanol capacity

AtJ (ML) and Bioethanol (ML) Capacity Required for 3–5%

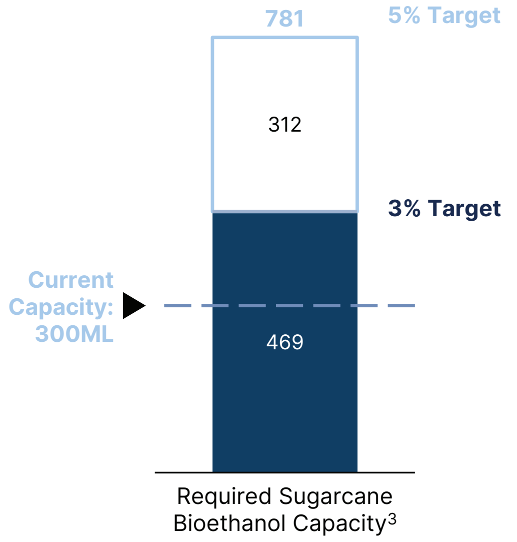
Meeting the 3–5% 2030 Target Requires 269–448 ML of AtJ Capacity[1]

Million litres per year



Supplying This Requires 469–781 ML of Bioethanol Capacity (vs ~300 ML Current)

Million litres per year



Planned AtJ Developments

Jet Zero Australia, Project Ulysses – Townsville, Qld

Description: Proposed large alcohol-to-jet facility producing SAF and renewable diesel
Feedstocks: Bioethanol (currently proposed to be from Wheat Starch)
Planned capacity: 113ML of LCLF per year (92,000 tonnes), of which ~90% will be SAF and ~10% renewable diesel
Development status: Front-End Engineering Design (FEED) stage, with $36.8 million committed, including $9 million funded by ARENA. FEED stage due for completion in January 2026, enabling a Class II cost estimate and further progression of commercial agreements
Construction status: Planned to commence construction in early 2026. Estimated to cost $600 million +
Operational date: Planned to commence operations in early 2028
Ethanol development focus: Future focus should be on building integrated ethanol and SAF facilities, limiting transportation cost and carbon intensity

Notes: (1) Capacity calculation based of ethanol density of 0.789kg/L and SAF density of 0.825kg/L. This assumes 100% of ethanol capacity is diverted for SAF production use. (2) Required/target capacity refers to 3–5% of Australia's 2030 jet fuel demand (~9,000 ML), in line with Singapore's proposed 2030 targets. (3) According to CORSIA default values. ~1.7L of ethanol is required to produce 1L of SAF.
Source: ARENA, 'Jet Zero Australia – FEED Study for Project Ulysses ATJ SAF Plant' (2026); International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); CSIRO / Boeing, 'Sustainable Aviation Fuel Roadmap' (2023); AECOM, 'Efficient Costs of New Entrant Ethanol Producers' (2016).

10

SAF feedstock deep dives

d. Used cooking oil (UCO)

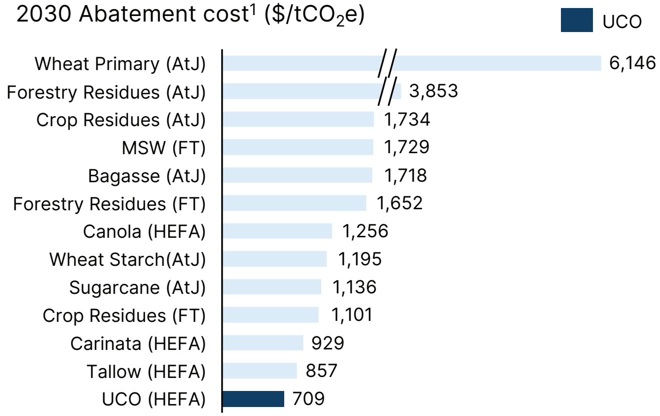
GrainCorp

Used Cooking Oil (UCO) summary

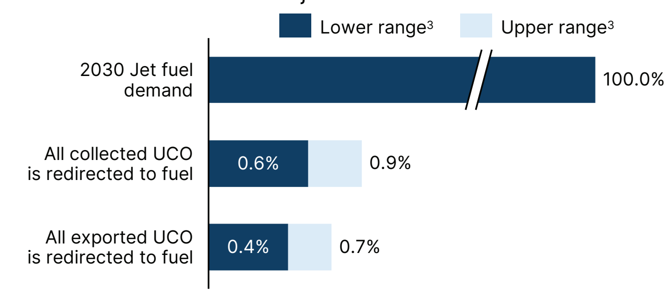
UCO is considered one of the most technically and economically viable feedstocks for producing Sustainable Aviation Fuel (SAF) in the short-to-medium term

Executive summary	
Technical viability	• UCO is a technically proven SAF feedstock via the HEFA pathway, leveraging established waste oil collection, pre-treatment and hydro-treating infrastructure • When optimised for HEFA production, SAF yield represents ~43–61% of collected UCO on a cumulative basis[4]
Emission reduction potential	• SAF from UCO delivers ~85% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~13.9 gCO_2e/MJ vs ~89 gCO_2e/MJ) • CI performance can improve further through optimised logistics, reduced transport emissions, and low-carbon pre-treatment and refining energy
Economic competitiveness	• UCO-based HEFA SAF is approximately ~2.2-3.5x more expensive than fossil jet fuel • Despite higher costs, UCO SAF sits at the lower end of Australia's abatement cost curve (~\$700/tCO_2e), reflecting strong CI performance
Australia's opportunity	• ~100 kt of UCO is currently collected annually in Australia, with additional volumes potentially recoverable through improved collection, most collected is exported for LCLF production • Australia currently exports ~80% of collected UCO, mostly used overseas as feedstock for renewable fuels, presenting a near-term opportunity to divert supply
Australia's scale potential	• Under 100% capture and diversion, UCO could supply ~0.6–0.9% of Australia's 2030 jet fuel demand; at current capture rates, ~0.4–0.7% • As a finite waste stream facing competition from biodiesel and renewable diesel markets, UCO supports early SAF volumes but cannot scale alone.

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand



Notes: (1) assumes conservative cost reductions, for detailed information refer to the slide 'Abatement cost curve position'. (2) For percent of 2030 Australian jet fuel demand refer to the slide 'UCO volume and potential implication'. (3) Ranges are calculated based on source differences in UCO volume and variation in product yield percentages and SAF yield. (4) For yields information please refer to 'UCO SAF yields'
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025); International Civil Aviation Organization (ICAO), 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); International Civil Aviation Organization (ICAO), 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

UCO value chain

UCO is a technically proven SAF feedstock via the HEFA pathway, leveraging established waste oil collection and hydro-processing infrastructure

→ Fuel pathway

Production Pathway

Feedstock generation → **Collection & Aggregation** → **Pre-treatment** → **Hydroprocessing** → **Product Separation & Blending**

HEFA Process (Pre-treatment, Hydroprocessing, Product Separation & Blending)

- **Feedstock generation**: *Waste vegetable oils collected from commercial kitchens, food manufacturers, quick-service restaurants, and institutional facilities*
- **Collection & Aggregation**: *Temporary storage of UCO in drums, tanks, or under-counter units, followed by scheduled collection by licensed operators*
- **Pre-treatment**: *UCO is put through a process of filtration and heating to meet refinery specifications*
- **Hydroprocessing**: *UCO is hydro processed using hydrogen to remove oxygen and convert fatty acids into hydrocarbons*
- **Product Separation & Blending**: *Products are separated and conditioned to meet fuel specifications*

End Use Applications

Renewable diesel

Hydrotreated vegetable oil (HVO) is used as a drop-in diesel fuel for road transport.

SAF

HEFA-SPK, a synthetic paraffinic kerosene jet fuel, is produced and blended (up to 50%) with Jet A-1 for commercial aviation use

Naphtha/LPG

Co-products used as petrochemical feedstocks or refinery fuels.

UCO SAF yields

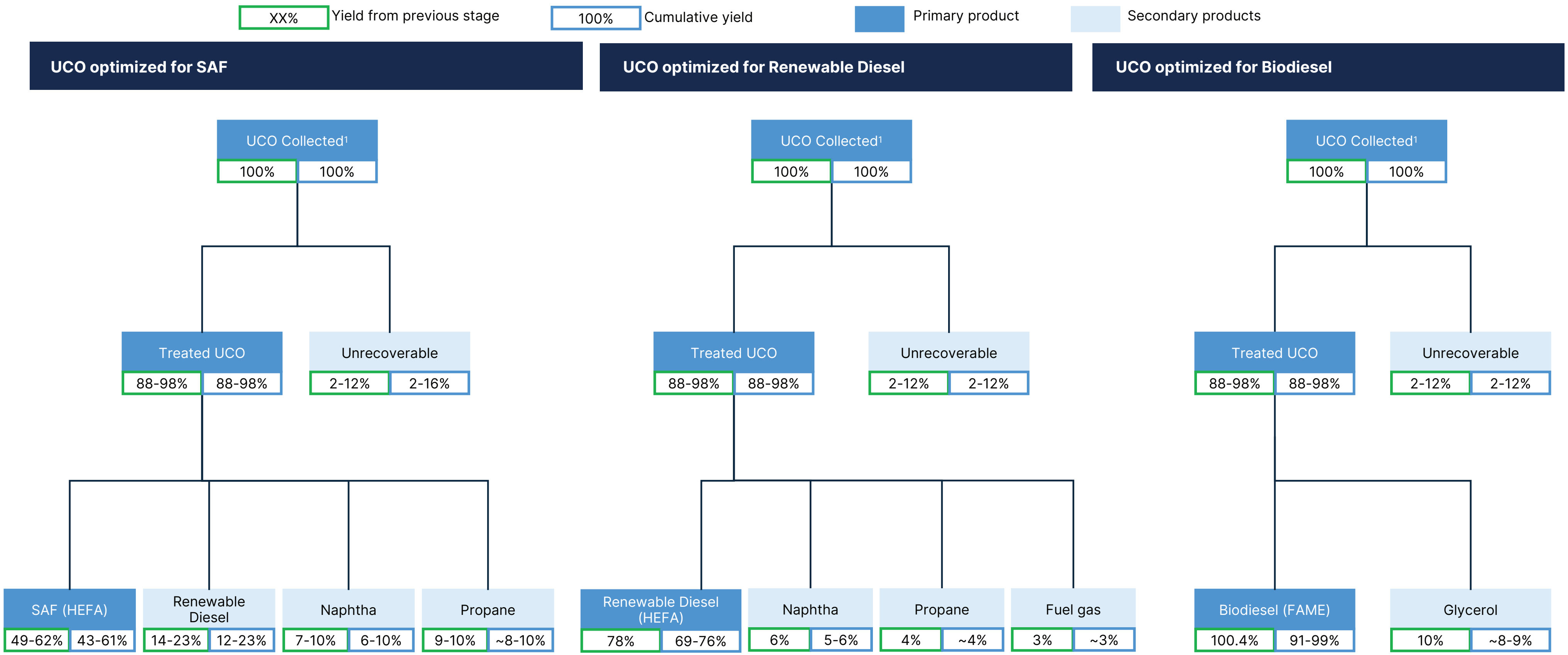
HEFA converts ~88–98% of treated UCO into hydrocarbons, of which ~435–606 kg per tonne of collected UCO qualifies as SAF

SAF Production output from 1 tonne of UCO by feedstock pathway

Notes: (1) Results reflect the yield calculations presented in the 'UCO SAF Yields' slide.

UCO SAF yields

~43–61% of collected UCO becomes SAF, with the remainder converted into renewable diesel and other co-products that also provide carbon abatement benefits

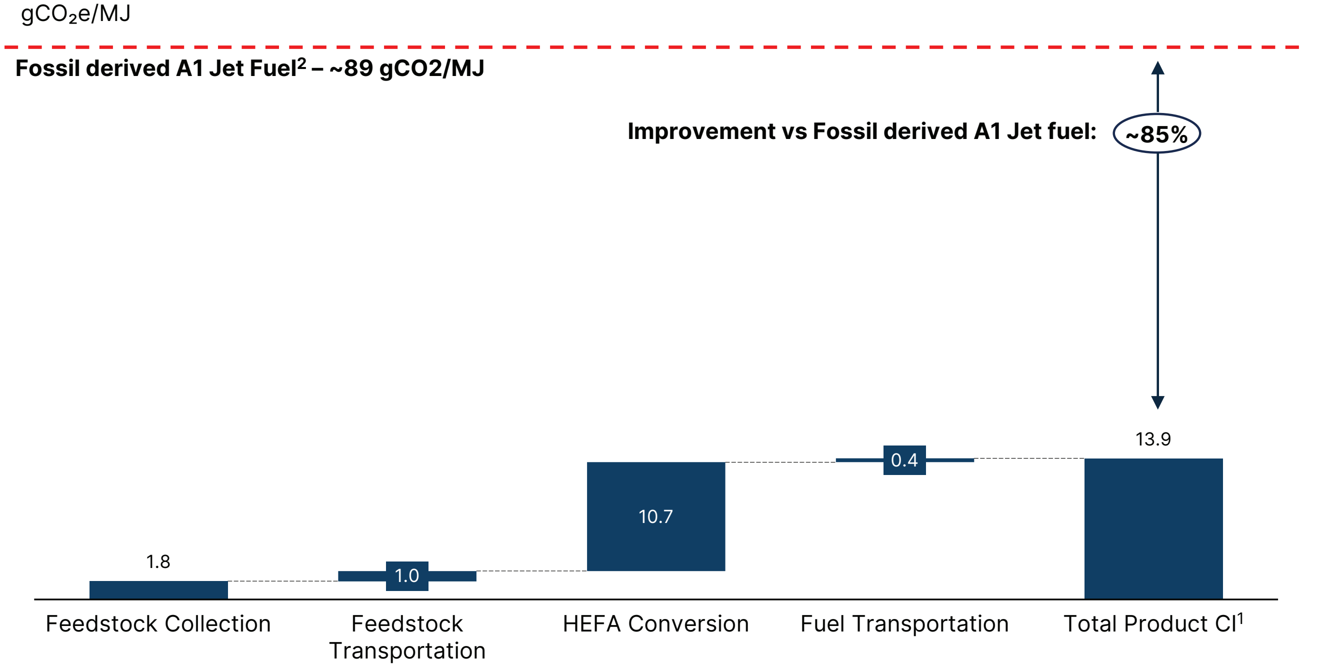


Notes: FAME yield exceeds 100% due to methanol incorporation during transesterification. These figures are theoretical, and a range has been provided based off available literature.
Source: Transport & Environment, 'UCO Study – Stratas' (2024); International Civil Aviation Organization (ICAO), 'Feasibility Study – Côte d'Ivoire SAF' (2023); Global Biofuels Alliance (GBA), 'SAF Whitepaper' (2023); CSIRO, 'Sustainable Aviation Fuel Roadmap' (2023).

UCO carbon intensity

SAF derived from UCO delivers a ~85% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Used Cooking Oil (UCO) Carbon Intensity (CI) Build Up



CI Reduction Levers

Levers primarily target feedstock collection and transportation

1 Optimised Feedstock Collection and Transportation

- **Optimised route logistics:** Use of fleet routing software and predictive pickup scheduling to minimise truck travel
- **Electrification of collection fleets:** Electric or hybrid UCO trucks can reduce emissions, especially on urban routes
- **Digitalised collection systems:** IoT tank sensors with real time updates on fill rates and data driven decision making
- **Quality incentives for suppliers:** Encouraging clean, separated UCO through pricing incentives reduces energy needed for pre-treatment
- **Co-location of aggregation and pre-treatment:** Reducing double handling by performing filtration near collection zones

2 Treatment and Refining Improvements

- **Renewable-powered pre-treatment:** Solar panels, bioenergy or renewable grid electricity to power filtration systems, heating and pumps
- **Onshore refining:** Eliminates international shipping-related emissions and improves end-to-end traceability

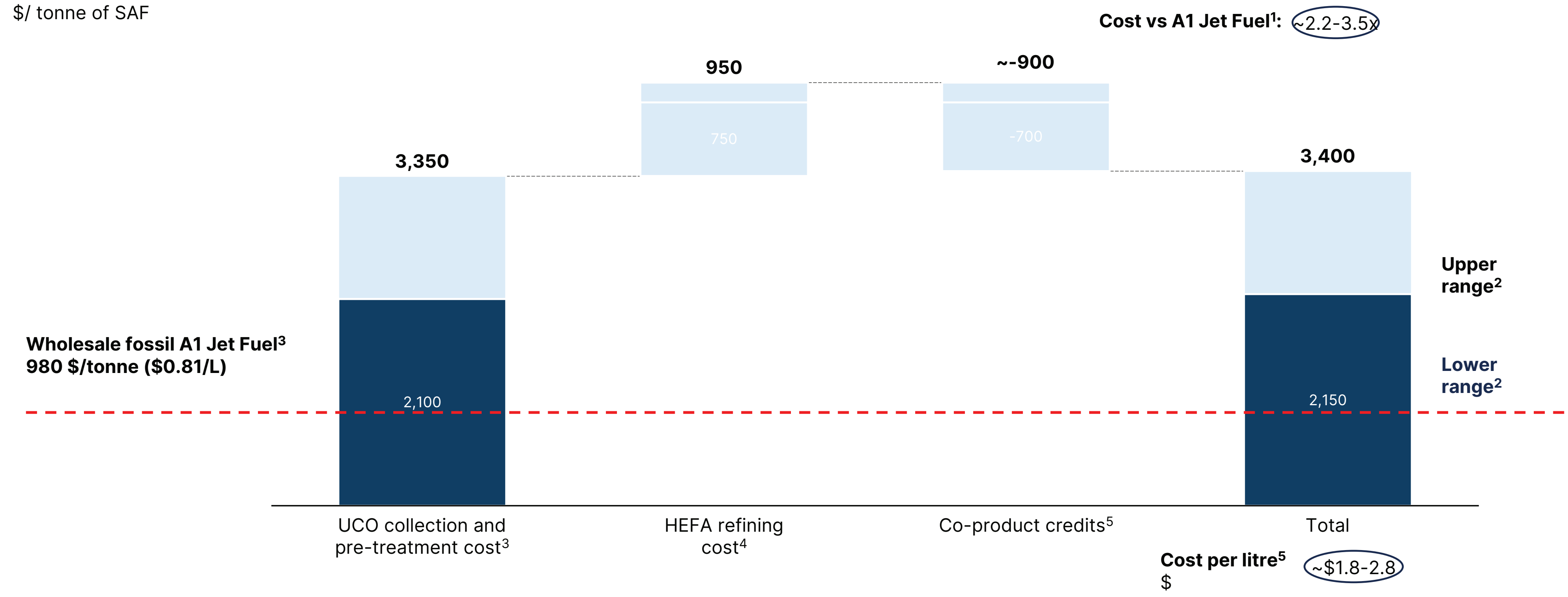
Notes: (1) Add 5.7 gCO2e/MJ if hydrogen used is produced from coal. Add 4.9 g CO2e/MJ if process heat is produced from coal. (2) Standard fossil fuel derived value from CORSIA. CI score calculated under a standalone conversion design

Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

UCO SAF cost

UCO-based SAF remains ~2.2-3.5x more expensive than fossil jet fuel, at around ~ $1.8-2.8/L versus ~$0.81/L for fossil jet fuel

Cost of Production

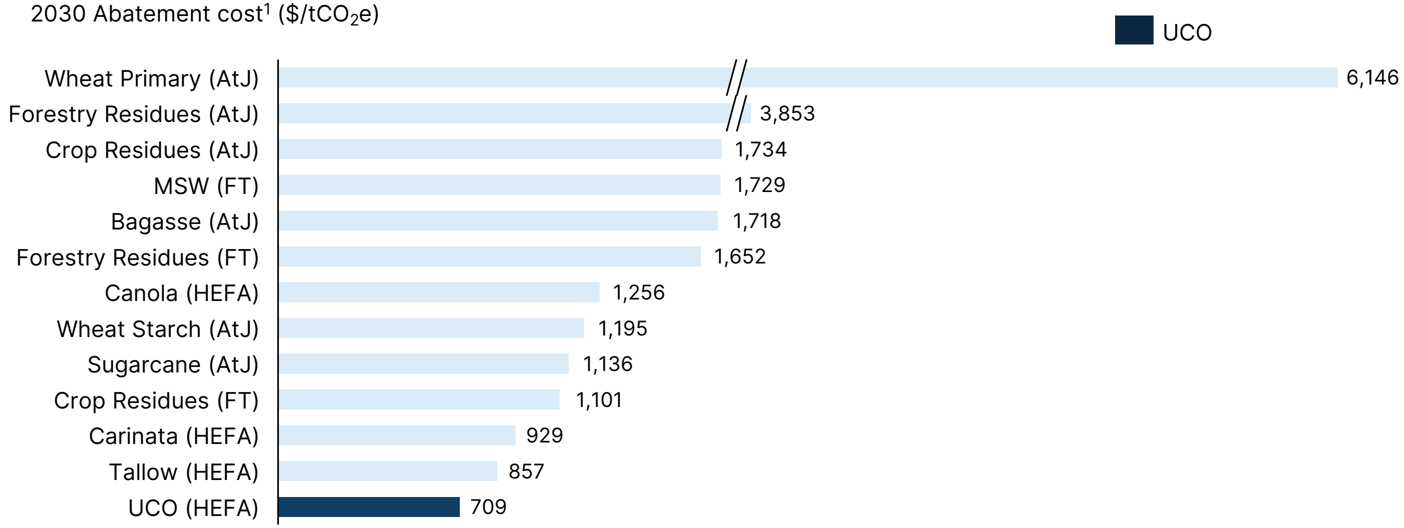


Notes: (1) A conventional jet-fuel price of 686 USD/t for Asia & Oceania (≈980 $/t) is taken from the IATA/S&P Global Platts Jet Fuel Price Index for 30 January 2026. (2) Upper and lower ranges capture uncertainty in UCO commodity prices and HEFA capex / opex. (3) UCO commodity prices are taken from August 2025, Rotterdam, according to Fastmarkets. Range is reflective of the high and low values in the trailing 12 months. (5) Co-product credits include sale of by-products (renewable diesel); renewable diesel reference price range $2/L, taken as 2x fossil diesel (Australian Institute of Petroleum, 2024).
Source: International Air Transport Association (IATA) & S&P Global Platts, 'Jet Fuel Price Monitor' (2026); Fastmarkets, 'Used Cooking Oil (UCO) Prices – Rotterdam' (2025); Bioenergy Australia, 'Renewable Diesel Market Update' (2024); International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025).

Abatement cost curve position

Australian UCO SAF sits at the lower end of the abatement cost curve, making it a cost-effective early decarbonisation option

SAF Abatement Costs - Australia



$709
UCO SAF
$/tCO2e

~2.2-3.5x
Costs
vs. fossil jet

~85%
GHG Reduction
vs. fossil jet

SAF – Abatement cost drivers

- Limited incremental emissions reduction
- HEFA processing requires hydrogen and intensive pre-treatment, increasing operating costs

Competitive Context

Delivers strong CI performance, but limited marginal abatement versus fossil jet

Abatement cost driven by feedstock scarcity and export-linked pricing

Scale constrained by finite waste availability and competing non-aviation uses

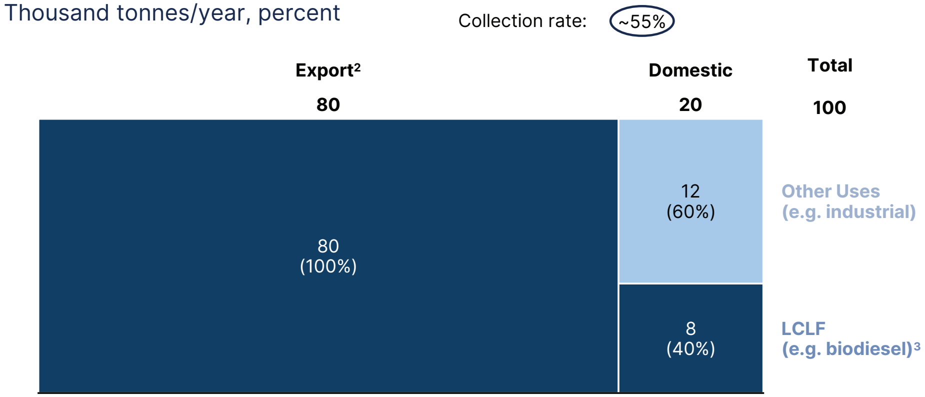
Notes: (1) Abatement cost is calculated as the SAF–fossil jet price differential divided by emissions reduction per tonne of fuel, where emissions reduction equals (CI_fossil − CI_SAF) × 43,000 MJ/t ÷ 1,000,000, based on CORSIA default CI values and corn-ethanol as a proxy for wheat. (2) assumes conservative cost reductions.
Source: Clean Energy Finance Corporation (CEFC), 'Refined Ambitions' (2024).

UCO supply potential

~100 kt of UCO is currently collected annually in Australia, with additional volumes potentially recoverable through improved collection and aggregation; most collected supply is exported for LCLF production

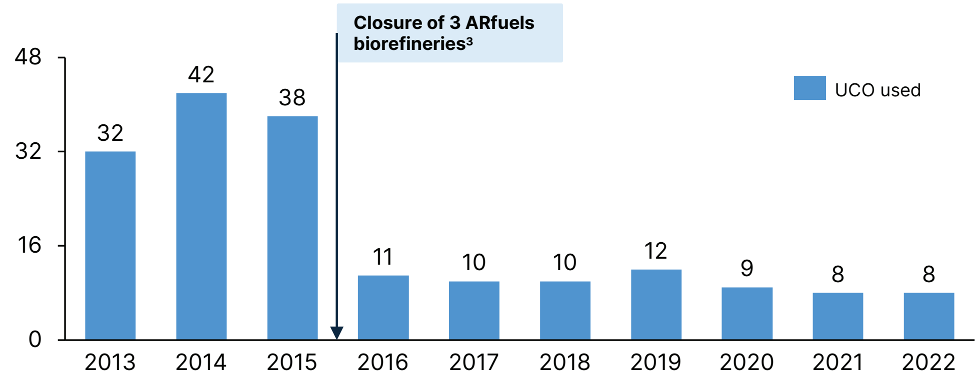
UCO Overview

Australia UCO collected[1]
Thousand tonnes/year, percent



Domestic Production

Australia UCO domestic use in LCLF Biodiesel
Thousand tonnes/year



Current uses

Industrial and Cleaning Products
Uses in soaps, detergents, lubricants and other chemical products

Animal feed
Processed and recycled into a high-energy ingredient for animal feed. Use limited by health regulations

Biofuels (export)
Exported and converted overseas into biodiesel and renewable diesel

Industry challenges

Constrained supply
Fragmented collection, contamination and distance make recovery difficult

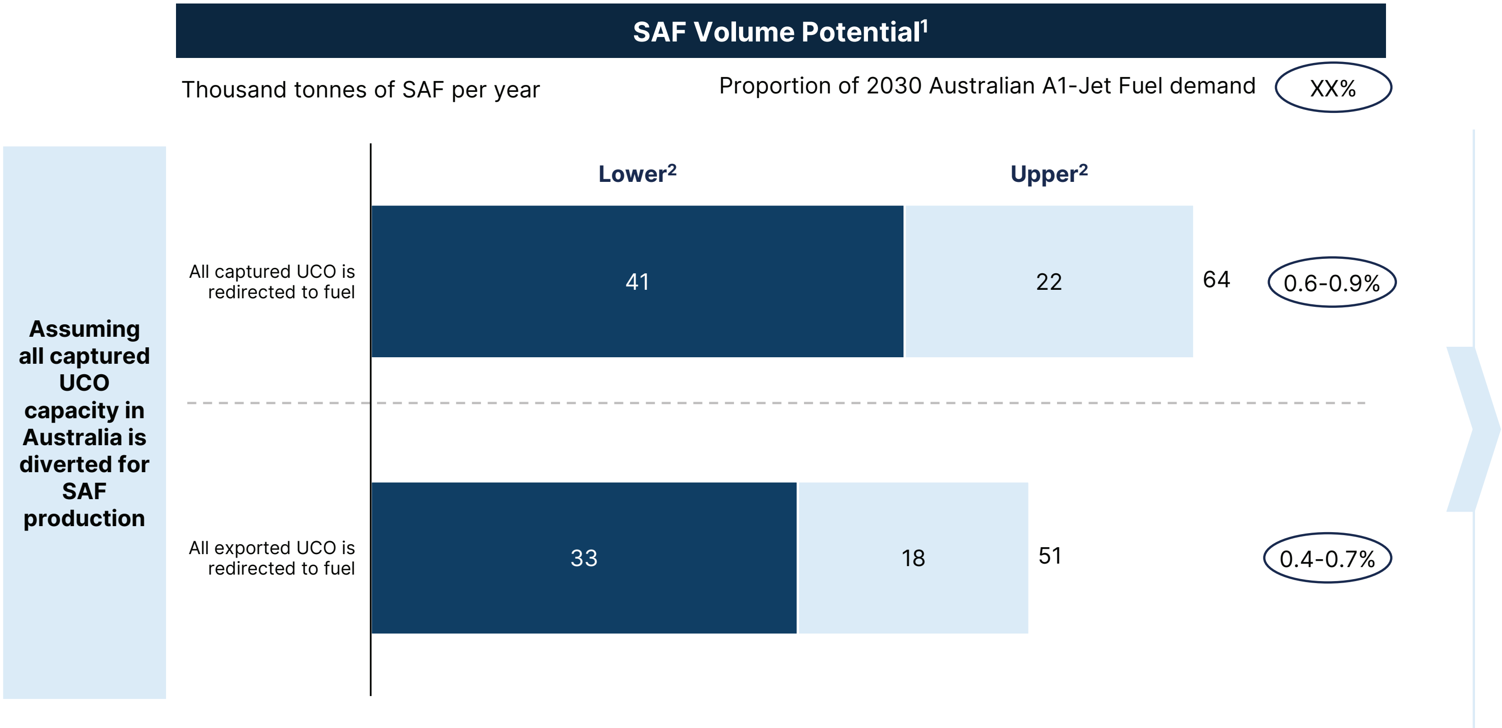
Competition and price volatility
Strong demand from biodiesel and renewable diesel competes for the same UCO pool

Sulfur, phosphorous and trace metals
UCO can contain trace contaminants which may trigger regulatory constraints on outputs

Notes: (1) ~100 kt UCO collected annually in Australia based on CSIRO SAF Roadmap (2023) and EU per-capita generation benchmarks (~8 L/person/year) with ~50–55% recovery rate applied; (2) ~80% of collected UCO exported, consistent with industry and trade reporting; (3) Domestic LCFL use decline reflects closure of three ARfuels biorefineries (2016), based on USDA FAS Biofuels Annual (2022).
Source: CSIRO, 'Sustainable Aviation Fuel Roadmap' (2023); Transport & Environment / Stratas Advisors, 'UCO Study' (2024); European Biomass Industry Association (EUBIA), 'Used cooking oil challenges'; USDA Foreign Agricultural Service, 'Biofuels Annual – Australia' (2022); Ampol, 'Brisbane Renewable Fuels Project: Market Context and Interim Report' (2025).

UCO SAF volume potential and implications

If 100% of UCO was captured and converted to SAF, it could supply ~0.6-0.9% of domestic jet fuel demand; at current UCO capture rates, supply potential drops to~0.4-0.7% when 100% diverted for SAF



Insights

- If all collected Australian UCO volume was redirected for SAF production, UCO could theoretically supply ~0.6-0.9% of Australia's 2030 jet fuel demand
- Assuming an export rate of ~80%, using only exported volumes could support potential SAF production equating to ~0.4-0.7% of 2030 jet fuel demand

Notes: (1) potential volume is calculated through UCO production volume, capture percentage, product yield percentage and SAF yield from UCO. It assumes 100% of all available feedstock in that category is diverted to produce SAF. See 'UCO SAF yields' slide for more detailed methodology and sources. (2) Ranges are calculated based on source differences in UCO volume and variation in product yield percentages and SAF yield.
Source: International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025); CSIRO, 'Sustainable Aviation Fuel Roadmap' (2023); USDA Foreign Agricultural Service, 'Biofuels Annual – Australia' (2022).

SAF vs others uses

Established biodiesel markets, alongside emerging material uses, shape how UCO is priced and allocated

Current Market Uses

Road Fuels

Biodiesel (FAME)

- Road diesel blending
- Heady duty transport
- Marine fuel blend

Biodiesel production capacity in Australia[1]

110m liters/year

(2023)

Renewable Diesel (HVO)

- Dron-in diesel for road transport
- Mining and off-road equipment
- Rail and construction fleets

Biodiesel Australia production[1]

1.5m liters/year
(~2% of total capacity)

(2023)

Emerging uses

- Bioplastics and flexible packaging
- Bio-based coatings, resins and adhesives
- Cosmetics and personal care ingredients
- Sustainable lubricants
- Animal feed

Renewable diesel production

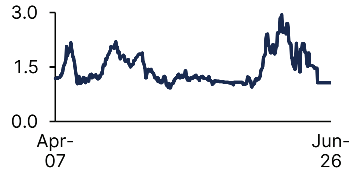
Australia does not produce renewable diesel

Investment and Economic Challenges

1 Road fuel demand anchors UCO pricing

- Biodiesel prices have been consistently volatile but elevated (~$1–3/L over time)
- This pricing sets a global floor for UCO that SAF must compete against
- Emerging material uses

USA biodiesel historical price[2]
$/L



2 Established biodiesel markets absorb UCO volumes

- Australia has ~110 million litres/year of biodiesel capacity, creating a large, established outlet for UCO
- This capacity absorbs UCO volumes ahead of SAF, tightening availability unless SAF matches road-fuel pricing
- Additional diversion to non-fuel material markets reduces feedstock available for aviation

3 Investment follows road fuel returns

- Biodiesel offers near-term returns with lower risk than SAF pathways
- Without aviation-specific incentives, capital and feedstock favour biodiesel over UCO-to-SAF
- Higher-margin emerging uses may further shift allocation away from fuel markets

Notes: (1) The 110 m L/year figure is installed biodiesel nameplate capacity, not current output. It comes from three existing plants - Eco Tech Biodiesel (QLD, ≈30 m L/yr), Biodiesel Industries Australia (NSW, ≈20 m L/yr) and Just Biodiesel (VIC, ≈60 m L/yr) - which produced only ~1.5 m L in 2023 (≈1% utilisation), as they are largely idle without national blending mandates or price support
Source: Argus Media, 'Australia should incentivise renewable fuels lobby' (2023); Australian Renewable Fuels Project – Infrastructure Australia documentation (2024); Cardno / RMIT biodiesel operating margins database.

Strategic opportunities

Australia's UCO supply creates a strong early SAF opportunity; unlocking scale depends on leveraging existing infrastructure and taking advantage of favourable abatement economics

Feedstock Market

Strong Global Demand and Export Substitution

Redirecting UCO from export markets to domestic SAF production retains economic and environmental value in-country.

Infrastructure & Processing

Existing Collection and Export Infrastructure

Australia already exports >80% of collected UCO via companies such as Auscol, Cookers and EcoTech.[1]

Short-Term Refining Potential

UCO is one of the few feedstocks available today in usable volumes, with minimal agricultural scale-up required. It can be used in HEFA technology, which is commercially mature globally.

Abatement Economics

Ultra-low Carbon Intensity

UCO has one of the lowest CORSIA default values (13.9 gCO_2e/MJ), making it highly attractive under international policy schemes.[2]

Strong Co-Product Value Streams

SAF from UCO also yields valuable co-products such as naphtha and renewable diesel, increasing total project returns. Co-products may also qualify for decarbonisation credits.

Improved Traceability and Digital Tracking

Growing uptake of digital waste tracking platforms can support SAF credit compliance (e.g. Book & Claim systems, ISCC certification).

Policy Preference for Waste-Based Feedstocks

UCO is a non-edible, waste-based feedstock, offering a 'double dividend'. It diverts waste from landfill or improper disposal and avoids ILUC penalties under CORSIA, lowering the overall CI.

Source: Ampol, 'Brisbane Renewable Fuels Project: Market Context and Interim Report' (2025); International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025).

Structural and execution challenges

While Australia's UCO system has several logistical strengths for SAF, scalability remains constrained by low domestic volume potential

Feedstock Market

1 Limited Supply Scale

At 100% national recovery, UCO volumes are capped at ~182,000 tonnes per year[1]. This is insufficient to scale the entire SAF industry and must be complemented by other feedstocks.

2 High and Volatile Feedstock Prices

Intense international competition (especially from the EU and Singapore) inflates local UCO prices. Price can fluctuate by >$500/tonne[2] in short periods, exposing refinery margins.

3 Competing Demand from Other Sectors

Animal feed, oleochemical and industrial users also rely on UCO as a cost-effective input. Without strong SAF incentives, UCO may be diverted toward simpler and higher-margin markets.

Infrastructure & Processing

4 Logistics and Fragmentation

UCO collection is decentralised, often involving small-volume pickups across a wide geographic area. This results in high transport and aggregation costs.

5 Processing Infrastructure Demands

UCO purity varies by collection point. This results in costly pre-treatment infrastructure and strict QA processes being required to meet refinery input specifications.

6 Sulfur and Trace Contaminants

UCO can contain sulfur and trace metals from frying oils and detergents. This may require additional processing steps and trigger regulatory constraints on sulfur in the final SAF product.[3]

Notes: (1) See 'UCO supply potential' slide for detailed sources and methodology.
Source: See e.g. Fastmarkets, 'Used Cooking Oil Prices'; ASTM, 'Standard Specification for Aviation Turbine Fuel Containing Synthesised Hydrocarbons' (2022)

Infrastructure and processing gaps

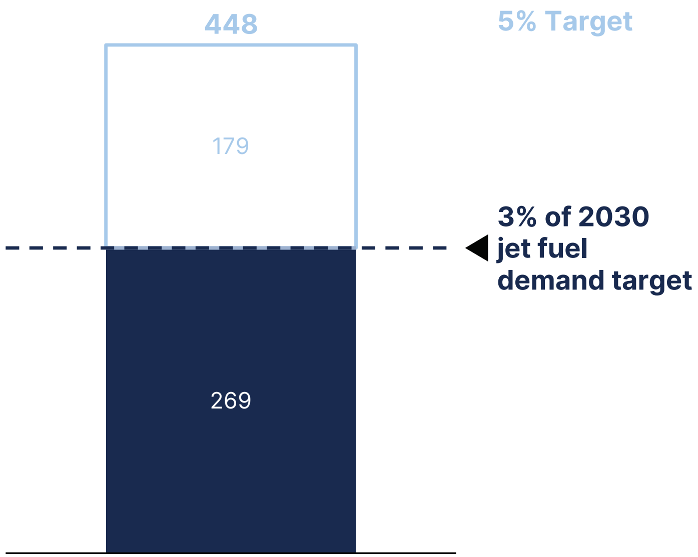
UCO is a SAF-ready feedstock, with only HEFA infrastructure investment required to create SAF

Required Refining Capacity

Meeting the 3–5% 2030 Target Requires 269–448 ML of HEFA Capacity[1]

Million litres per year

~1.6kg of UCO is required to produce 1L of SAF



Required HEFA SAF Capacity[1]

Planned HEFA Developments

AMPOL, GrainCorp & IFM, Lytton Refinery – Brisbane, Qld

Description: Proposed large HEFA facility producing SAF and RD
Feedstocks: Waste oils (e.g. UCO), tallow and canola oil
Planned capacity: 750ML of LCLF per year, a mix of SAF (~90%) and RD (~10%)
Development status: Pre-FEED stage completed late 2025, co-funded by ARENA

Jet Zero Australia & Apeiron Bioenergy, Project Mandala – Gladstone, Qld

Description: Proposed large HEFA facility producing SAF and renewable diesel (RD)
Feedstocks: Waste oils (e.g. UCO), tallow and oilseed crops
Planned capacity: 402ML of LCLF per year (308,000 tonnes), a mix of SAF and RD
Development status: Pre-FEED stage. Feasibility study due for completion by 2026

APAC Regional HEFA Refineries

Neste, Tuas Refinery, Singapore

- HEFA facility using waste (e.g. UCO) and crop oils completed in April 2023
- Capacity: ~1,200ML per year, supplied to airlines such as Singapore Airlines

SK Energy, Ulsan Refinery, South Korea

- HEFA facility using waste oils (e.g. UCO) completed in September 2024
- Capacity: ~120ML per year (~80% SAF), supplied to airlines such as Korean Air and Cathay Pacific

Notes: (1) Required/target capacity refers to 3–5% of Australia's 2030 jet fuel demand (~9,000 ML), in line with Singapore's proposed 2030 targets.
Source: Jet Zero Australia – Projects; Ampol – Brisbane Renewable Fuels (Pre-FEED Study); Manifold / Mandala project disclosures; ARENA funding announcements; Argus Media; Neste; SK Energy corporate releases.

10

SAF feedstock deep dives

e. Tallow and animal fats

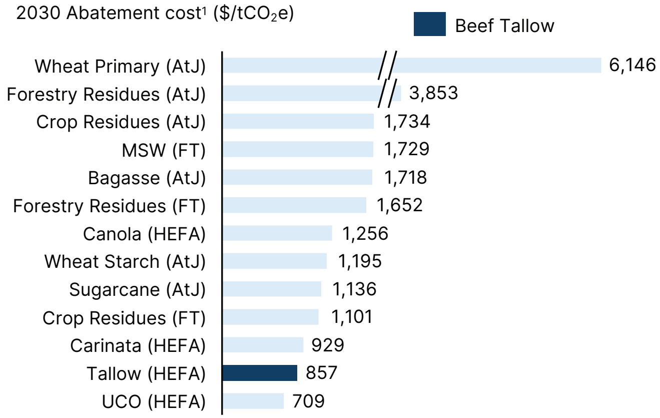
GrainCorp

Beef Tallow summary

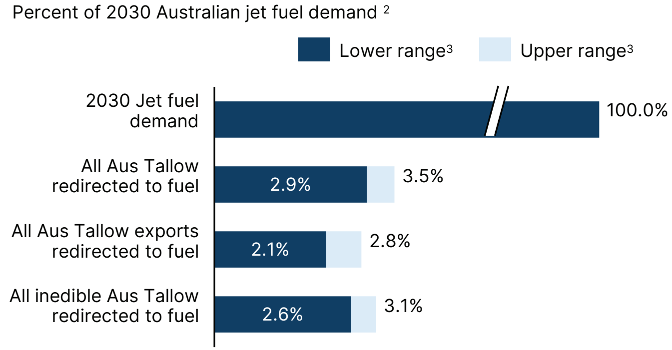
Australian beef tallow represents a credible early SAF pathway with strong carbon performance and existing infrastructure, but its long-term impact is structurally constrained by limited volumes and competing end uses

Executive Summary	
Technical viability	• Beef Tallow is a commercially proven HEFA feedstock, supported by Australia's established rendering, upgrading and export infrastructure • Tallow delivers ~43% SAF yield via HEFA conversion, alongside renewable diesel and co-products, enabling integrated fuel production pathways[4]
Emission reduction potential	• Tallow-derived SAF delivers ~67% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~29.7 gCO_2e/MJ vs ~89 gCO_2e/MJ) • Additional reductions are possible through improved rendering efficiency, renewable electricity use in pre-treatment, and optimisation of logistics and hydrogen inputs
Economic competitiveness	• Tallow-based SAF remains ~2.1-4.2x more expensive than fossil jet, driven by feedstock pricing, hydrogen intensity and refining costs • However, with an abatement cost of ~$860/$tCO_2e$, Beef Tallow SAF sits at the lower end of Australia's SAF cost curve relative to crop-based pathways
Australia's opportunity	• Australia produces ~550kt of Tallow annually, with ~70% exported, creating near-term redirection potential under the right policy and market signals • Established rendering, storage and export systems, combined with planned HEFA investments, position Tallow as a credible early SAF deployment pathway
Australia's scale potential	• Under 100% diversion, Tallow could supply ~2.9–3.5% of Australia's 2030 jet fuel demand (or ~2.6–3.1% using inedible Tallow) • Supply is structurally capped by red meat throughput and faces strong competition from food, feed and industrial markets, limiting long-term scalability

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand[2]



Notes: (1) assumes conservative cost reductions, for detailed information refer to the slide 'Abatement cost curve position'. (2) For percent of 2030 Australian jet fuel demand refer to the slide 'Beef Tallow volume and potential implication'. (3) Ranges are calculated based on source differences in tallow volume, export percentage and variation in product yield percentages and SAF yield. (4) For yields information please refer to 'Beef Tallow SAF yields'
Source: Clean Energy Finance Corporation (CEFC), Refined Ambitions (2024); International Civil Aviation Organization (ICAO), SAF Rules of Thumb; Meat & Livestock Australia (MLA); Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES).

Beef Tallow value chain

Beef tallow is a technically proven SAF feedstock via the HEFA pathway, while also serving multiple established end markets

→ Fuel pathway

Production Pathway

Animal Slaughter & Carcass Processing
Animal fats collected as a by-product of livestock processing.

→

Rendering
Fats are heated and separated into tallow and protein meal.

→

Tallow grading & finishing
Tallow is tested, filtered, and upgraded to fuel-grade quality

→

Pre-treatment
Additional cleaning removes trace contaminants and prepares tallow for downstream applications.

→

Storage & aggregation
Pre-treated tallow is stored and aggregated to achieve consistent volumes and quality

End Use Applications

Food
Used as shortening and cooking fat in food manufacturing and processing

SAF
Pre-treated tallow is converted into sustainable aviation fuel and renewable diesel.

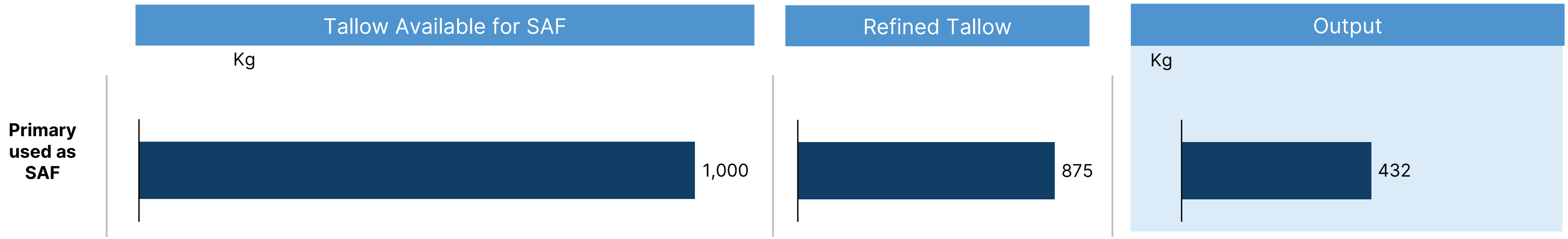
Animal & pet feed
Used as an energy-rich fat ingredient in livestock and pet food formulations.

Soaps & personal care
Converted into fatty acids for soap, detergent, and personal care product manufacturing.

Beef Tallow SAF yields

One tonne of refined beef tallow yields approximately 432 kg of SAF through HEFA conversion

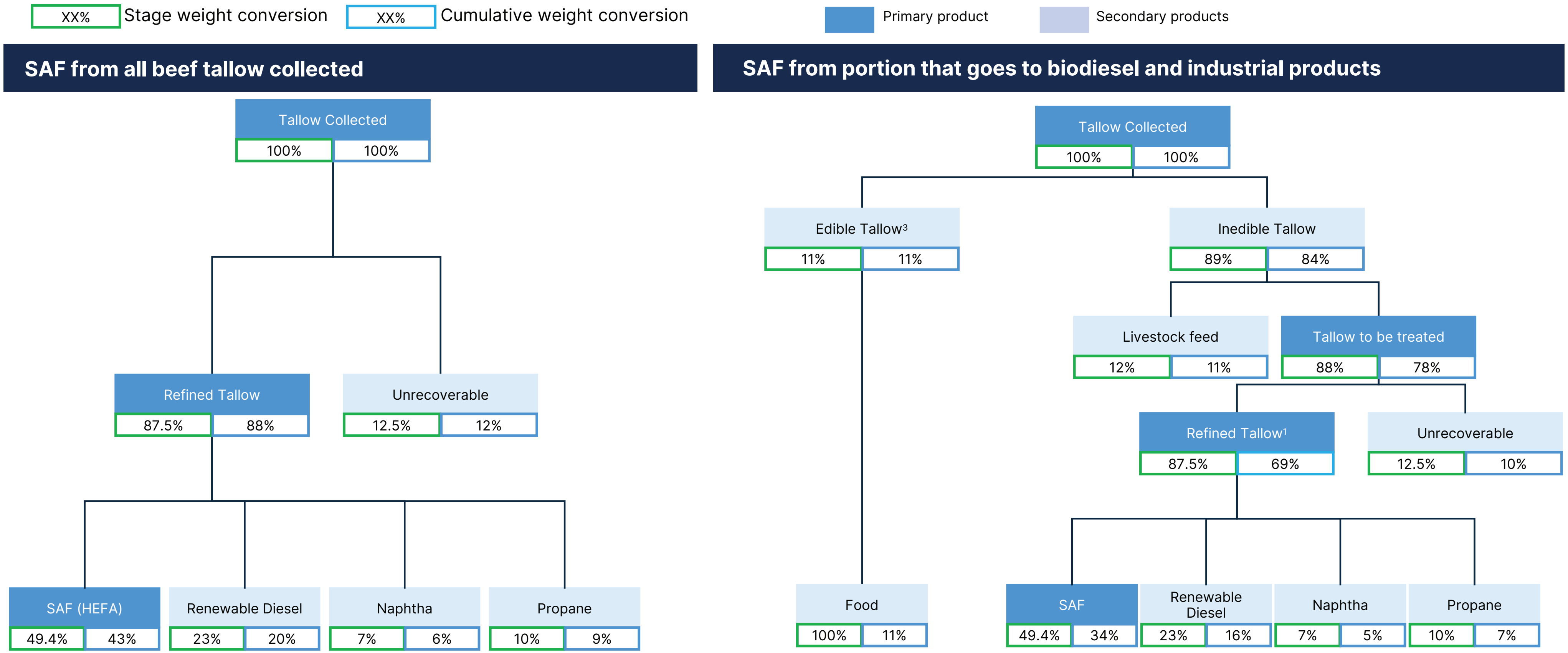
SAF Production output from 1 tonne of Beef Tallow by feedstock pathway



Notes: (1) Results reflect the yield calculations presented in the 'Beef Tallow SAF Yields' slide.

Beef Tallow SAF yields

Beef tallow delivers ~43% SAF yield via the HEFA pathway, with additional renewable diesel and co-products



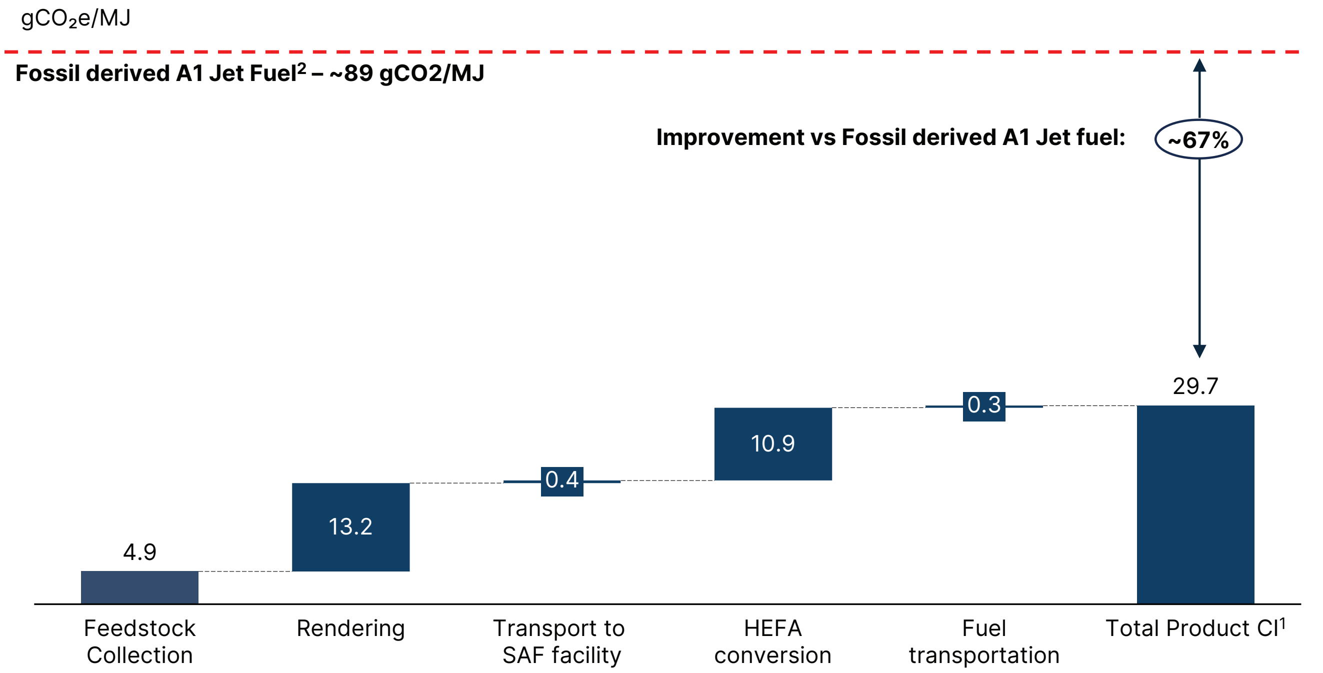
Notes: While there may be smaller, fragmented sources of tallow (such as individual butcheries) whose collection is not fully captured in available data, the vast majority of recoverable tallow is generated and collected at large slaughterhouses and rendering facilities. (1) Assume that instead of producing industrial product and biodiesel we produce SAF

Source: ACT SAF Feasibility Study, Feasibility Study – Côte d'Ivoire (Page 112); Argonne National Laboratory, GREET Model – Beef Tallow Update (2017); Australian Renderers Association, ARA Rendering Fact Book (2023); Meat & Livestock Australia, Tallow Market Report.

Beef Tallow carbon intensity

SAF derived from Beef Tallow delivers a ~67% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Beef Tallow Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers primarily target pre-treatment and rendering – large contributors to CI

1 Feedstock Quality and Pre-treatment

- **Reduce moisture and impurities at source:** Improving abattoir handling practices can produce a cleaner tallow upfront. Higher water content and impurities in raw tallow require more intensive drying and filtering downstream
- **Use renewable electricity in pre-treatment:** Tallow pre-treatment (drying, bleaching, filtration) typically consumes grid electricity or on-site diesel. Shifting to solar-powered pre-treatment units or grid-sourced renewable electricity would reduce emissions

2 Improving Rendering Efficiency

- **Use renewable energy input in rendering:** Switching to renewable energy sources or installing heat recovery systems to improve thermal efficiency could reduce fossil fuel input
- **Optimise rendering yields and minimise waste:** Adopting continuous rendering systems with better fat recovery and heat exchange could reduce overcooking or under-recovery
- **Valorise rendering co-product:** Using meat and bone meal (MBM) from rendering as fuel or feedstock can reduce the net carbon burden under system expansion methodology, or allow for co-product credits

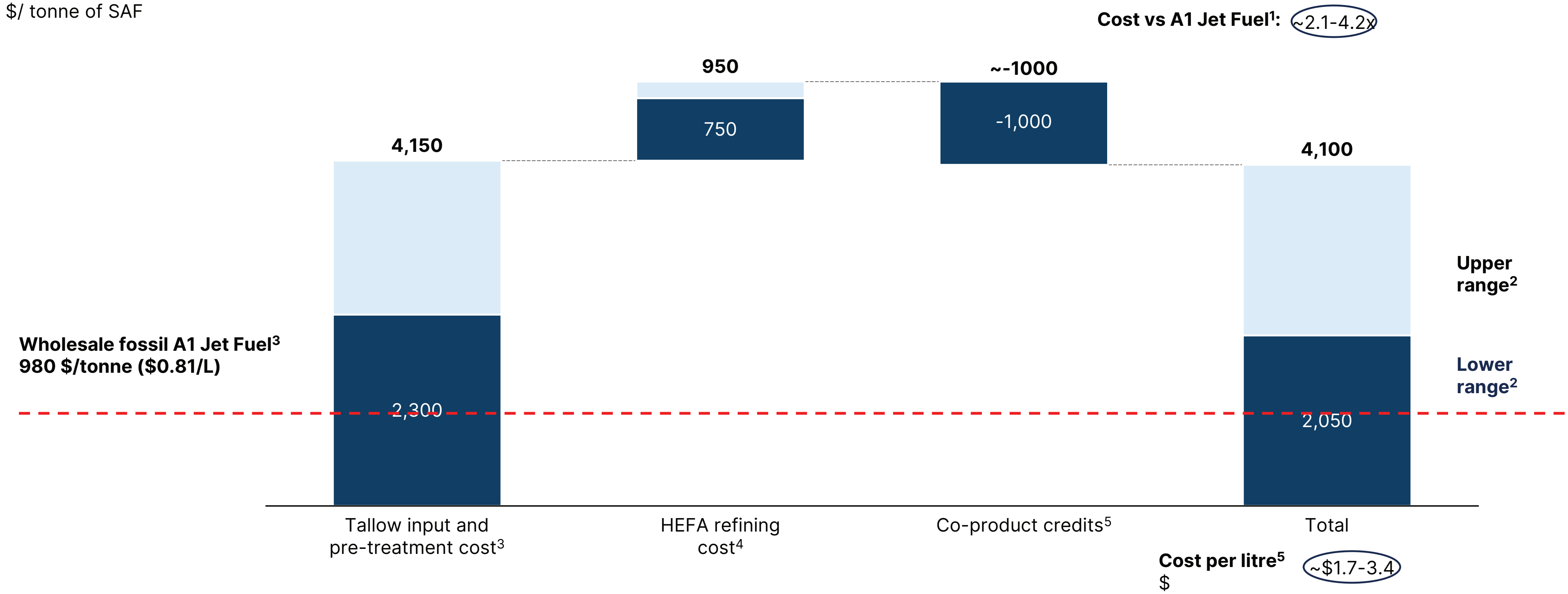
Notes: (1) Add 6.0 gCO2e/MJ if hydrogen used is produced from coal. Add 6.4 g CO2e/MJ if process heat is produced from coal. (2) Standard fossil fuel derived value from CORSIA. CI score calculated under a standalone conversion design

Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Tallow SAF cost

Tallow-based SAF remains ~2.1-4.2x more expensive than fossil jet fuel, at around ~ $1.7-3.4/L versus ~$0.8/L for fossil jet fuel

Cost of Production



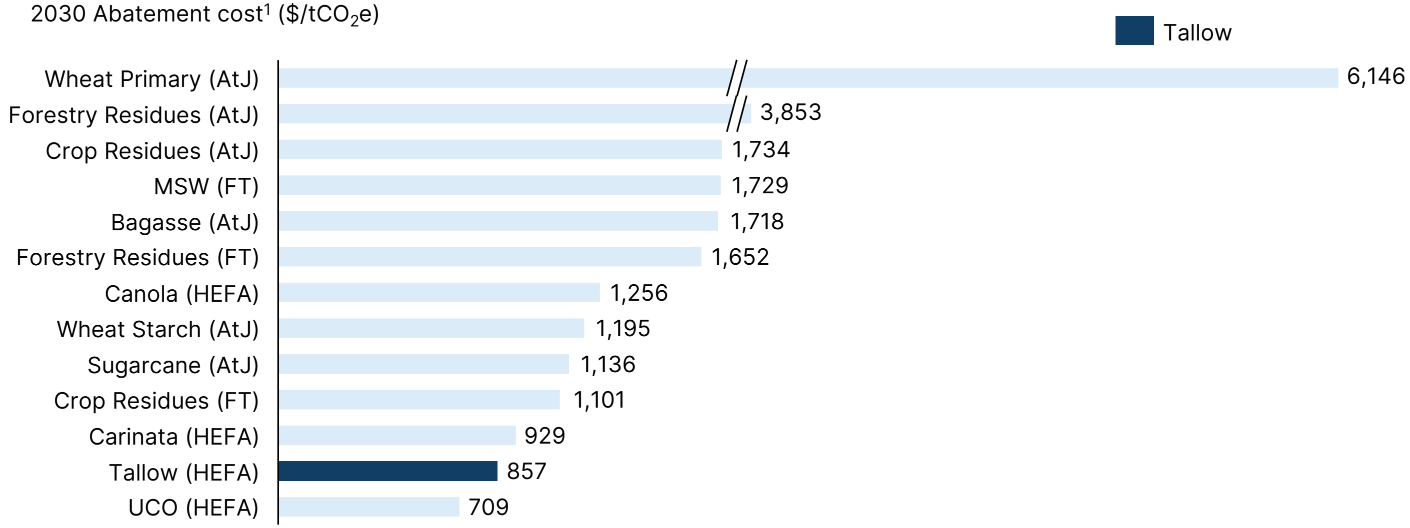
Notes: (1) Fossil A1 reference price based on IATA/S&P Global Platts Jet Fuel Price Index (~USD 686/t Asia & Oceania; ~$980/t equivalent); (2) Cost range reflects uncertainty in tallow commodity pricing and HEFA capital/opex; (3) Tallow input cost range ~$1,100–2,100/t, reflective of last five years variation (MLA data); (4) HEFA refining cost includes hydrogen, utilities and operating costs; (5) Co-product credits include sale of by-products (renewable diesel); renewable diesel reference price range $2/L, taken as 2x fossil diesel (Australian Institute of Petroleum, 2024).

Source: International Air Transport Association (IATA), Jet Fuel Price Monitor (2026); S&P Global Platts, Global Jet Fuel Price Index (2026); Meat & Livestock Australia (MLA), Rendered Products and Tallow Price Statistics (2024); Bioenergy Australia, Renewable Diesel Market Pricing Overview (2024); International Civil Aviation Organization (ICAO), SAF Rules of Thumb (2023).

Abatement cost curve position

Australian Tallow–based SAF sits at the lower end of the abatement cost curve, reflecting its low carbon intensity as a waste-derived feedstock

SAF Abatement Costs - Australia



$857
BEEF TALLOW SAF
$/tCO2e

~2.1-4.2x
Costs
vs. fossil jet

~67%
GHG Reduction
vs. fossil jet

SAF – Abatement cost drivers

- Waste by-product from red meat processing, not a primary feedstock
- Low lifecycle CI due to by-product attribution
- Mature HEFA pathway
- Hydrogen and pre-treatment intensity increase OPEX

Competitive Context

Strong CI performance vs fossil jet

Costs driven by limited waste availability and export pricing

Scale constrained by red meat processing volumes

Attractive early SAF feedstock, but structurally capped

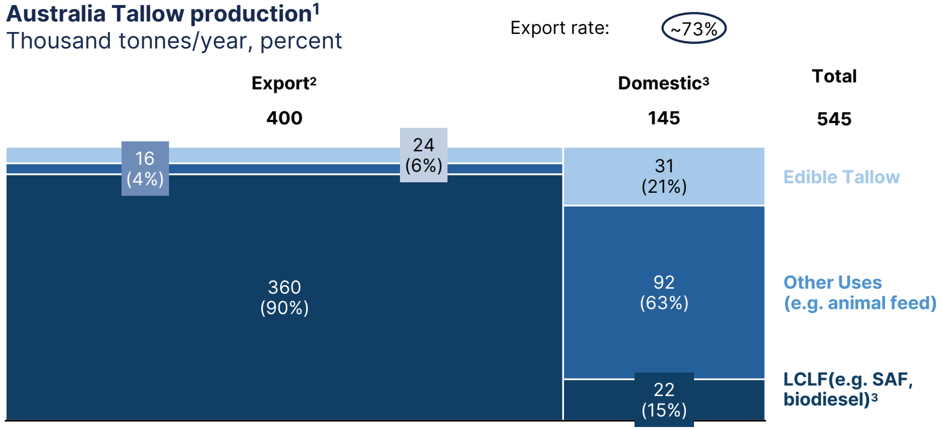
Note: (1) assumes conservative cost reductions.
Source: Clean Energy Finance Corporation (CEFC), ‘Refined Ambitions’ (2024).

Tallow supply potential

~545 thousand tonnes of Tallow is produced in Australia annually with exports for overseas LCLF production dominating Tallow usage

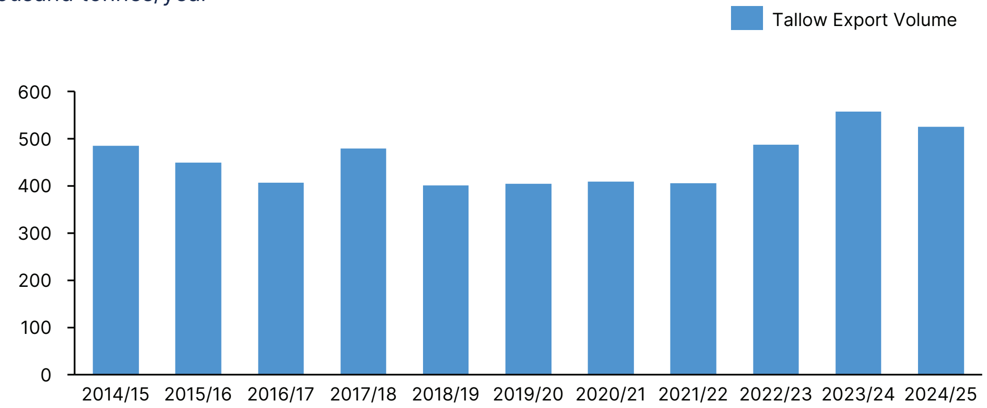
Tallow Overview

Australia Tallow production[1]
Thousand tonnes/year, percent



Domestic Production

Australia Tallow exports by year[4]
Thousand tonnes/year



Current uses

Edible tallow (food)
Used for frying and roasting due to its flavour and high smoke point

Animal feed
High-energy, cost-effective product to increase nutrient density in livestock and pet feed

Biofuels
Low-carbon feedstock to create renewable diesel and SAF, predominantly in Singapore and the US

Industry challenges

Feedstock quality variability
Tallow is a heterogeneous feedstock, sourced from different animals and rendering methods

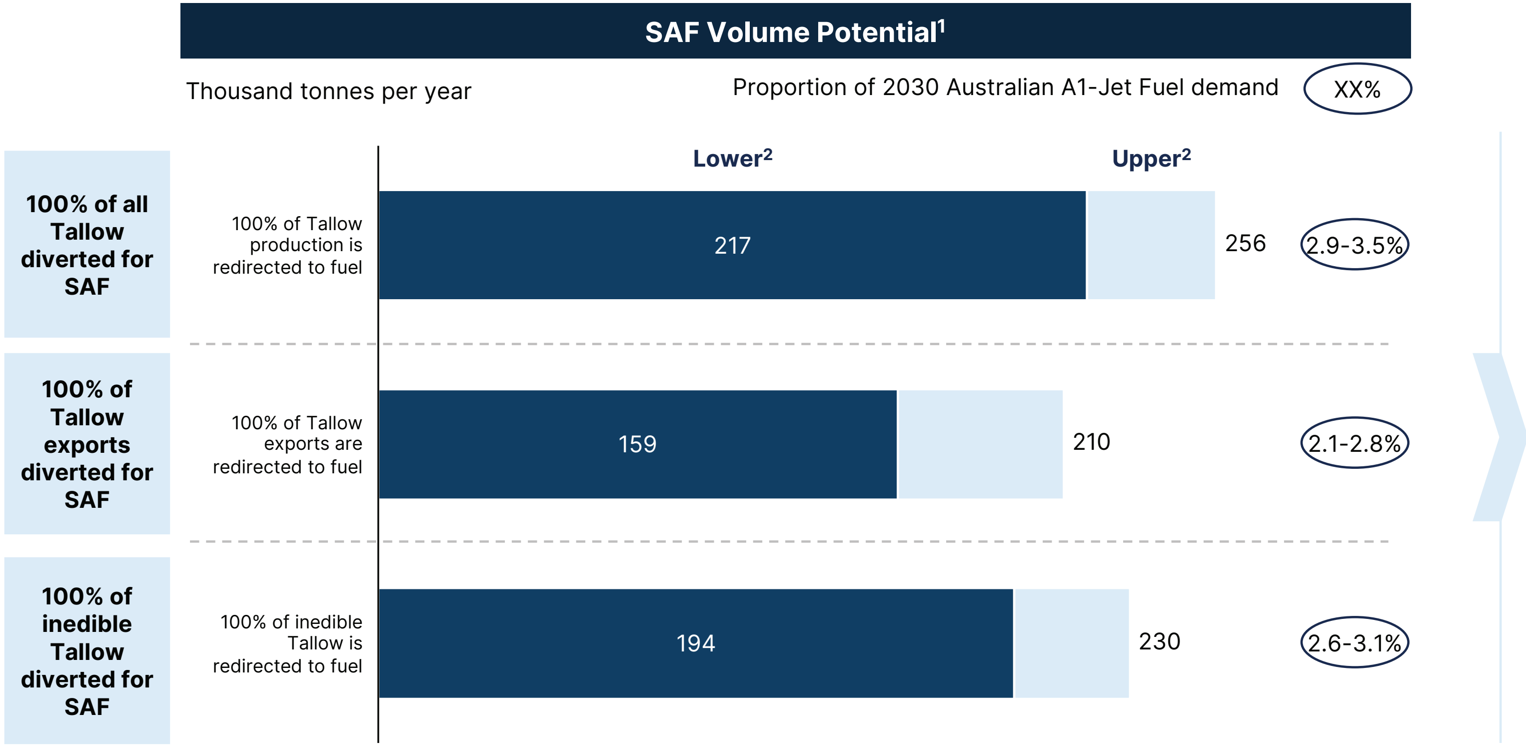
Dependent on meat demand
As a by-product of the meat industry, tallow volumes are dependent on meat demand

Dispersed geography
Tallow collection may not be maximised from regional locations due to transportation and logistical barriers

Notes: (1) Total tallow volume of 545 thousand tonnes refers to beef, sheep and goat tallow per ARA Rendering Fact Book (2023); (2) Export percentage (~81.8%) is calculated based on ~450,000 tonnes exported out of ~550,000 tonnes produced, with edible tallow exports taken from MLA data and LCFL share (90%) taken from Advanced Biofuels USA; (3) Allocation ratios were estimated using ARA Rendering Fact Book (2015/16) data, poultry-derived tallow excluded, edible shares calculated relative to total domestic tallow, and residual volumes assigned to other uses and LCFL; (4) Domestic use percentages are taken from ARA Rendering Fact Book (2023); (5) Export time series data sourced from ABS Trade data – exports by 8-digit ABHECC 2014–15 to 2024–25 pivot table.
Source: Australian Renderers Association, ARA Rendering Fact Book (2023); Meat & Livestock Australia, Tallow Export Data (2023); Advanced Biofuels USA, Australian Tallow Exports Exceed $1bn for First Time (2023); Australian Bureau of Statistics, International Trade Data – Exports by 8-digit ABHECC 2014–15 to 2024–25 (2025).

Tallow volume potential and implications

If 100% diverted, Tallow could supply ~2.9-3.5% of domestic jet fuel demand; using inedible Tallow would further reduce potential supply to ~2.6-3.1%



Insights

- If 100% of all Australian Tallow production is diverted into SAF production, Tallow could theoretically supply ~2.9-3.5% of Australia's 2030 jet fuel demand
- Assuming an export rate of ~80%, diverting all Tallow exports into domestic SAF production would supply ~2.1-2.8% of 2030 jet fuel demand
- Assuming an inedible tallow rate of 89.7%, with a 100% diversion rate of inedible Tallow into SAF production, inedible Tallow could supply ~2.6-3.1% of 2030 jet fuel demand

Notes: (1) potential volume is calculated through Tallow production volume, export percentage, product yield percentage and SAF yield from tallow. It assumes 100% of all available feedstock in that category is diverted to produce SAF. See 'Tallow SAF yields' slide for more detailed methodology and sources. (2) Ranges are calculated based on source differences in tallow volume, export percentage and variation in product yield percentages and SAF yield.

Source: International Civil Aviation Organization (ICAO), 'SAF Rules of Thumb' (2025); CSIRO, 'Sustainable Aviation Fuel Roadmap' (2023); USDA Foreign Agricultural Service, 'Biofuels Annual – Australia''(2022).

SAF vs other uses

Established food, feed and industrial markets structurally anchor Australian tallow demand, shaping availability and pricing for SAF

Current Market Uses

Food Applications

- Shortening and cooking fats
- Food manufacturing inputs

↓ -4.2% from 2023

Consumption of fats and oils per capita[1]

20.4 grams/day

(2024)

Animal Feed & Pet Food

- High-energy fat in livestock rations
- Pet food formulations

Ownership of pets[2]

69%, Australia one the highest ownership rate in the world

(2023)

Soap & Personal Care

- Soaps, detergents and surfactants

↑ CAGR +3.2%

Annual sales of personal care manufacturing[3]

$4.2 billion

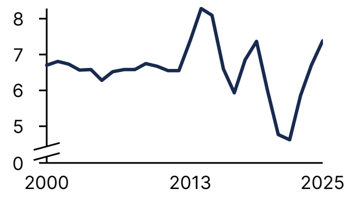
(2022)

Investment and Economic Challenges

1 Supply linked to slaughter cycles

- Beef tallow production is directly linked to cattle slaughter volumes, which exhibit clear cyclical volatility over time
- Periods of herd rebuilding or lower slaughter materially constrain available tallow supply, limiting scalability for SAF.

Number of cattle slaughtered historically[4]
Million of heads per quarter



2 Established food, feed and export markets absorb tallow volumes

- The majority of Australian tallow is either exported or directed to established food, feed and industrial markets
- Incremental volumes for SAF therefore require displacement of existing, price-competitive end uses.

3 Investment follows road fuel returns

- Australian tallow trades at international parity and is influenced by global demand dynamics
- Domestic SAF projects must compete with international buyers, exposing margins to export netbacks and currency movements.

Notes: (1) Consumption of fats and oils per capita reported as 20.4 grams/day (2024) per ABS; (2) Pet ownership reported at 69% in 2023 per RSPCA source; (3) Annual sales of personal care manufacturing reported at $4.2 billion (2022) with CAGR +3.2% per ACCORD industry report; (4) Cattle slaughter volumes presented in million heads per quarter from 2000 to 2025 per MLA statistics
Source: Australian Bureau of Statistics, Apparent Consumption of Selected Foodstuffs (2024); RSPCA Australia, Pet Ownership in Australia (2023); ACCORD Australasia, Economic State of the Industry Report (2022); Meat & Livestock Australia, Historical Slaughter Statistics (2025).

Strategic opportunities

Australia's Tallow supply creates a strong early SAF opportunity; unlocking scale depends on leveraging existing infrastructure and taking advantage of favourable abatement economics

Feedstock Market

Export Redirection Potential

Australia exports ~73% of tallow annually – with the right incentive structures, a proportion of this volume could be redirected to local SAF production.

Abatement Economics

Low Carbon Intensity

Tallow has one of the lowest CORSIA default values (29.7 gCO_2e/MJ), making it highly attractive under international policy schemes.[2]

Infrastructure & Processing

Established Rendering and Export Infrastructure

Australia has a mature rendering industry with existing tallow collection, aggregation and export supply chains. This enables rapid mobilisation of feedstock volumes.

Refining Technology Compatibility

Tallow is well-proven in commercial HEFA operations, with over a decade of use in global facilities. This lowers development risk, allowing leverage over existing IP and operations experience.

Policy and Direction

Alignment with Meat Sector Growth

Increase in red meat processing – driven by live export bans and processing efficiency – could grow the available tallow pool

Potential for Government Support

Tallow offers a strong domestic story for government support, particularly as it delivers regional jobs, supports decarbonisation and reuses waste materials.

Source: Ampol, 'Brisbane Renewable Fuels Project: Market Context and Interim Report' (2025); International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025).

Structural and execution challenges

While Australia's Tallow system has several logistical strengths for SAF, scalability remains constrained by low domestic volume potential and high competition from competing use streams

Feedstock Market

1 Feedstock Volume Constraints

Tallow supply is constrained by red meat throughput, with national output unlikely to exceed ~550,000 tpa (beef and poultry tallow combined) without higher livestock volumes

2 Price Volatility and Exposure to Global Markets

As Tallow is a globally traded commodity, its price is influence by international demand for renewable fuels, exchange rates and freight dynamics. This exposes SAF projects to input shocks.

3 Selective Competition from Other Uses

Certain industrial and feed markets compete for specific tallow grades; however, overlap with LCLF-grade specifications may be limited

Abatement Economics

4 Sustainability Scrutiny and ILUC Risk

Although tallow is currently classified as a waste product under CORSIA, classification and treatment under international sustainability frameworks may evolve over time

Infrastructure & Processing

5 Pre-Treatment and Refining Complexity

Tallow requires rigorous pre-treatment, and variability in composition can increase operational costs and reduce catalyst life.

6 Logistics and Storage Challenges

Tallow solidifies below ~35°C[2], creating handling and transport challenges in cooler months. Heated tankage and insulated pipelines may be required, especially for multi-modal supply chains.

Notes: (2) Exact temperature can depend on many factors e.g. type of fat, degree of saturation.
Source: CEFC, 'Refined Ambitions' (2024).

Infrastructure and processing gaps

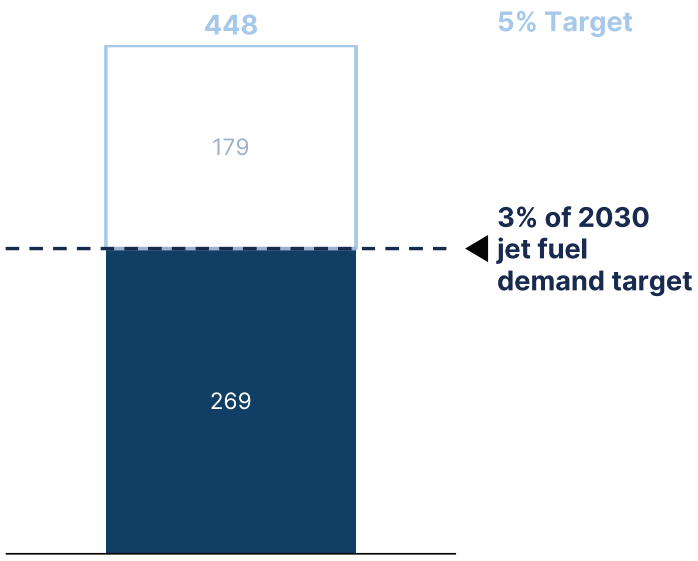
Tallow is a SAF-ready feedstock, with only HEFA infrastructure investment required to create SAF

Required Refining Capacity

Meeting the 3–5% 2030 Target Requires 269–448 ML of HEFA Capacity[1]

Million litres per year

~1.9kg of Tallow is required to produce 1L of SAF



Required HEFA SAF Capacity[1]

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Description: Proposed large HEFA facility producing SAF and RD
Feedstocks: Waste oils (e.g. UCO), tallow and canola oil
Planned capacity: 750ML of LCLF per year, a mix of SAF (~90%) and RD (~10%)
Development status: Pre-FEED stage completed late 2025, co-funded by ARENA

Jet Zero Australia & Apeiron Bioenergy, Project Mandala – Gladstone, Qld

Description: Proposed large HEFA facility producing SAF and renewable diesel (RD)
Feedstocks: Waste oils (e.g. UCO), tallow and oilseed crops
Planned capacity: 402ML of LCLF per year (308,000 tonnes), a mix of SAF and RD
Development status: Pre-FEED stage. Feasibility study due for completion by 2026

APAC Regional HEFA Refineries

Neste, Tuas Refinery, Singapore

- HEFA facility using waste (e.g. Tallow) and crop oils completed in April 2023
- Capacity: ~1,200ML per year, supplied to airlines such as Singapore Airlines

SK Energy, Ulsan Refinery, South Korea

- HEFA facility using waste oils (e.g. Tallow) completed in September 2024
- Capacity: ~120ML per year (~80% SAF), supplied to airlines such as Korean Air and Cathay Pacific

Notes: (1) Required/target capacity refers to 3–5% of Australia's 2030 jet fuel demand (~9,000 ML), in line with Singapore's proposed 2030 targets.
Source: Jet Zero Australia – Projects; Ampol – Brisbane Renewable Fuels (Pre-FEED Study); Manifold / Mandala project disclosures; ARENA funding announcements; Argus Media; Neste; SK Energy corporate releases.

10

SAF feedstock deep dives

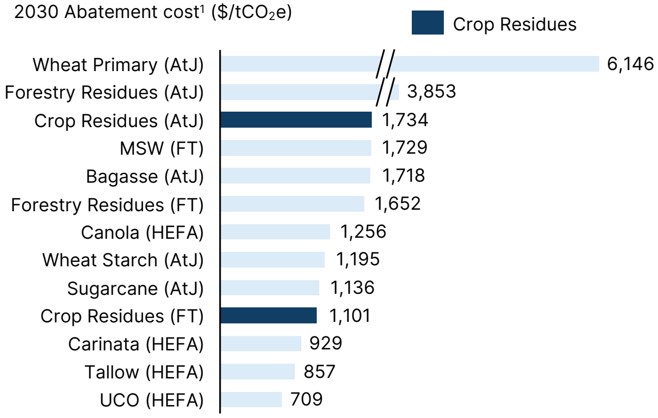
f. Crop residues

Crop residue summary

Crop residues have high potential for CI reduction but rely on less proven refining technology

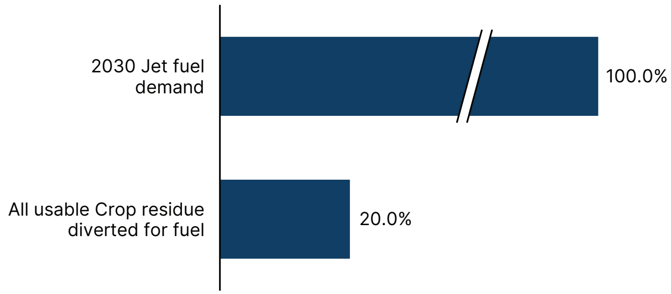
Executive Summary	
Technical viability	• Crop residues are converted to SAF via Fischer–Tropsch (FT) or Alcohol-to-Jet (AtJ) pathways, requiring gasification or cellulosic ethanol upgrading infrastructure • SAF conversion delivers ~11% AtJ SAF yield from dry biomass input, reflecting process losses and product fractionation
Emission reduction potential	• Via FT refining pathway, crop residue-derived SAF delivers ~90% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~7.7 gCO_2e/MJ vs ~89 gCO_2e/MJ) • Via AtJ refining pathway, crop residue-derived SAF delivers ~55% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~39.7 gCO_2e/MJ vs ~89 gCO_2e/MJ)
Economic competitiveness	• The FT pathway sits at ~$1,101/$tCO_2e$ on Australia's abatement cost curve • The AtJ pathway sits higher at ~$1,734/$tCO_2e$, reflecting lower carbon reduction and higher processing intensity
Australia's opportunity	• Australia generates ~84 Mt of crop residues annually (IPCC RPR-based estimate), including from cereals and sugarcane • Applying a 24%[1] removable fraction yields ~20 Mt of potentially available biomass for energy use
Australia's scale potential	• Under a 100% diversion scenario, crop residues could supply ~20% of Australia's 2030 jet fuel demand[2] • Given the feedstock is a byproduct, it is structurally capped by the volume of crop material produced in Australia

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand

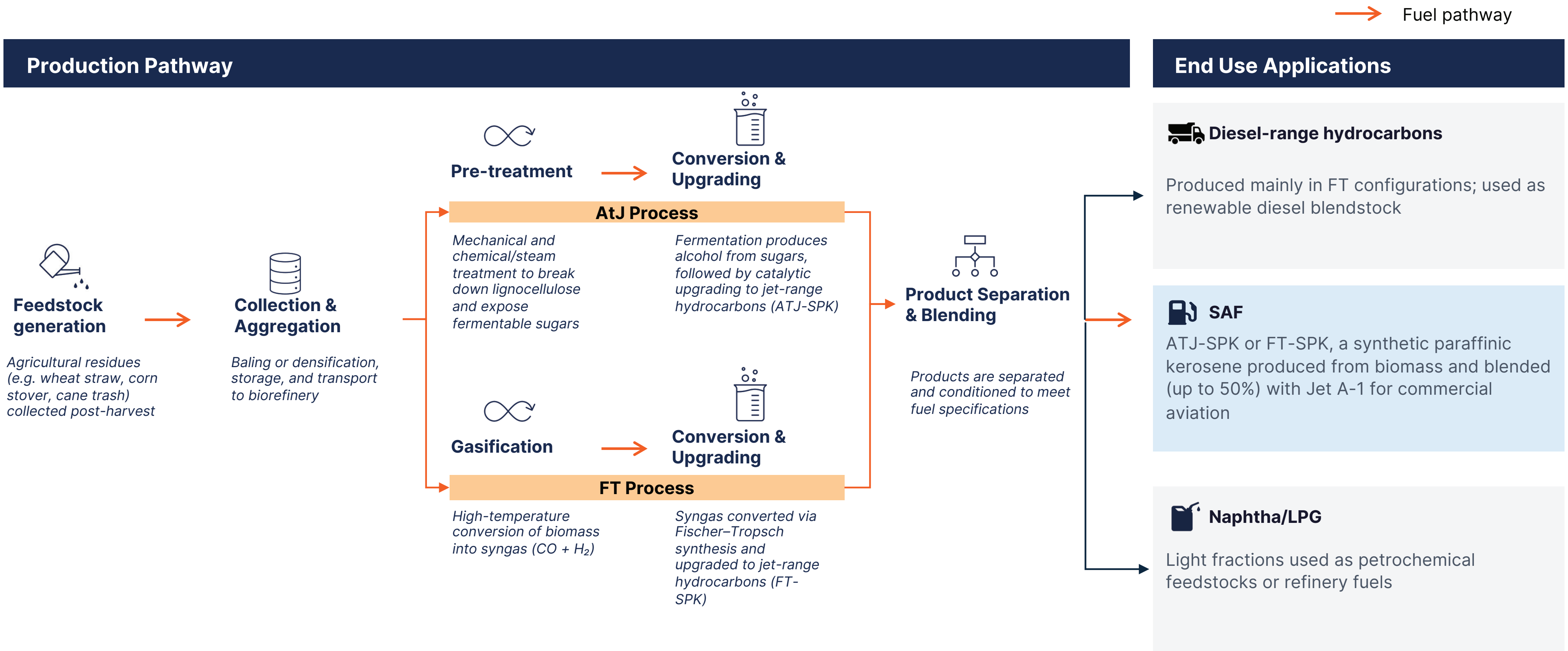
Percent of 2030 Australian jet fuel demand



Notes: (1) 24% non-return rate based on ABS-referenced estimates of residues not returned to soil under current Australian practices (2) Calculation based on potential volume supply analysis, assuming 67% use rate (benchmarked to forestry residues).Source: Braun, M., Grimme, W., & Oesingmann, K. (2024). 'Pathway to net zero: Reviewing sustainable aviation fuels, environmental impacts and pricing'. Journal of Air Transport Management, 117, 102580; Clean Energy Finance Corporation, 'Refined Ambitions' (2024); International Civil Aviation Organization, 'SAF Rules of Thumb'; US Department of Energy, 'Lift Off'; Smerald A, Rahimi J, Scheer C, 'A global dataset for the production and usage of cereal residues in the period 1997–2021'. Sci Data (2023).

Crop residues value chain

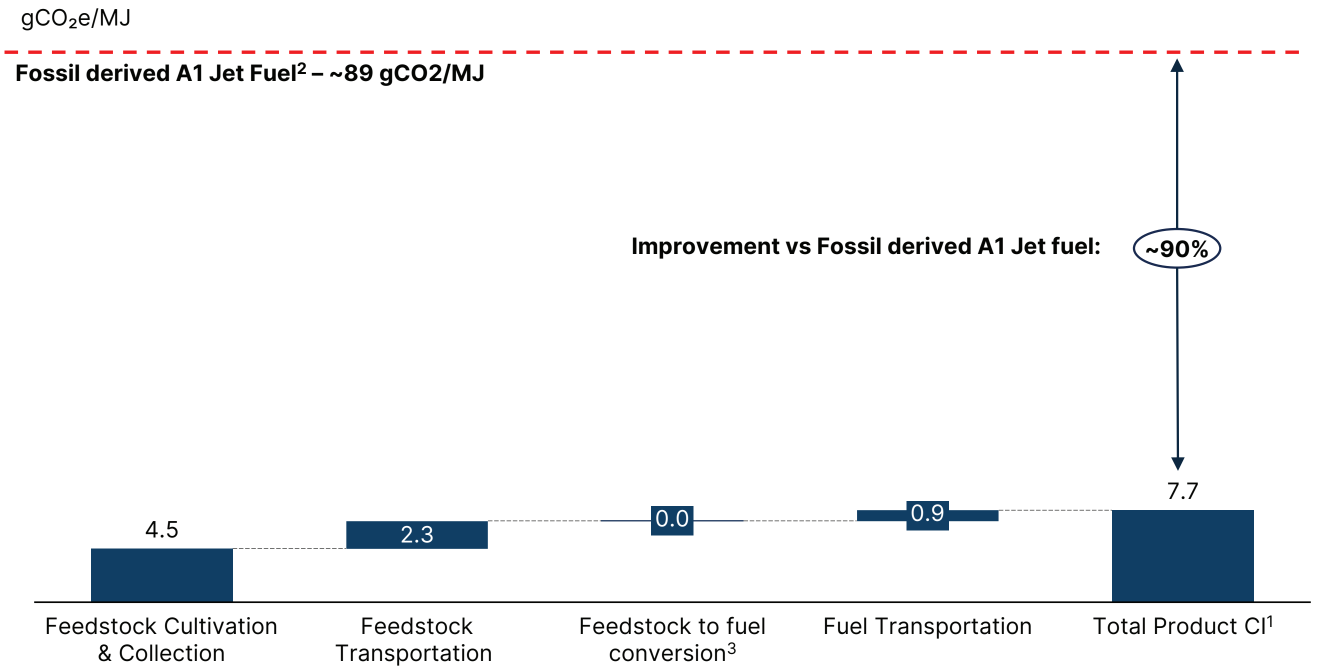
Crop residues are converted into SAF through biochemical (ATJ) or thermochemical (FT) conversion routes



Crop residues carbon intensity (FT)

SAF derived from Crop Residues via the FT pathway delivers a ~90% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Crop Residues Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers primarily target feedstock logistics, gasification, and fuel synthesis, the main contributors to FT carbon intensity

1 Feedstock Quality and Pre-processing

- **Optimise collection and transport logistics:** Increase densification, develop regional aggregation hubs, and site gasification facilities near residue supply to reduce diesel use and transport emissions
- **Control moisture and size uniformity:** Improve drying and feedstock preparation to enhance gasifier efficiency and reduce energy losses
- **Implement sustainable removal rates:** Maintain soil carbon and nutrient balance to avoid indirect land-use impacts and long-term yield decline

2 Gasification & Fuel Synthesis Efficiency

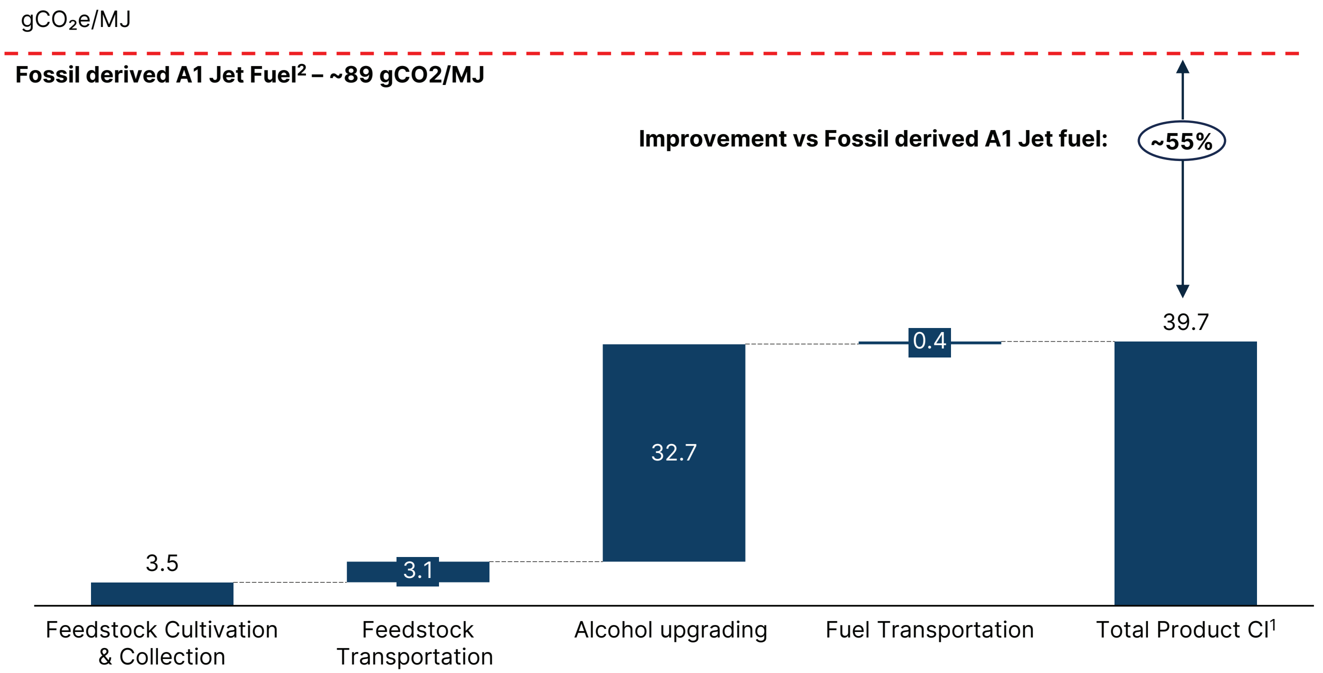
- **Improve gasification performance:** Enhance syngas yield and reduce tar formation to increase carbon conversion efficiency
- **Maximise heat and power integration:** Recover high-temperature process heat for internal steam and electricity generation to reduce external energy demand
- **Reduce hydrogen and upgrading emissions:** Source low-carbon hydrogen for hydrocracking/isomerisation and optimise catalyst performance to lower CI in fuel upgrading

Notes: (1) CI score calculated under a standalone conversion design Default value calculated as the mid-point between the highest and lowest total emissions reported across MIT GREET, JRC GREET, and JRC E3 results for corn stover and wheat straw (without nutrient replacement). (2) Standard fossil fuel derived value from CORSIA.
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025), page 48.

Crop residues carbon intensity (AtJ)

SAF derived from Crop Residues via the AtJ pathway delivers a ~55% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Crop Residues Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers primarily target feedstock logistics, pre-treatment, and alcohol upgrading, main contributors to AtJ CI

1 Feedstock Quality and Pre-treatment

- **Optimise collection and transport logistics:** Increase bale density, develop regional aggregation hubs, and site facilities close to high-residue regions to reduce diesel consumption and transport emissions per tonne of biomass
- **Decarbonise pre-treatment energy demand:** Electrify drying and size reduction processes or integrate renewable electricity and recovered waste heat to reduce fossil energy inputs
- **Implement sustainable removal rates:** Define residue extraction thresholds that preserve soil organic carbon, nutrient balance, and long-term yield stability

2 Conversion & Upgrading Efficiency

- **Improve hydrolysis and fermentation performance:** Increase sugar recovery and ethanol yields to reduce biomass input and process energy intensity per MJ of SAF produced
- **Maximise heat integration across units:** Recover and reuse process heat between hydrolysis, distillation, dehydration, and upgrading to lower overall utility demand
- **Reduce hydrogen-related emissions:** Source renewable or low-carbon hydrogen and optimise upgrading reactor efficiency (dehydration, oligomerisation, hydrotreating) to lower CI in the ATJ conversion step

Notes: (1) CI score calculated under a standalone conversion design (2) Standard fossil fuel derived value from CORSIA.
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025)

Strategic opportunities

Australia's crop residue resource creates a scalable SAF opportunity; unlocking value depends on efficient aggregation, sustainable harvesting, and integration with regional processing infrastructure

Feedstock Market

Underutilised Domestic Resource

Annual harvests generate more than 40 million tonnes[1] of cereal straw and stubble, yet only a fraction is commercially utilised, leaving substantial potential as SAF feedstock

Abatement Economics

Low Carbon Intensity Potential

Residue-based SAF delivers low CORSIA default values (FT ~7.7 gCO_2e/MJ; ATJ ~39.7 gCO_2e/MJ), with further reductions achievable through renewable hydrogen and process electrification

Infrastructure & Processing

Regional Aggregation and Processing Opportunity

Co-locating densification, ethanol, or gasification facilities near cropping regions can reduce logistics costs and support regional investment and job creation.

Energy Integration and Co-Product Value

FT and ATJ pathways enable internal energy recovery and potential co-products (biochar, lignin streams), improving overall carbon and economic performance.

Policy and Direction

Alignment with Net Zero and Safeguard Mechanism

Residue-based SAF aligns with Jet Zero ambitions and emerging compliance frameworks, supporting domestic decarbonisation and fuel security objectives.

Notes: (1) According to MLA each year, about 25 million hectares of dryland crops are sown in Australia, typically producing more than 40 million tonnes of grain, with a roughly equivalent mass of crop residue (stubble) remaining in the paddock
Sources: International Civil Aviation Organization, CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025 (2025); Meat & Livestock Australia, Modern Stubbles Booklet; Royal Society of Chemistry, Article on Residue-Based Pathways (2025).

Structural and execution challenges

While crop residues offer scale and carbon advantages, commercial deployment requires overcoming aggregation, sustainability, and capital intensity constraints

Feedstock Market

1 Competing On-Field Uses of Residues

Crop residues support soil carbon, erosion control, and nutrient cycling. Excess removal risks soil degradation, particularly in marginal areas

2 Aggregation and Logistics Complexity

Low bulk density and geographic dispersion increase collection and transport costs without densification infrastructure

Regulation & Enablers

3 Regulatory and Investment Gaps

Policy frameworks do not yet fully support residue-based SAF pathways. Limited market signals and eligibility clarity constrain early investment

Abatement Economics

4 Technology Cost and Complexity

FT and cellulosic AtJ pathways are capital-intensive and require reliable, large-scale feedstock supply. Fragmented production and limited infrastructure increase aggregation costs

Infrastructure & Processing

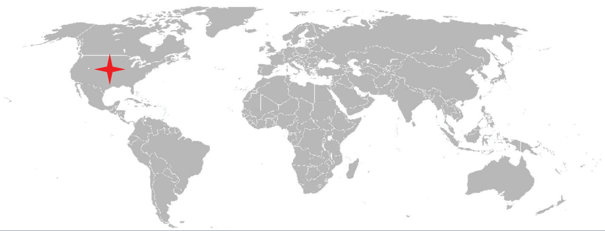
5 Seasonality and Feedstock Variability

Residues are seasonal and moisture-sensitive, requiring storage and pre-processing. Inconsistent quality can raise logistics costs and reduce fuel yields

Case study | Project Liberty – Cellulosic Ethanol from Corn Stover (1 of 2)

OVERVIEW
Project Liberty, launched in 2014 by POET-DSM Advanced Biofuels, was heralded as one of the first commercial-scale cellulosic ethanol plants in the world. Despite strong policy support (e.g., U.S. Renewable Fuel Standard), the plant never reached commercial viability and was repurposed as a research facility by 2021.

Facility: Project Liberty, Emmetsburg, Iowa, USA
Developer: POET-DSM Advanced Biofuels (joint venture between POET LLC and Royal DSM)
Technology: Enzymatic hydrolysis + fermentation to produce cellulosic ethanol (intended for AtJ SAF)
Feedstock: Corn stover
Capacity: ~25 million gallons/year (~75 million litres), launched in 2014
Status: Commercial struggles; JV dissolved in 2021, plant transitioned to R&D



Feedstock Sourcing

- Corn stover sourced from surrounding farms in a ~40 km radius
- Contracts with local growers to collect ~1–2 tonnes of residue per acre, leaving sufficient biomass to preserve soil health
- Targeted >275,000 tonnes/year of stover to support full operation
- Developed local supplier networks and logistics hubs for collection, baling, and storage)

Challenges in Feedstock Management

- Supply chain complexity: Coordinating dozens of growers and contractors across planting, harvesting, baling, and hauling
- Soil sustainability trade-offs: Overharvesting stover can reduce soil carbon and increase erosion, limiting supply volumes
- Feedstock variability: Composition varies based on location, weather, crop variety, and harvesting practices
- Moisture and ash: Excessive moisture and inorganic contaminants damaged equipment and reduced processing efficiency
- Cost of logistics: High transport and handling costs for low-density, bulky biomass
- Seasonality: Limited harvesting windows and year-round plant operation misaligned

Feedstock Preparation and Logistics

- Farmers harvested and baled stover separately from grain using specialised equipment
- Bales transported to central depots or directly to the refinery
- Pre-treatment included mechanical size reduction, steam explosion, and enzymatic hydrolysis to release sugars
- Moisture content, ash levels, and contamination (dirt, rocks) were constant operational concerns
- Off-season storage of large biomass volumes posed fire risk and required significant real estate

Feedstock-Driven Opportunities

- Abundant and distributed: The U.S. Midwest produces hundreds of millions of tonnes of corn stover annually
- Low carbon intensity: Residues are 'waste' products with no land-use change penalty under CORSIA
- No food-fuel conflict: Enables fuel production without diverting edible grain
- Improved soil carbon modelling: New tools may allow more stover removal while maintaining soil health
- Policy tailwinds: Stronger SAF demand and incentives (e.g. 45Z) make second-generation feedstocks more viable

Key Feedstock Lessons:

- **Logistics is king:** Collecting, aggregating, and storing agricultural residues at scale is complex, fragmented, and inherently costly
- **Partnerships are essential:** Long-term collaboration with growers underpins both supply security and compliance with soil conservation requirements
- **Quality starts at the farm gate:** Managing ash, moisture, and contamination must be embedded at the point of production, not corrected downstream
- **Infrastructure enables scale:** Depots, storage yards, and specialised handling equipment must be developed in parallel with refining capacity
- **Integration drives viability:** Commercial success depends on aligning agronomy, logistics, and refining within a single, coordinated operating model

Source: 'Project Liberty biorefinery starts cellulosic ethanol production' U.S. Department of Energy (DOE) (2014); 'Commercial-scale cellulosic ethanol plant opens' U.S. Energy Information Administration (EIA) (2014); 'Project LIBERTY in 'ramp-up' phase' POET press release (2016); 'POET-DSM halts Project Liberty production over RFS mismanagement' Ethanol Producer (2019); 'Project Liberty' cellulosic ethanol plant in Emmetsburg closed' Radio Iowa (2020); 'Project Liberty: Launch of an Integrated Bio-Refinery with Eco-Sustainable and Renewable Technologies' U.S. DOE OSTI technical report (2021); 'Farmers now delivering biomass to POET's Project LIBERTY storage POET press release (2011); 'Fantasy' of Fuel From Corn Waste Gets Big U.S. Test (Project Liberty)' National Geographic (2014); U.S. Department of Energy. (2025). POET-DSM: Project LIBERTY.

Case study | Project Liberty – Cellulosic Ethanol from Corn Stover (2 of 2)

Project Liberty – Why the Project Was Paused

Feedstock Collection and Logistics Were More Complex Than Expected

- High operational complexity: Corn stover must be collected shortly after harvest, which required precise coordination with dozens of growers and third-party contractors.
- Equipment constraints: Specialised baling and loading equipment was needed, which many farmers lacked.
- Low bulk density: Stover is light and voluminous, making it costly to store and transport.
- Weather dependencies: Wet seasons disrupted harvest schedules, degraded feedstock quality, and limited collection windows.

Feedstock Quality Issues Hampered Processing

- Ash and contamination: Soil, rocks, and other inorganics in the bales damaged equipment and reduced yields.
- Moisture content: High-moisture bales increased the risk of spoilage and required extra drying and handling.
- Inconsistency: Variability in fibre composition and lignin content reduced process control and conversion efficiency.

Technical and Commercial Challenges at the Refinery

- Scale-up difficulties: While the underlying enzymatic hydrolysis and fermentation processes were proven in pilot trials, they didn't translate easily to commercial scale.
- Enzyme costs: DSM's proprietary enzyme cocktail was expensive, and dosage rates were higher than anticipated due to feedstock variability.
- Frequent downtime: The plant struggled with mechanical reliability, partly due to harsh feedstock characteristics.

Economic Headwinds

- High cost per gallon: Even after multiple years of operation, the cost of cellulosic ethanol from stover remained far above corn ethanol or fossil fuel alternatives.
- Low ethanol prices: Depressed fuel prices in the late 2010s made the economics even less favourable.
- Limited market pull: Cellulosic ethanol blending mandates under the U.S. RFS were under-enforced, reducing demand certainty.

Strategic Disengagement from DSM

- JV breakup: In 2021, DSM exited the joint venture, citing misalignment in strategy and challenges scaling the technology.
- Shift in focus: POET retained the facility and pivoted it to R&D rather than full-scale commercial operation, hoping to de-risk future deployments

Lessons for Future Projects

- **Plan for logistics at scale**: Biofuel refineries that rely on agricultural residues must invest early in regional logistics infrastructure and farmer engagement.
- **Feedstock preparation is as critical as refining**: Quality control at the farm and depot level is essential to protect downstream processing.
- **Tech scale-up must be conservative**: Jumping from pilot to commercial scale without sufficient bridging can lead to unanticipated cost blowouts.
- **Policy needs to be enforceable and bankable**: Soft or shifting mandates do not provide the security needed for capital-intensive projects.
- **Co-location with first-generation assets helps**: Liberty's adjacency to POET's corn ethanol plant provided some synergies (steam, utilities), but more vertical integration may be required.

Source: 'Project Liberty biorefinery starts cellulosic ethanol production' U.S. Department of Energy (DOE) (2014); 'Commercial-scale cellulosic ethanol plant opens' U.S. Energy Information Administration (EIA) (2014); 'Project LIBERTY in ramp-up phase' POET press release (2016); 'POET-DSM halts Project Liberty production over RFS mismanagement' Ethanol Producer (2019); 'Project Liberty cellulosic ethanol plant in Emmetsburg closed' Radio Iowa (2020); 'Project Liberty: Launch of an Integrated Bio-Refinery with Eco-Sustainable and Renewable Technologies' U.S. DOE OSTI technical report (2021); 'Farmers now delivering biomass to POET's Project LIBERTY storage site' POET press release (2011); 'Fantasy of fuel from corn waste gets big U.S. test (Project Liberty)' National Geographic (2014).

10

SAF feedstock deep dives

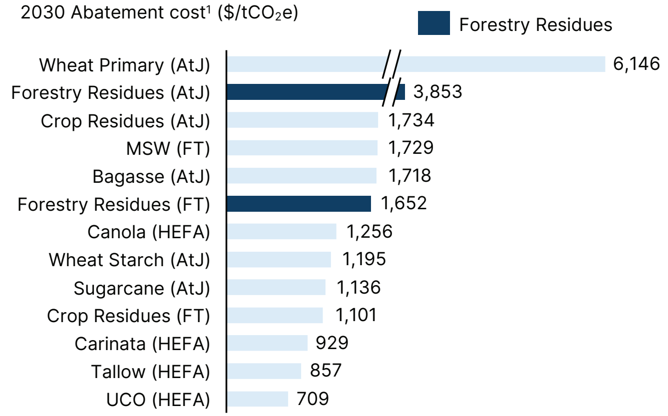
g. Forestry residues

Forestry residue summary

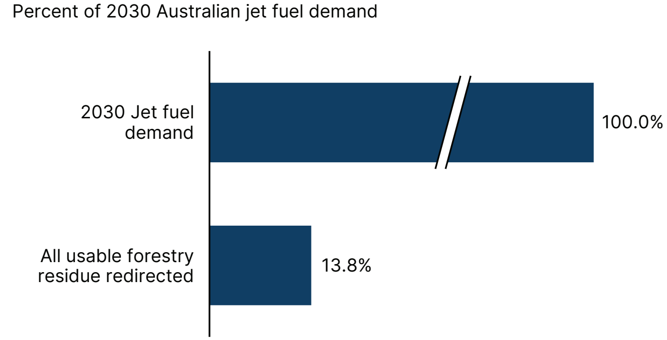
Forestry residues have sufficient volume to create a scalable SAF opportunity, once technology is proven

Executive Summary	
Technical viability	• Forestry residues are converted to SAF primarily via the Fischer–Tropsch (FT) pathway, requiring gasification and fuel synthesis infrastructure; large-scale forestry-to-SAF deployment remains limited • FT conversion delivers ~13.5% AtJ SAF yield from dry woody biomass input, reflecting process losses and product fractionation
Emission reduction potential	• Via AtJ refining pathway, forestry residue-derived SAF relivers ~55% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~40.0 gCO_2e/MJ vs ~89 gCO_2e/MJ) • Via FT refining pathway, forestry residue-derived SAF delivers ~90% lifecycle carbon intensity reduction versus fossil jet fuel under default CORSIA assumptions (~8.3 gCO_2e/MJ vs ~89 gCO_2e/MJ)
Economic competitiveness	• The FT pathway sits at ~\$1,652/tCO_2e, placing forestry residue SAF in the upper half of Australia's abatement cost curve relative to waste-based pathways • The AtJ pathway sits significantly higher at ~\$3,853/tCO_2e, reflecting higher capital intensity and lower carbon reduction relative to FT
Australia's opportunity	• Australia generates ~12.5 Mt of sawmill residues annually from ~25 million m^3 of sawlog production • Up to ~11.3 Mt could be technically recoverable for energy or fuel production pathways[1]
Australia's scale potential	• Under a 100% diversion scenario, forestry residues could supply ~14% of Australia's 2030 jet fuel demand • Given the feedstock is a byproduct, it is structurally capped by the volume of forest material produced in Australia

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand



Notes: (1) Estimate based on 0.5 t/m^3 residue factor and 90% technical recoverability assumption. Commercial availability depends on competing uses (pulp, board, pellets, bioenergy) and recovery logistics (2) Calculation based on potential volume supply analysis.Source: Braun, M., Grimme, W., & Oesingmann, K. (2024). Pathway to net zero: Reviewing sustainable aviation fuels, environmental impacts and pricing. Journal of Air Transport Management, 117, 102580.; Clean Energy Finance Corporation, Refined Ambitions (2024); International Civil Aviation Organization, SAF Rules of Thumb; US Department of Energy 'Lift off'; Smerald A, Rahimi J, Scheer C. A global dataset for the production and usage of cereal residues in the period 1997-2021. Sci Data. 2023

Forestry residues value chain

Forestry residues are converted into SAF through biochemical (ATJ) or thermochemical (FT) conversion routes

→ Fuel pathway

Production Pathway

Feedstock generation

Forestry residues (e.g. harvest slash, thinning residues, sawmill offcuts, bark) generated during timber harvesting and wood processing operations

Collection & Aggregation

Chipping, grinding, and bulk transport to processing facilities; often sourced from forest landings or sawmill sites

AtJ Process

Pre-treatment → **Conversion & Upgrading**

Mechanical size reduction and chemical/steam treatment to break down lignocellulose and expose fermentable sugars

Hydrolysis and fermentation produce alcohol, followed by catalytic upgrading to jet-range hydrocarbons (ATJ-SPK).

FT Process

Gasification → **Conversion & Upgrading**

High-temperature conversion of biomass into syngas ($CO + H_2$)

Syngas converted via Fischer–Tropsch synthesis and upgraded to jet-range hydrocarbons (FT-SPK)

Product Separation & Blending

Products are separated and conditioned to meet fuel specifications

End Use Applications

Diesel-range hydrocarbons

Produced mainly in FT configurations; used as renewable diesel blendstock

SAF

ATJ-SPK or FT-SPK, a synthetic paraffinic kerosene produced from biomass and blended (up to 50%) with Jet A-1 for commercial aviation

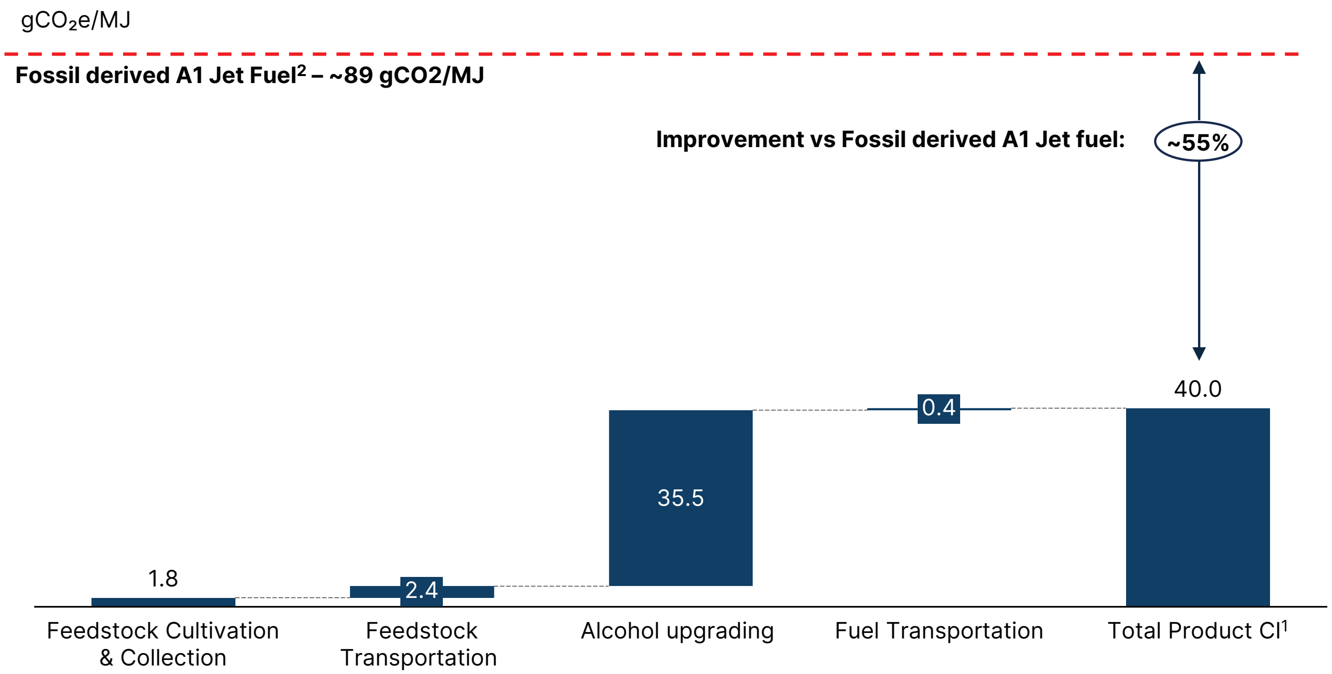
Naphtha/LPG

Light fractions used as petrochemical feedstocks or refinery fuels

Forestry residues carbon intensity (AtJ)

SAF derived from Forestry Residues via the AtJ pathway delivers a ~55% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Forestry Residues Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target the main emission drivers in the forestry residues ATJ pathway

1 Feedstock & Pre-Treatment

- **Decarbonise drying and chipping**: Use biomass boilers at sawmills or renewable electricity to eliminate fossil fuel use in size reduction and moisture control
- **Optimise moisture management:** Improve storage, covered stockpiles, and transport planning to reduce drying intensity and diesel consumption
- **Define sustainable recovery rates:** Align extraction levels with forest carbon and soil management standards to preserve lifecycle benefits

2 Alcohol Conversion & Upgrading

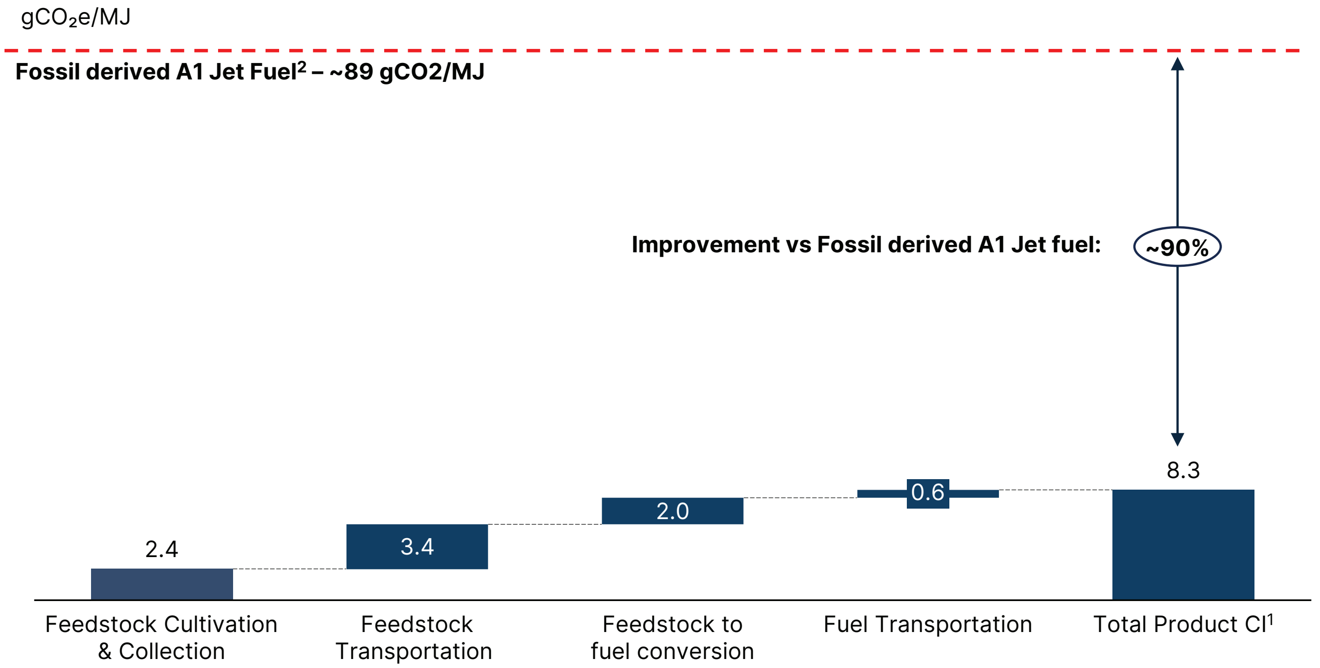
- **Increase sugar and ethanol yields:** Optimise pre-treatment severity and enzyme performance for high-lignin woody biomass
- **Maximise heat integration:** Integrate hydrolysis, fermentation, and distillation to lower external energy demand
- **Use low-carbon hydrogen:** Source renewable hydrogen for upgrading (dehydration, oligomerisation, hydrotreating)

Notes: (1) Standard fossil fuel derived value from CORSIA. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Forestry residues carbon intensity (FT)

SAF derived from Forestry Residues via the FT pathway delivers a ~90% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to reduce CI further

Forestry Residues Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target the primary emission contributors in the forestry residues FT pathway

1 Gasification & Energy Integration

- **Improve gasifier efficiency:** Optimise temperature control and syngas conditioning to reduce process energy intensity
- **Use biomass-derived process energy:** Generate steam and power from internal biomass streams to displace fossil inputs
- **Enhance heat recovery:** Recover and reuse high-temperature process heat across gasification and synthesis units

2 Gasification & Fuel Synthesis Efficiency

- **Reduce hydrogen intensity:** Improve reactor efficiency and source renewable hydrogen for hydrocracking and refining
- **Capture concentrated CO_2 streams:** Apply carbon capture from syngas conditioning or shift reactors to reduce net CI
- **Valorise co-products:** Use power export or biochar pathways to improve overall lifecycle emissions balance

Notes: (1) Standard fossil fuel derived value from CORSIA. CI score calculated under a standalone conversion design Mid-point values calculated as (maximum + minimum) / 2 across MIT GREET, JRC GREET, and JRC E3 results. Total of 8.3 gCO_2e/MJ reflects the agreed CORSIA default for the forest residue FT pathway.
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Strategic opportunities

Australia's forestry residue resource creates a scalable SAF opportunity; unlocking value depends on efficient aggregation, co-location with mills, and deployment of thermochemical conversion pathways

Feedstock Market

Underutilised Domestic Resource

'ABARES estimates that around 6.5 million tonnes of harvest residues and 5.2 million tonnes of sawmill residues were generated in Australia in 2016–17

Waste-Based Classification

Recognised as lignocellulosic waste under major frameworks, supporting eligibility under CORSIA and advanced fuel categories

Infrastructure & Processing

Co-location with Sawmills and Hubs

Siting pre-treatment, gasification, or upgrading facilities near sawmills reduces transport distances, improves feedstock consistency, and leverages infrastructure.

Thermochemical Pathway Readiness (FT-first)

Forestry residues suit gasification and FT synthesis; the pathway is mature and enables drop-in hydrocarbons with refinery integration.

Abatement Economics

Low Baseline Carbon Intensity

Forestry residues deliver ~ FT ~8.3 gCO_2e/MJ and ATJ ~40.0 gCO_2e/MJ, well below fossil jet (~89 gCO_2e/MJ), enabling strong lifecycle reductions.

Policy & Direction

Alignment with Net Zero and Safeguard Mechanism

Residue-based SAF aligns with Jet Zero ambitions and emerging compliance frameworks, supporting domestic decarbonisation and fuel security objectives.

Rural Economic Development

SAF investment in regional forestry regions could support high-quality jobs, improve infrastructure, and create value from waste streams, aligning with broader government priorities

Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025). ABARES (2019). Future opportunities for using forest and sawmill residues in Australia. Department of Agriculture and Water Resources, Canberra

Structural and execution challenges

While forestry residues offer carbon and waste-diversion benefits, deployment depends on resolving logistics, capital intensity, and operational constraints

Feedstock Market

1 Collection and Aggregation Complexity

Residues are bulky, dispersed, and often located in remote terrain, increasing harvesting and transport costs without densification

2 Competing Uses and Market Pull

Sawmill residues serve pulp, board, pellets, and bioenergy, requiring SAF projects to secure long-term contracts at competitive pricing

3 Moisture and Quality Variability

Harvest cycles, bushfire risk, and weather events create inter-annual fluctuations requiring diversified sourcing strategies.

4 Supply Seasonality & Security

Feedstock volumes can vary year-to-year with harvest cycles, bushfires, or policy restrictions on native forestry access

Abatement Economics

5 High Capital Intensity and Cost Sensitivity

FT facilities require significant upfront investment, and project economics remain sensitive to hydrogen pricing and sustained feedstock throughput

Infrastructure & Regulation

6 Limited Precedents

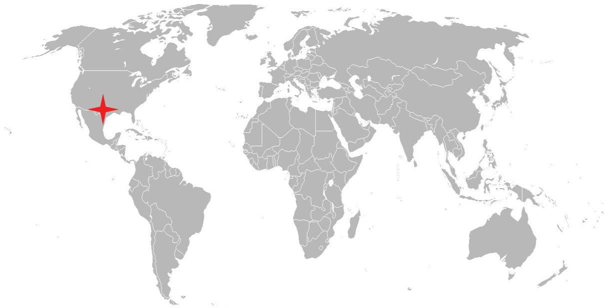
There are few commercial-scale FT plants globally using forestry residues; technical risk and financing hurdles remain high without proven references

7 Sustainability and Regulatory Risk

In some regions, residue removal from forests is politically and ecologically sensitive, requiring robust sustainability certification and stakeholder engagement

Case study | Red Rock Biofuels – Forestry Residues (1 of 2)

OVERVIEW
Location: Lakeview, Oregon, USA
Technology: Fischer-Tropsch (FT) syngas from woody biomass
Output: Designed for ~15 million gallons/year of renewable jet and diesel
Feedstock: Forestry slash and mill residues
Status: Project suspended due to financial / feedstock challenges



Feedstock Sourcing

- Red Rock planned to use woody biomass residues sourced from forest thinning, logging slash, and sawmill waste in southern Oregon and northern California.
- The project aimed to help reduce wildfire risk by monetising hazardous forest fuel loads through public-private partnerships with the US Forest Service and timber operators.
- Contracts were arranged with local forest management groups, but volumes and timelines proved difficult to match with refinery demand.

Challenges in Feedstock Management

- **Logistics and Scale**: Gathering sufficient volumes of residue in a consistent and cost-effective manner proved more difficult than anticipated. A 15-million-gallon FT facility required hundreds of thousands of tonnes annually.
- **Cost Volatility**: While the feedstock was technically low-cost, **high collection, handling, and transport costs** eroded the advantage.
- **Supply Risk**: Forestry operations were subject to weather, wildfire, regulatory restrictions, and lack of skilled labour, introducing risk to year-round availability.
- **Moisture and Variability**: Biomass moisture content varied widely and posed challenges for consistent gasification and syngas quality.

Feedstock Preparation and Logistics

- **Collection**: Feedstock had to be gathered from remote forest areas, often steep or inaccessible terrain, using manual and mechanised thinning methods.
- **Chipping and Drying**: Wood had to be chipped and dried to reduce moisture content (target ~10–15%) before transport to the gasifier.
- **Transport**: Biomass was hauled by truck to the refinery - often over long distances due to fragmented harvesting operations and lack of dense collection nodes.
- **Storage**: Dry woody biomass posed fire risk and required specialised infrastructure to store safely and maintain quality.

Feedstock-Driven Opportunities

- **Wildfire Mitigation**: Red Rock's model aligned with state and federal priorities to reduce forest fire risk by removing combustible waste - offering potential for grants and long-term supply partnerships.
- **Rural Economic Development**: The plant promised job creation and economic diversification in timber communities facing mill closures.
- **Carbon Benefits**: Avoiding open burning or decomposition of forest residues enabled significant lifecycle GHG reductions. Estimated CI values for this feedstock pathway ranged from **15–30 gCO_2e/MJ** under US LCFS.

Key Feedstock Lessons:

- **Aggregation is critical**: Success hinges on establishing regional biomass collection hubs and coordinating across landowners and forestry contractors.
- **Pre-treatment infrastructure must scale with ambition**: Feedstock drying, chipping, and storage need robust design to ensure consistent gasifier input quality.
- **Financial viability needs policy support**: Without reliable carbon credits, grants, or procurement contracts, projects using diffuse feedstocks like forest residues face margin pressure.

Source: Red Rock Biofuels website; 'Red Rock Biofuels, Frontline BioEnergy Successfully Gasify Residual Woody Biomass into Syngas for Production of Sustainable Aviation Fuel' AdvancedBiofuelsUSA.info (2022); 'Red Rock Biofuels readies 'fuel from forests' for take-off' Trellis (2015); 'Red Rock Biofuels wins US Forest Service Wood Innovations Grant' Biomass Magazine (2022); 'Next Renewables Fuels acquires assets of Red Rock Biofuels' Biomass Magazine (2023); 'NEXT Renewable to redevelop foreclosed Red Rock Biofuels project' Fuels & Lubes (2023); 'Red Rock Biofuels signs biojet fuel off-take agreement with FedEx Express' Bioenergy International (2015)

Case study | Red Rock Biofuels – Forestry Residues (2 of 2)

OVERVIEW
Location: Lakeview, Oregon, USA
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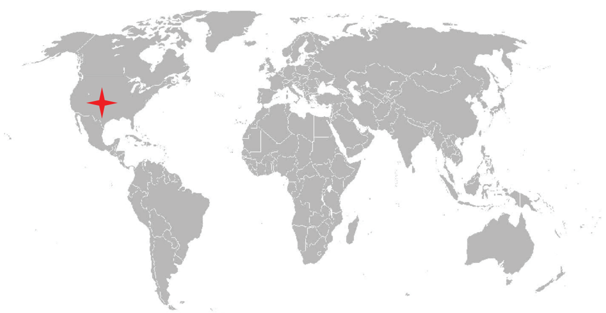

Why the Red Rock Biofuels Project Was Suspended

Underestimated Feedstock Logistics Complexity
- Fragmented sourcing: The project relied on distributed forest residues from remote and often rugged terrain. This made large-scale collection labour-intensive, seasonal, and unpredictable.
- Long-haul transport: Many collection zones were over 150 km from the refinery site, resulting in high fuel costs and increased emissions for what was intended to be a low-CI feedstock.
- Lack of aggregation infrastructure: There were no pre-existing biomass depots or drying facilities in the area, requiring Red Rock to integrate upstream processing - a capital and operational burden.

Inconsistent Feedstock Supply
- Feedstock supply agreements fell through: Some early-stage contracts and supply MOU arrangements were not formalised, and volumes promised by forestry partners didn't materialise at the scale or consistency required.
- Seasonality and weather impacts: Snow, rain, and wildfire risk delayed or restricted access to biomass harvesting zones for long stretches of the year.
- Permitting issues: Some planned biomass sources were located on federal or state-managed lands that required complex environmental permitting, slowing access to material.

Moisture and Fuel Quality Variability
- Forestry residues are highly heterogeneous, and Red Rock struggled to manage:
  - Variable moisture content – leading to inconsistent syngas quality during FT processing.
  - High ash and dirt content – which increased wear on equipment and reduced process efficiency.
  - Drying bottlenecks – due to lack of scalable drying infrastructure, material was often too wet to meet input specs.

Cost Overruns Due to Feedstock Handling
- Feedstock preparation (chipping, drying, cleaning) proved more expensive than projected, requiring more equipment and labour.
- These costs directly impacted the economics of the plant, undermining projected margins and investor confidence.
- By 2022–2023, reports from contractors and court documents indicated ongoing disputes over unpaid feedstock suppliers and delivery shortfalls.

Investor Uncertainty and Bankruptcy Filing
- These feedstock challenges - combined with cost inflation and delays in construction - contributed to missed project milestones.
- Red Rock was unable to secure additional investment to finish and commission the facility.
- The project ultimately entered bankruptcy proceedings in late 2022, with equipment auctioned off in 2023.

Source: Red Rock Biofuels website; 'Red Rock Biofuels, Frontline BioEnergy Successfully Gasify Residual Woody Biomass into Syngas for Production of Sustainable Aviation Fuel' AdvancedBiofuelsUSA.info (2022); 'Red Rock Biofuels readies 'fuel from forests' for take-off' Trellis (2015); 'Red Rock Biofuels wins US Forest Service Wood Innovations Grant' Biomass Magazine (2022); 'Next Renewables Fuels acquires assets of Red Rock Biofuels' Biomass Magazine (2023); 'NEXT Renewable to redevelop foreclosed Red Rock Biofuels project' Fuels & Lubes (2023); 'Red Rock Biofuels signs biojet fuel off-take agreement with FedEx Express' Bioenergy International (2015)

10

SAF feedstock deep dives

h. Municipal solid waste

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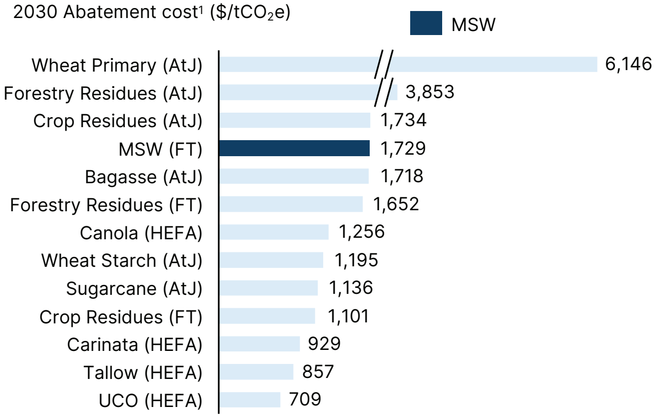
Municipal solid waste summary

Australia produces significant MSW, however, it is difficult to scale and relies on low readiness technology

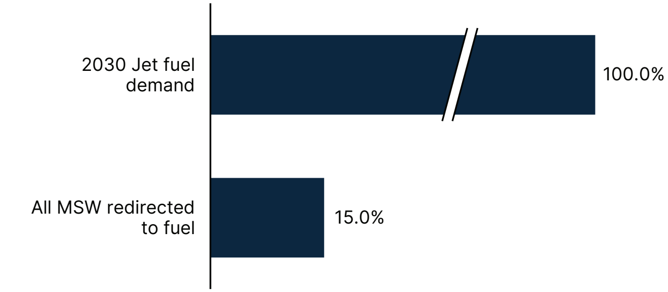
Executive Summary

Technical viability	• MSW is a technically viable SAF feedstock via the FT pathway, requiring advanced gasification and upgrading infrastructure • SAF yield of ~30% from processed MSW-derived feedstock, based on ICAO SAF Rules of Thumb guidance for FT pathways
Emission reduction potential	• At ≤5% non-biogenic carbon (NBC), MSW-derived SAF delivers ~90% lifecycle carbon intensity reduction (~9.5 gCO_2e/MJ vs ~89 gCO_2e/MJ fossil baseline) • At high NBC levels (45–50%), lifecycle emissions rise to ~86 gCO_2e/MJ, reducing abatement to ~3%, making fossil fraction control critical
Economic competitiveness	• MSW SAF sits at ~$1,729/$tCO_2e$, placing it toward the higher end of Australia's SAF cost curve • Project economics depend on stable gate fees, fossil fraction control, and plant scale to offset high capital intensity
Australia's opportunity	• Australia generates ~15.3 Mt of MSW annually; ~3.7 Mt of non-recycled biogenic material could be available for fuel conversion • Urban waste streams provide continuous, geographically concentrated feedstock supply near major fuel demand centres
Australia's scale potential	• Full diversion of available MSW could support ~0.74 Mt of fuel production annually • This equates to ~15% of projected 2030 domestic jet fuel demand, capped by total waste generation and fossil-derived content

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand



Source: Clean Energy Finance Corporation, Refined Ambitions (2024); International Civil Aviation Organization, SAF Rules of Thumb; Environment Protection Authority NSW. (2025). NSW waste and recycling performance data: 2023–24.

Municipal solid waste value chain

Municipal waste can be converted into SAF through thermochemical gasification and Fischer–Tropsch synthesis

→ Fuel pathway

Production Pathway

Waste Collection →

Municipal solid waste collected and transported to centralised treatment facilities.

Sorting & Feedstock Preparation →

Mechanical sorting removes recyclables and inerts .Drying and shredding produce a prepared refuse-derived fuel (RDF).

Gasification →

Prepared MSW converted at high temperature into syngas ($CO + H_2$).

Conversion & Upgrading →

Syngas cleaned and catalytically converted into liquid hydrocarbons, then hydroprocessed to jet-range fuel.

Product Separation & Blending →

Hydrocarbon fractions separated and conditioned to meet ASTM specifications prior to blending.

End Use Applications

Diesel-range hydrocarbons

Renewable diesel blending component.

SAF

Synthetic paraffinic kerosene blended (up to 50%) with Jet A-1 for commercial aviation.

Naphtha/LPG

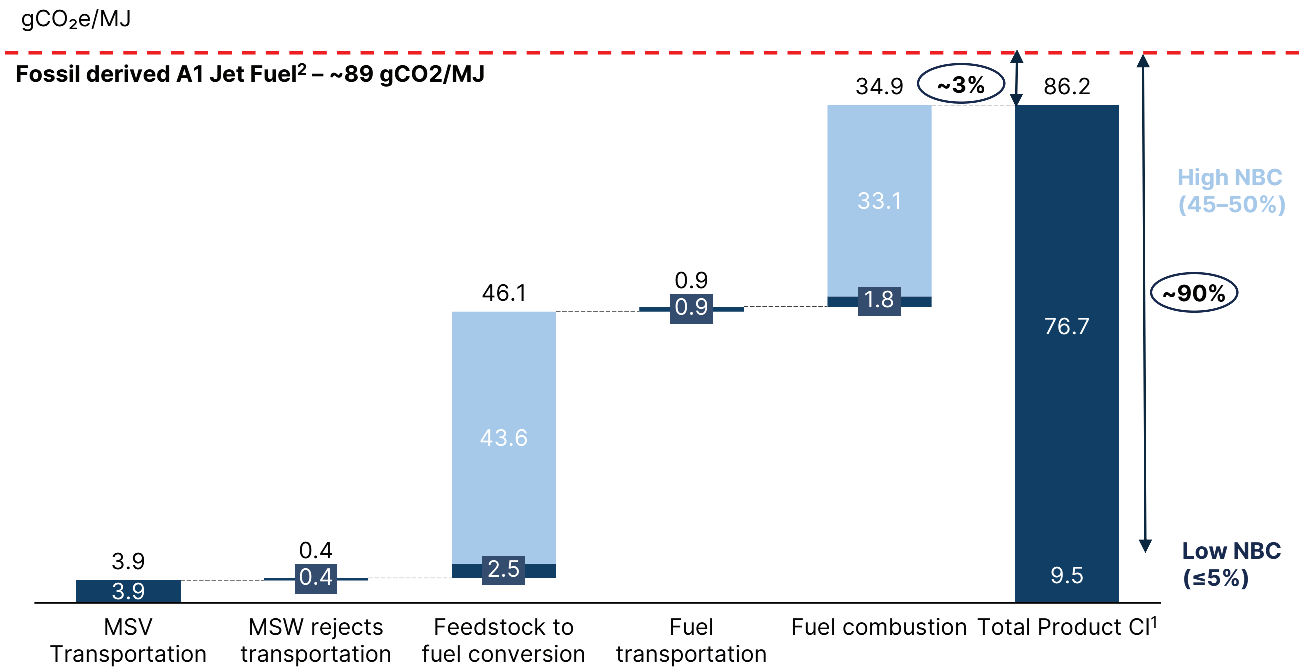
Light fractions used as petrochemical feedstocks or refinery fuels

Municipal solid waste carbon intensity

MSW SAF carbon intensity depends on the share of non-biogenic carbon (fossil-derived plastics and rubber) in the waste stream, ranging from ~9 gCO_2e/MJ at ≤5% NBC to ~86 gCO_2e/MJ near 50% NBC

Improvement vs Fossil derived A1 Jet fuel: ~X%

Municipal Waste Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target the primary emission drivers in the MSW FT pathway

1 Feedstock Quality & Fossil Fraction Control

- **Reduce fossil-derived content:** Improve source separation to limit plastics and synthetic materials in the waste stream
- **Optimise sorting efficiency:** Enhance MRF/MBT recovery to increase biogenic share in RDF
- **Control moisture and inerts:** Improve pre-treatment to reduce drying energy demand and improve gasifier efficiency.

2 Conversion & Energy Integration

- **Increase gasification efficiency:** Optimise syngas yield and minimise tar formation to reduce process energy intensity
- **Maximise heat and power recovery:** Use off-gas and waste heat to reduce external fossil energy inputs
- **Integrate carbon capture:** Capture concentrated CO_2 streams from syngas processing to lower net lifecycle emissions

Notes: (1) Unlike biomass pathways, MSW contains a fossil-derived fraction (e.g. plastics and synthetic materials), referred to as non-biogenic carbon (NBC). Because this portion is not climate neutral at combustion, the default CI is calculated as CI = (NBC × 170.5) + 5.2. Pathways with NBC above 50% exceed 89 gCO_2e/MJ and are not eligible under CORSIA. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Strategic opportunities

Municipal solid waste provides an urban-scale SAF pathway; lifecycle performance depends on feedstock composition and conversion efficiency

Feedstock Market

Abundant Urban Waste Stream

Municipal waste streams provide continuous feedstock in metropolitan regions, with households and local governments generating about 13.5 million tonnes of municipal solid waste in 2022–23

Waste-Based Classification

Classified as waste under CORSIA methodology, with system boundary starting at collection (no upstream cultivation emissions)

Abatement Economics

Low Baseline Carbon Intensity

Lifecycle emissions range from ~9 gCO_2e/MJ at ≤5% non-biogenic carbon (NBC) to ~86 gCO_2e/MJ near 50% NBC (CORSIA default)

Negative Feedstock Cost Potential

Gate fees of roughly $150–200 per tonne for mixed municipal solid waste in Australian metropolitan areas mean the refinery is effectively paid to accept feedstock

Infrastructure & Processing

Established Collection and Sorting Systems

Improving CI and economics depends on sorting infrastructure to reduce fossil fractions. Existing municipal, MRF, and MBT systems could be leveraged, with operators expanding feedstock supply

Thermochemical Pathway Readiness (FT-first)

Gasification and Fischer–Tropsch synthesis enable production of drop-in SAF and hydrocarbon co-products

Policy and Direction

Alignment with Net Zero and Safeguard Mechanism

Residue-based SAF aligns with Jet Zero ambitions and emerging compliance frameworks, supporting domestic decarbonisation and fuel security objectives.

Policy and Social Licence Alignment

Australia has exported waste volumes to Asia. Import rules now require quality specs, limiting exports and increasing domestic pressure to process waste through waste-to-fuel technologies

Source: International Civil Aviation Organization, CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025 (2025); NSW Environment Protection Authority, Waste Performance Data; ACT City Services, Fees and Charges.

Structural and execution challenges

MSW-to-SAF deployment depends on controlling fossil-derived content, ensuring feedstock quality, and achieving commercial scale

Feedstock Market

1 Composition and NBC Variability

Lifecycle emissions depend on fossil materials (plastics, rubber, synthetics) in the waste stream. Competition for non-fossil fractions may reduce supply, including organics, paper, metals, and glass

2 Heterogeneity and Contamination

MSW composition varies by municipality and season. High moisture, inerts, metals, and mixed plastics require robust sorting and quality control to ensure stable gasification performance

Abatement Economics

5 Capital Intensity and Policy Sensitivity

Gasification and FT plants require high upfront investment and scale to be competitive. Project viability depends on stable gate fees, landfill levies, and renewable fuel policy support

6 Co-product Monetisation

Unlike HEFA (where renewable diesel and naphtha have well-established markets), co-products from MSW-based FT synthesis may be harder to monetise due to trace contaminants or regulation

Policy & Regulation

3 Uncertain Policy Landscape

Australia does not currently offer strong policy support equivalent to the U.S. IRA or EU RED II. Without these mechanisms, long-term SAF offtake pricing may not justify investment

4 Permitting and Community Resistance

Siting waste conversion facilities often triggers local opposition (NIMBYism), and projects may face prolonged permitting timelines due to environmental and health concerns

Infrastructure & Processing

7 Pre-treatment Requirements

Drying, shredding, contaminant removal, and preparation of refuse-derived fuel (RDF) are required to meet gasifier specifications and protect downstream catalysts

8 Scale and Aggregation Complexity

Commercial-scale plants require coordinated supply from multiple municipalities, long-term contracts, and integrated logistics to maintain stable feedstock flow

10

SAF feedstock deep dives

i. Energy crops

GrainCorp

Energy crops summary

There is limited data on the economic benefit of energy crops; they are currently volume constrained

Executive Summary

Technical viability

- Energy crops are converted to SAF via the HEFA pathway, leveraging established oilseed crushing and hydroprocessing infrastructure
- Commercial-scale production in Australia remains limited, and crop-specific yield and supply data are still emerging

Emission reduction potential

- Under default CORSIA assumptions, Carinata-derived SAF delivers ~61% lifecycle carbon intensity reduction (~34.4 gCO_2e/MJ vs ~89 gCO_2e/MJ fossil baseline)
- With ILUC-adjusted performance, lifecycle CI may fall to ~23.6 gCO_2e/MJ, equivalent to ~73% reduction, subject to land-use and agronomic conditions

Economic competitiveness

- Carinata (HEFA) sits at ~$929/$tCO_2e$ on Australia's 2030 SAF abatement cost curve, positioned below several lignocellulosic pathways and above waste oils
- Economics remain sensitive to crop yield, oil content, input intensity, and integration with existing crushing and hydroprocessing infrastructure

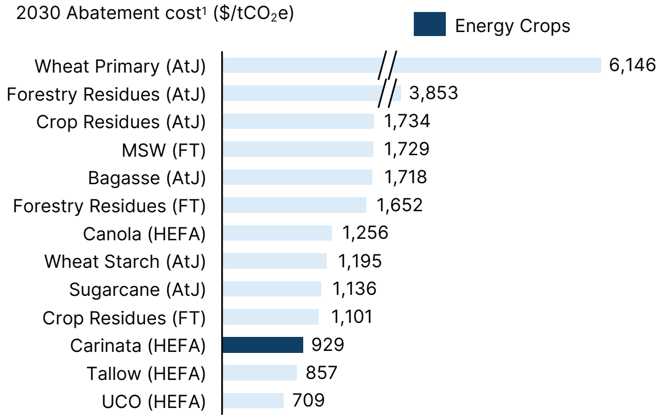
Australia's opportunity

- Energy crops such as Carinata and Pongamia can be integrated into low-productivity or rotational systems, supporting feedstock diversification
- Dedicated non-food crops can strengthen long-term supply security relative to waste-based feedstocks

Australia's scale potential

- Field trials are underway to validate agronomic performance and regional suitability
- Commercial volumes depend on demonstrated farm-level economics and sustained SAF demand signals

2030 SAF Abatement Cost Comparison - Australia



2030 Jet Fuel Volume Potential vs. 2030 demand

No available data

Source: Clean Energy Finance Corporation, Refined Ambitions (2024); International Civil Aviation Organization, SAF Rules of Thumb; GRDC, Energy Crops – Grower Information

Energy crops value chain

Energy crops are converted into SAF via the HEFA pathway, leveraging established oilseed crushing and hydroprocessing infrastructure

→ Fuel pathway

Production Pathway

Production → *Farmers grow oilseed crops (carinata, pongamia, jatropha) in rotational or perennial systems to produce oil-bearing biomass*

Harvesting & Aggregation → *Operators harvest, dry, and transport seeds to regional crushing facilities*

Crushing & Oil Extraction → *Processors crush seeds and extract crude vegetable oil. They sell protein meal into feed markets as a co-product.*

Oil Pre-treatment → *Refiners degum, filter, and dry the oil to remove impurities and meet HEFA specifications*

Hydroprocessing → *Refiners hydrotreat the oil to remove oxygen, hydrocrack and isomerise hydrocarbons to meet jet specifications, then separate SAF, renewable diesel, and light fractions via distillation*

End Use Applications

Renewable diesel

Drop-in diesel fuel produced via HEFA hydroprocessing

SAF

HEFA-SPK blended (up to 50%) with Jet A-1 for commercial aviation

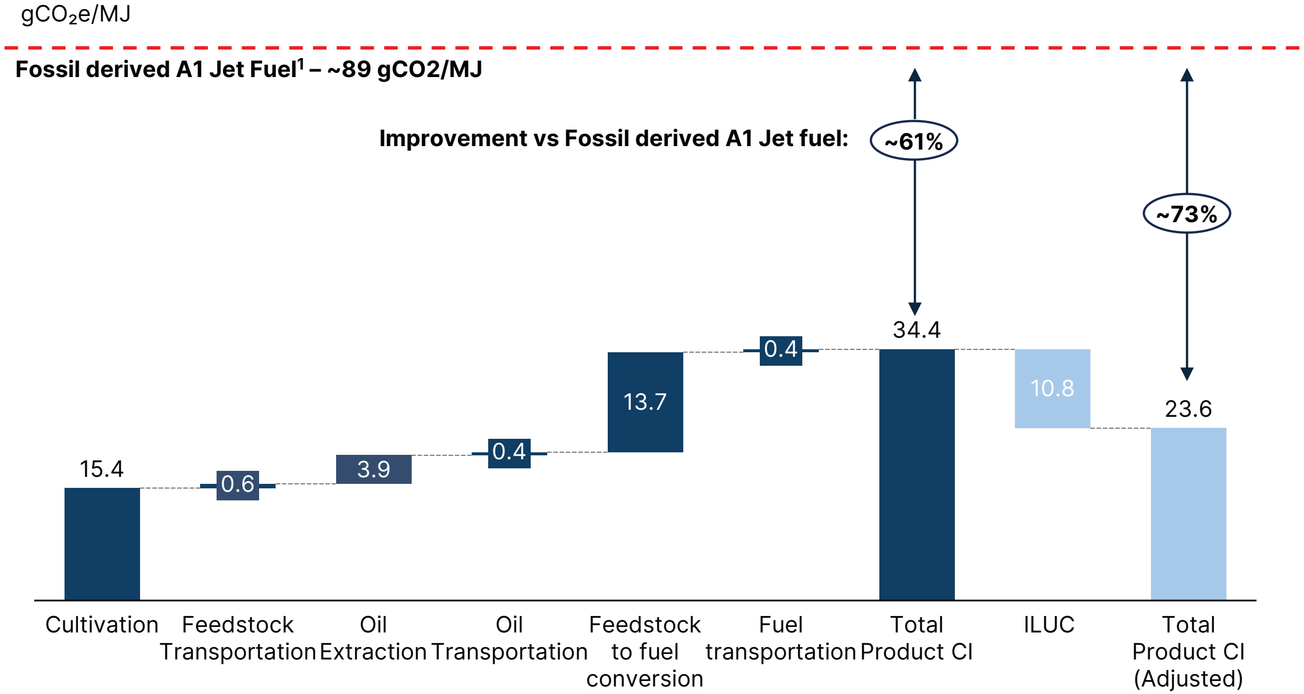
Naphtha/LPG

Light fractions used as petrochemical feedstocks or refinery fuels

Carinata carbon intensity

Carinata-based SAF delivers ~61% carbon intensity reduction versus fossil jet fuel based on default CORSIA LCA values alone, which increases to ~73% if ILUC is included

Carinata Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target cultivation practices and processing inputs that drive life-cycle CI in Carinata-based HEFA SAF production

1 Feedstock & Land Management

- **Low-input rotational cropping:** Maintain carinata as a winter rotational crop to avoid ILUC and limit additional land-use
- **Optimised fertiliser management:** Reduce nitrogen application rates and improve timing to lower N_2O emissions
- **Yield improvement per hectare:** Improve genetics and agronomic practices to increase oil yield, reducing gCO_2e/MJ through higher output
- **Residue and soil carbon management:** Apply reduced tillage and residue retention practices to maintain or increase soil carbon stocks, subject to project-level LCA verification

2 Processing & Conversion (HEFA)

- **Renewable electricity in crushing and refining:** Power oil extraction and refining steps with renewable energy to reduce Scope 2 emissions
- **Low-carbon hydrogen sourcing:** Use renewable or low-carbon hydrogen in HEFA upgrading to materially reduce refining-stage CI compared to conventional SMR-derived hydrogen
- **Onshore integration of crushing and refining**: Co-locate oil extraction and HEFA refining to reduce transport emissions, handling losses, and intermediate logistics energy use

Notes: (1) Standard fossil fuel derived value from CORSIA. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Strategic opportunities

Energy crops provide a scalable SAF pathway by strengthening feedstock security, improving agronomic resilience, and enhancing project economics

Feedstock & Land Base

Dedicated Non-Food Feedstock

Energy crops provide a purpose-grown biomass source for SAF, reducing exposure to waste feedstock constraints and improving long-term supply security

Marginal or Degraded Land Use

Crops such as carinata can be integrated into low-productivity and/or rotational systems, enabling feedstock expansion without displacing primary food production

Climate Resilience

Species like pongamia and switchgrass exhibit strong drought tolerance, pest resistance, and adaptability to changing climate conditions, making them suitable for long-term production

Abatement Economics

Low Baseline Carbon Intensity

Energy crops deliver ~23.6 gCO_2e/MJ, well below fossil jet (~89 gCO_2e/MJ), enabling strong lifecycle reductions

Environmental & Agronomic Benefits

Carbon Sequestration

Deep-rooted perennial energy crops improve soil carbon stocks and reduce erosion, offering co-benefits for land restoration and greenhouse gas mitigation beyond fuel displacement.

High Oil or Biomass Yields

Oilseed energy crops like carinata and pongamia produce high-oil yields with minimal inputs, while lignocellulosic crops like miscanthus produce dense biomass suitable for FT or cellulosic AtJ

Supportive Policy Potential

As a 'clean slate' category with strong GHG and land-use credentials, energy crops are well-positioned to benefit from government support schemes tied to carbon intensity, biodiversity, or regional development

Structural and execution challenges

Scaling energy crops for SAF requires coordinated development across supply chains, processing infrastructure, and regulatory frameworks

Feedstock Market

1 Immature Supply Chains

Energy crop deployment requires established infrastructure, validated conversion pathways, and demonstrated proof of concept before expansion or testing

2 Land Access and Grower Incentives

Convincing farmers to switch to unproven crops, especially those with multi-year establishment periods like pongamia, requires strong, long-term demand signals and risk-sharing mechanisms

3 Uncertain Agronomic Performance

Limited field trials in Australia mean yield variability, input requirements, and harvesting systems are not yet well understood at scale

Infrastructure & Processing

4 Technology Compatibility

Some crops (e.g. miscanthus, switchgrass) require gasification or cellulosic ethanol pathways (FT or AtJ), which are capital-intensive and less commercially mature than HEFA

5 Genetic and R&D Needs

Yield and oil content improvements for crops like pongamia are still under development, and limited breeding programs constrain commercial viability

Regulation

6 Regulatory Gaps

Current certification pathways (e.g. CORSIA, LCFS) may not fully capture the climate and land-use benefits of energy crops, limiting market incentives unless methodologies are updated

10

SAF feedstock deep dives

j. Perennials

GrainCorp

Perennials summary

Perennials show strong carbon reduction potential; commercial scale depends on agronomic validation and demand signals in Australia

Executive Summary	
Technical viability	• Perennials are converted to SAF via AtJ (biochemical) or FT (thermochemical) pathways • Field trials are underway to assess agronomic suitability, yield stability and regional fit; commercial deployment depends on demonstrated on-farm economics
Emission reduction potential	• Miscanthus via AtJ delivers ~86% lifecycle carbon intensity reduction versus fossil jet under default CORSIA assumptions (~12.9 gCO_2e/MJ vs ~89 gCO_2e/MJ) • Miscanthus via FT delivers ~104% reduction under default CORSIA values, resulting in negative lifecycle CI (~-3.4 gCO_2e/MJ adjusted).)
Economic competitiveness	*No available data*
Australia's opportunity	• Once established perennials offer consistent and predictable yields and grow well on underutilized, degraded or marginal lands not suitable for food crops • Perennials improve soil health and present a carbon sequestration opportunity
Australia's scale potential	• Scale-up depends on proven farm performance, grower adoption, and sustained SAF demand signals or policy support

2030 SAF Abatement Cost Comparison - Australia

No available data

2030 Jet Fuel Volume Potential vs. 2030 demand

No available data

Source: Clean Energy Finance Corporation, Refined Ambitions (2024)

Perennials value chain

Perennials such as Miscanthus are converted into SAF through biochemical (ATJ) or thermochemical (FT) conversion routes

→ Fuel pathway

Production Pathway

Feedstock generation

Perennial grasses are planted once and harvested annually for 10-15 years. Initial establishment takes 2-3 years before reaching commercial yield

Harvest and Collection

Harvesting occurs once per year, usually in late summer or autumn when moisture content is low. Collected biomass is transported to regional depots or straight to biorefineries

Pre-treatment → **Conversion & Upgrading**

AtJ Process

Mechanical size reduction and chemical/steam treatment to break down lignocellulose and expose fermentable sugars

Hydrolysis and fermentation produce alcohol, followed by catalytic upgrading to jet-range hydrocarbons (ATJ-SPK).

Gasification → **Conversion & Upgrading**

FT Process

High-temperature conversion of biomass into syngas ($CO + H_2$)

Syngas converted via Fischer–Tropsch synthesis and upgraded to jet-range hydrocarbons (FT-SPK)

Product Separation & Blending

Products are separated and conditioned to meet fuel specifications

End Use Applications

Diesel-range hydrocarbons

Produced mainly in FT configurations; used as renewable diesel blendstock

SAF

ATJ-SPK or FT-SPK, a synthetic paraffinic kerosene produced from biomass and blended (up to 50%) with Jet A-1 for commercial aviation

Naphtha/LPG

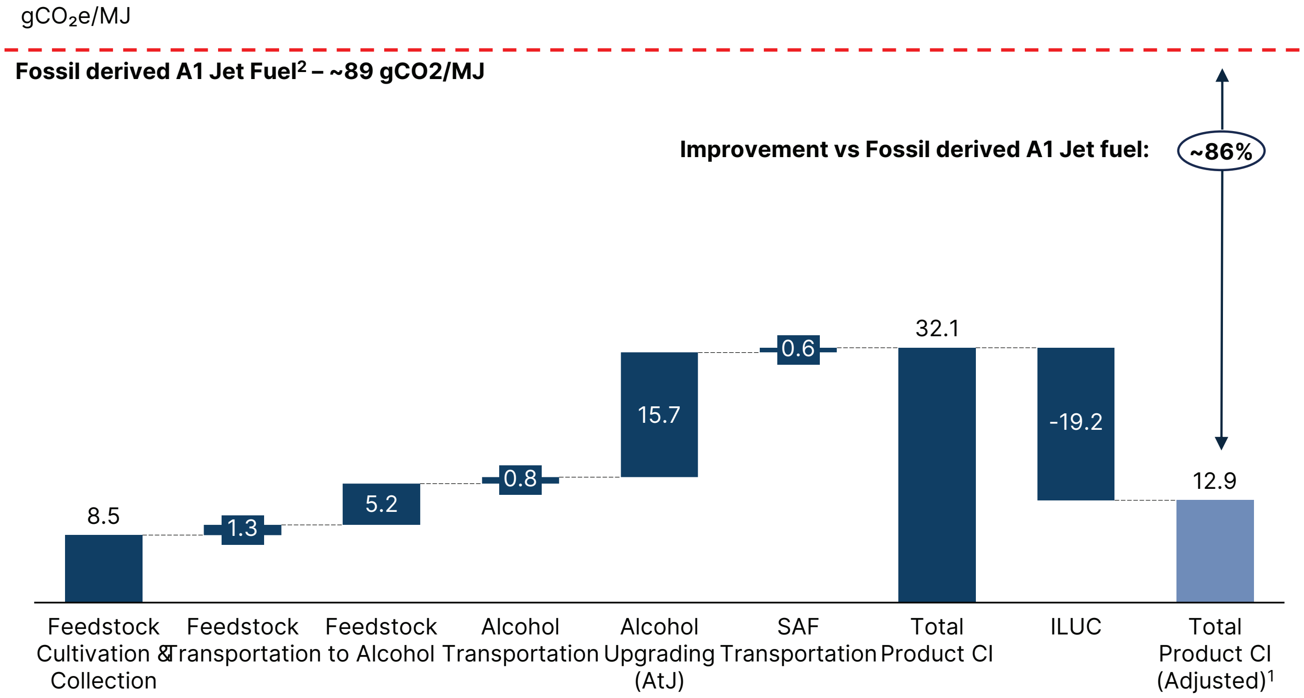
Light fractions used as petrochemical feedstocks or refinery fuels

Source: ScienceDirect, Perennial Grass – Engineering Topic Overview; EverGraze, Perennial Pasture Establishment Guide.

Miscanthus carbon intensity (AtJ)

SAF derived from Miscanthus via the AtJ pathway delivers a ~86% carbon intensity reduction versus fossil jet fuel using default CORSIA values, with potential to further reduce CI

Miscanthus AtJ Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target potential areas of further CI reduction for Miscanthus AtJ SAF

1 Transportation Efficiency

- **Shorter transport distances:** Establishing decentralized processing hubs can minimize diesel use in feedstock logistics
- **Densification technologies:** Pre-processing to increase feedstock bulk density (e.g. torrefaction, pelletisation) improves transport and reduces energy use downstream

2 Integration Opportunities

- **Integrate with co-product markets:** Using lignin-rich residues for power or chemical production boosts displacement credits under CORSIA
- **Integration with carbon capture:** SAF biorefineries can integrate BECCS (Bioenergy with carbon capture and storage) to achieve net-negative lifecycle emissions

3 Agricultural Practices

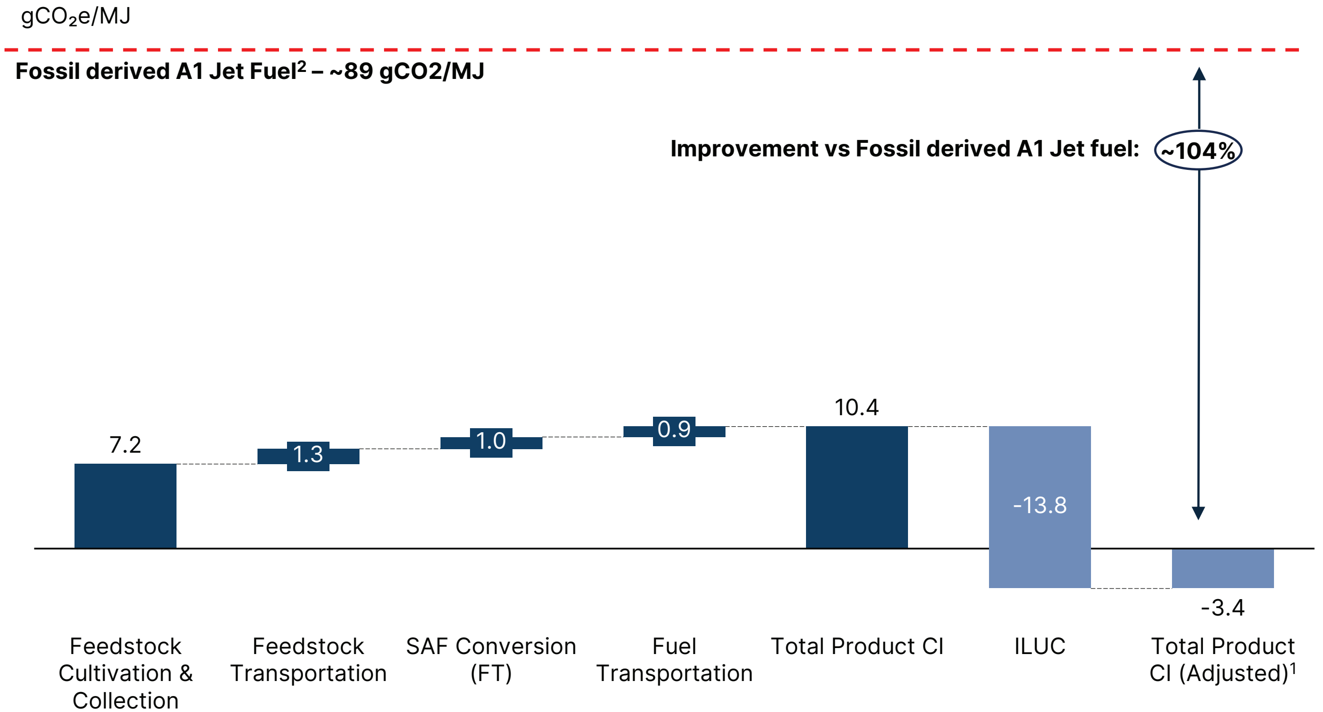
- **Improved land management:** Adopting no-till and precision agriculture practices increases soil carbon retention, especially in degraded or previously overused land
- **Optimised cultivar selection:** New Miscanthus varities with higher yields and root biomass can enhance carbon sequestration

Notes: (1) Add 4.1 gCO2e/MJ if process heat for ethanol upgrading is produced from coal. Add 4.3 gCO2e/MJ if process hydrogen for ethanol upgrading is produced from coal. Add 11.3 gCO2e/MJ if using the isobutanol conversion process in place of ethanol. Subtract 3.8 gCO2e/MJ if it is an integrated process rather than standalone. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Miscanthus carbon intensity (FT)

SAF derived from Miscanthus via the FT pathway delivers a ~104% carbon intensity reduction versus fossil jet fuel using default CORSIA values, delivering a negative CI score

Miscanthus AtJ Carbon Intensity (CI) Build Up



CI Reduction Levers

These levers target potential areas of further CI reduction for Miscanthus FT SAF

1 Transportation Efficiency

- **Shorter transport distances:** Establishing decentralized processing hubs can minimize diesel use in feedstock logistics
- **Densification technologies: :** Pre-processing to increase feedstock bulk density (e.g. torrefaction, pelletisation) improves transport and reduces energy use downstream

2 Integration Opportunities

- **Integrate with co-product markets:** Using lignin-rich residues for power or chemical production boosts displacement credits under CORSIA
- **Integration with carbon capture:** SAF biorefineries can integrate BECCS (Bioenergy with carbon capture and storage) to achieve net-negative lifecycle emissions

3 Agricultural Practices

- **Improved land management:** Adopting no-till and precision agriculture practices increases soil carbon retention, especially in degraded or previously overused land
- **Optimised cultivar selection:** New Miscanthus varities with higher yields and root biomass can enhance carbon sequestration

Notes: (1) Value also applies for Switchgrass. CI score calculated under a standalone conversion design
Source: International Civil Aviation Organisation, 'CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels – November 2025' (2025); ICAO, 'CORSIA Supporting Document – CORSIA Eligible Fuels: Life Cycle Methodology – V7' (2025).

Strategic opportunities

Perennials present a highly-scalable SAF opportunity with very low CI values; unlocking value depends on continued technological investment and taking advantage of land use benefits

Feedstock Market

Consistent and Predictable Yields

Once established, perennials offers stable yields across multiple years, supporting consistent feedstock supply to refineries with less reliance on annual planting cycles or volatile markets.

Compatibility with Marginal Land

Perennials grow well on underutilized, degraded or marginal lands unsuitable for food crops, reducing land use conflict and avoiding any food production conflicts.

Soil Health and Carbon Sequestration

Perennials improve soil organic carbon, reduce erosion and enhance water retention. These ecosystem services may qualify for carbon credits or biodiversity incentives.

Infrastructure & Processing

Fit for Emerging Technologies

Perennials are well-suited to technologies like gasification (FT) and potentially HTL, which can process lignocellulosic biomass efficiently at scale.

Abatement Economics

Extremely Low Carbon Intensity

Perennial crops offer some of the lowest lifecycle profiles of any SAF feedstocks due to high carbon sequestration and low input requirements.

Potential for Regional Economic Development

Deployment of perennial crops near regional biofuel refineries can create new economic activity in rural areas, including jobs in cultivation, transport and biomass processing.

Policy and Direction

Long-term Policy Alignment

Perennial crops align well with Australia's long-term emissions reduction goals, biodiversity policies, and rural development programs.

Structural and execution challenges

While Perennials offer carbon and land-use benefits, deployment depends on resolving land access and economic difficulties

Feedstock Market

1 Limited Existing Industry Ecosystem

There is no established commercial supply chain for perennials in Australia today, meaning growers face uncertainty around seed supply, agronomic advice and equipment availability.

2 Land Access and Scale-up Complexity

Scaling up to the large land areas required to supply a single SAF plant demands significant landholder coordination, long-term land commitments and complex aggregation models

3 Agronomic Risk and Farmer Hesitancy

Australian farmers are traditionally focused on cereals, legumes and grazing systems. Switching to unfamiliar crops involves risk, and current incentive structures are not fit for purpose.

4 Competing Land Use and Biodiversity Trade-offs

If not carefully managed, large-scale monoculture plantations of perennials could impact biodiversity, water usage and local ecosystems, potentially undermining sustainability claims.

Abatement Economics

5 High Upfront Establishment Costs

Initial planting and establishment costs can be high, with a 2-3 year period before economic harvesting begins, limiting uptake without targeted subsidies or long-term contracts.

Infrastructure & Processing

6 Refining Technology Maturity and Cost

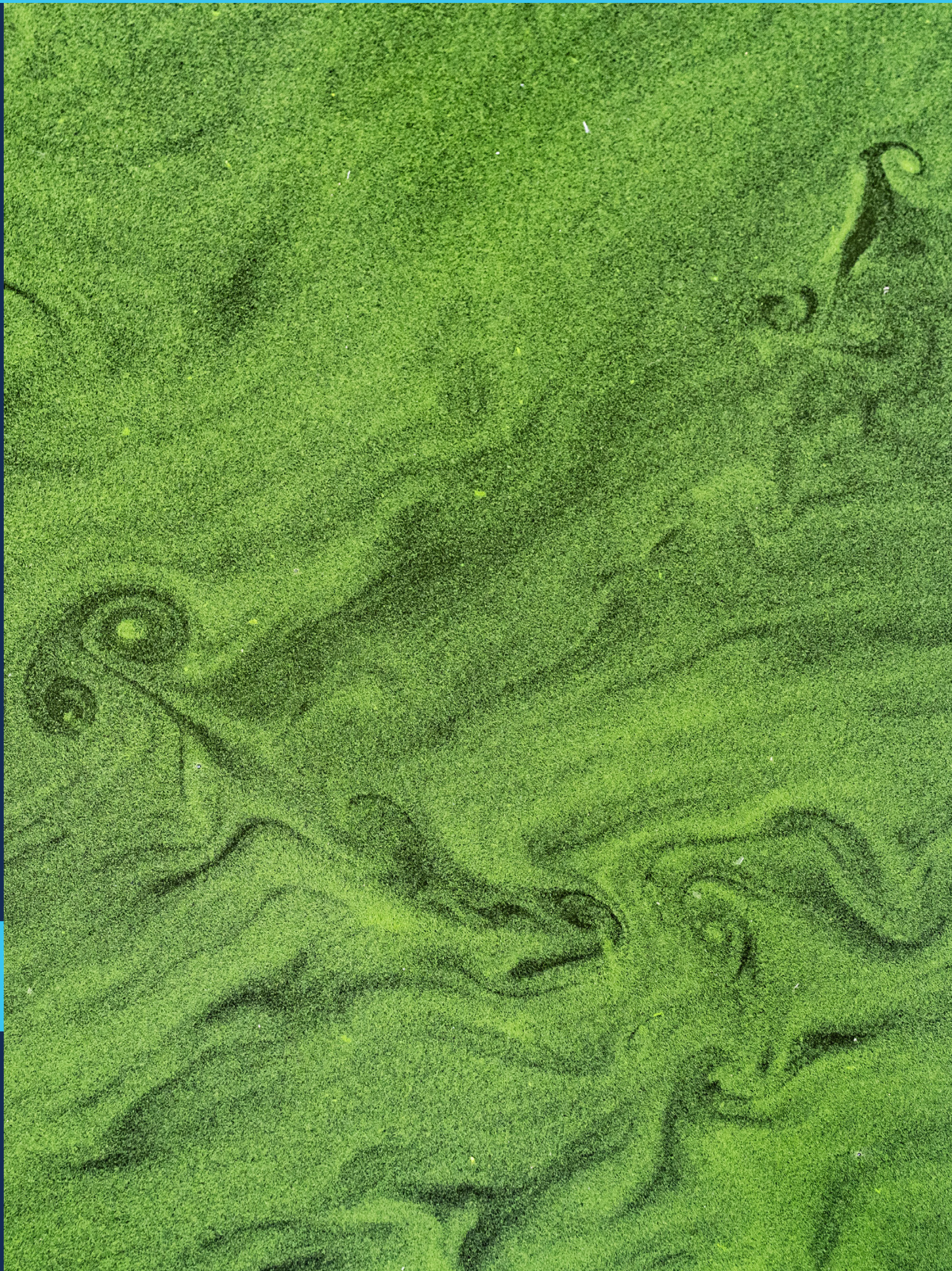
FT and HTL technologies are less commercially mature and more operationally complex, while lignocellulosic AtJ processes can be expensive and energy-intensive.

7 Infrastructure and Logistics Gap

Low bulk density and seasonal harvests make transport and storage of perennial biomass costly and operationally complex, particularly without densification infrastructure like pellet mills.

10
SAF feedstock deep dives

k. Algae



Algae summary

While algae is refined via the most well-established pathways, it remains a theoretical feedstock

Executive Summary

Technical viability	• Algae-to-SAF pathways include HTL (wet biomass) and lipid extraction + HEFA; both remain pre-commercial at scale • Large-scale cultivation faces biological instability, contamination risk, and performance variability
Emission reduction potential	• Algae-derived SAF delivers 64% lifecycle CI reduction versus fossil jet based on EU research values (non-CORSIA) (~31.8 gCO_2e/MJ vs ~89 gCO_2e/MJ) • Carbon intensity is highly sensitive to cultivation energy use, drying assumptions, and electricity source
Economic competitiveness	*No available data*
Australia's opportunity	• Australia has limited commercial-scale algae cultivation capacity • Saline and brackish regions offer theoretical siting advantages, but water, nutrients and infrastructure remain constraints
Australia's scale potential	• Commercial-scale algae SAF production has not been demonstrated in Australia • Scale-up is constrained by high capital intensity, energy-intensive harvesting and dewatering, and nutrient supply requirements

2030 SAF Abatement Cost Comparison - Australia

No available data

2030 Jet Fuel Volume Potential vs. 2030 demand

No available data

Source: Clean Energy Finance Corporation, Refined Ambitions (2024); International Civil Aviation Organization, SAF Rules of Thumb; U.S. Department of Energy, A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae (1998); ARENA (Knowledge Bank – Microalgae Biofuel); U.S. DOE (1998) Aquatic Species Program retrospective; Utah State University (Algae fuel scaling challenges).

Algae value chain

Algae can be cultivated via two different methods and converted to SAF through either the HEFA or HTL process

Fuel pathway

Production Pathway

Strain Selection and R&D

Selected microalgae strains are chosen for lipid content, growth rate, resilience and CO_2 uptake

Open Raceway Pond Cultivation

Algae grown in large shallow ponds stirred by paddle wheels, exposed to natural sunlight and atmosphere

Photobioreactor Cultivation

Algae grown in photobioreactors (PBRs) – closed systems made of glass or plastic tubes or flat panels, offering better control over growth conditions

Collection

Flocculation, centrifugation, filtration or dissolved air flotation are used to concentrate algal biomass for extraction

Lipid Extraction & Upgrading

Neutral lipids used in HEFA are extracted, or whole biomass is converted for HTL by mechanical, chemical or supercritical extraction

Product Separation & Blending

Hydrocarbon fractions separated and conditioned to meet ASTM specifications prior to blending

End Use Applications

Diesel-range hydrocarbons

Renewable diesel blending component.

SAF

Synthetic paraffinic kerosene blended (up to 50%) with Jet A-1 for commercial aviation.

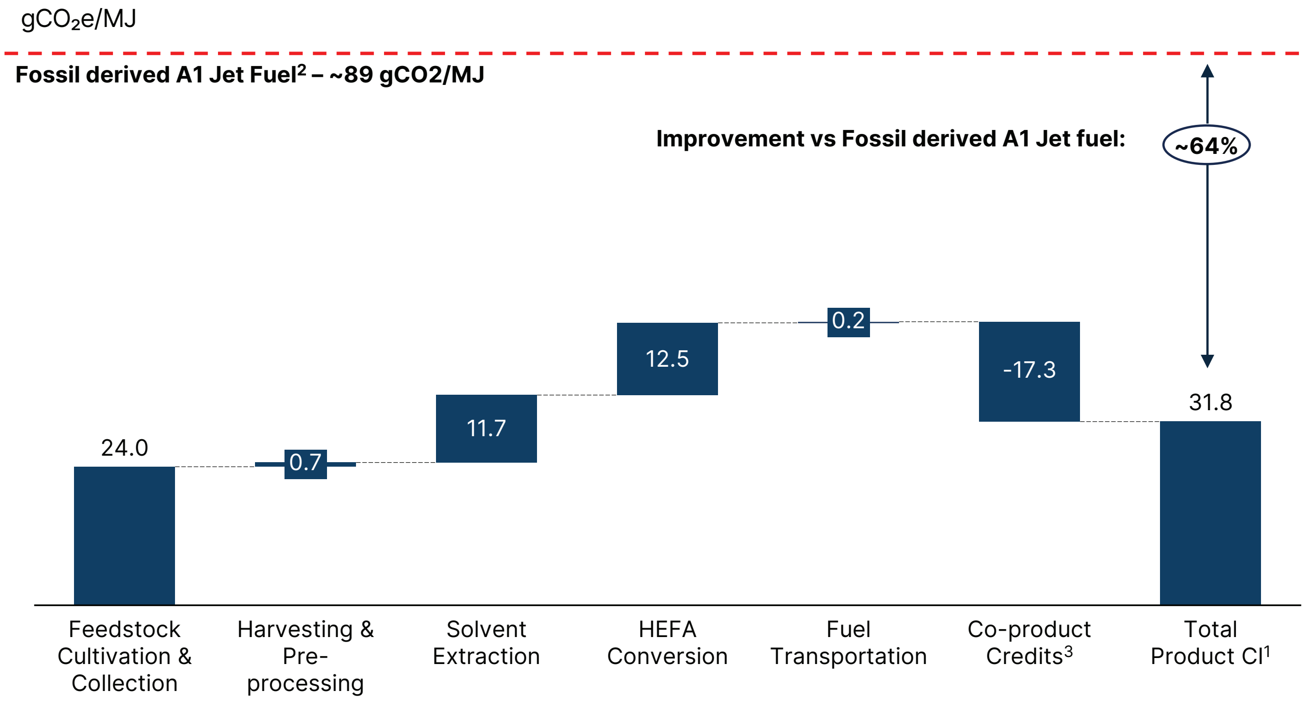
Naphtha/LPG

Light fractions used as petrochemical feedstocks or refinery fuels

Algae carbon intensity (HEFA)

SAF derived from Algae delivers a ~64% carbon intensity reduction versus fossil jet fuel using EU research values, with exact CI dependent on cultivation assumptions

Algae Carbon Intensity (CI) Build Up – Non CORSIA approved values



CI Reduction Levers

These levers target potential areas of high CI emissions in the Algae SAF process

1 Production Process Energy Efficiency

- **Switch to renewable electricity:** Replacing grid electricity with solar or wind to reduce emissions in water circulation, harvesting and extraction stages is a crucial assumption to keep CI low
- **Improve harvesting efficiency:** Develop low-energy harvesting methods such as bio-flocculation or membrane filtration to reduce energy demands
- **Avoid drying:** Use wet biomass conversion (HTL) can skip energy-intensive drying and extraction

2 Integration Opportunities

- **Integrate with co-product markets:** Use residual biomass for high-value products (e.g. fish feed) to enable allocation of emissions and reduce SAF CI
- **Optimise location:** Produce algae in regions with high insolation, cheap land and proximity to CO_2 and wastewater sources
- **Use waste CO_2 and nutrients:** Co-locate algae production with industrial emitters to capture flue gas CO_2. Recycle wastewater as a source of nitrogen and phosphorus to eliminate the need for synthetic fertilisers

Notes: (1) In the absence of CORSIA CI values, values are taken from EU research by Prussi et al. Case 3 values were taken – reflective of a standard raceway pond at 15cm water depth with nutrient reduction, powered by nearby solar or wind energy. (2) Standard fossil fuel derived value from CORSIA. (3) Co-product credits are for biogas production.
Source: Prussi et al., Applied Energy (2021), "Are algae ready to take off? GHG emission savings of algae-to-kerosene production; International Civil Aviation Organization, CORSIA Default Fossil Fuel Value

Strategic opportunities

Algae, at a theoretical level, presents a highly-scalable SAF opportunity; unlocking value depends on continued investment into technological processes to reduce costs

Feedstock Market

No Competition with Food Markets

Algae can be cultivated on non-arable land, avoiding direct conflict with agriculture and enhancing its sustainability and economic profile.

Infrastructure & Processing

Photobioreactor Design Optimisation

Advanced closed photobioreactor systems can increase productivity, improve contamination control and enhance lipid yields, reducing unit production costs over time.

Waste Stream Integration

Algae cultivation can be co-located with industrial emitters to use waste CO_2, or with wastewater treatment plants to recycle nutrients.

Tailored Biochemistry

Algae strains can be genetically selected or engineered to produce higher lipid yields or specific fatty acid profiles that improve refining efficiency and fuel quality.

Abatement Economics

Attractive Carbon Intensity Profile

Under life-cycle s, algae-derived SAF has strong potential for ultra-low or even negative CI scores, particularly when co-utilised with waste CO_2.

Extremely High Yield Potential

Algae can theoretically produce 10-100x more oil per hectare than terrestrial oilseed crops, offering a high-output pathway that avoids land use competition.

Potential for Co-products

Valuable co-products (animal feed, pigments, plastics) can boost the economic viability of algae systems and support early commercialisation.

Policy and Direction

Policy and Research Support

Governments continue to fund algae R&D and demonstration-scale projects, often under bioenergy, carbon capture or wastewater valorisation programs.

Source: Sheehan, J., et al., A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae (1998); U.S. Department of Energy, Bioenergy Technologies Office Algae Program Overview.

Structural and execution challenges

While Algae offers carbon and land-use benefits, deployment depends on resolving logistical, technological and economic uncertainties

Feedstock Market

1 Long Commercialisation Timeline

The Algae SAF market is unlikely to reach price parity without major technological breakthroughs or long-term, robust policy incentives.

2 Complex Supply-Chain Integration

Creating integrated systems for CO_2, water, nutrients and energy use requires significant coordination and co-location, limiting site flexibility.

3 Uncertain Social License and Water Use

Developing the Algae market may raise local concerns due to its high water and nutrient use, and the visual footprint of large-scale ponds or reactors.

4 Low Land-Use Efficiency at Scale

While theoretical yields are high, real-world productivity drops due to contamination, weather and infrastructure constraints, particularly in open pond systems.

Abatement Economics

5 High Production Cost

Even in optimised systems, algal oil remains significantly more expensive than conventional feedstocks.

Infrastructure & Processing

6 Technical Immaturity and Scale

Most algae SAF projects remain at lab or pilot scale. Very few have reached commercial scale, and major challenges exist at larger volumes.

7 Intensive Energy and Infrastructure Requirements

Harvesting, dewatering, drying and lipid extraction steps are energy-intensive and often require bespoke infrastructure, limiting near-term scalability.

8 Capital-Intensive Cultivation Systems

Photobioreactors offer better control but are extremely expensive to build and operate, limiting their use in large-scale fuel production.

Theoretical Case Study | Algae-to-SAF in Coastal Queensland

OVERVIEW

This hypothetical case study examines the potential to develop a commercial-scale algae-based SAF facility near Gladstone, Queensland, using photobioreactor or open-pond systems to cultivate lipid-rich microalgae. The region is chosen due to its high solar irradiance, access to seawater, industrial energy infrastructure, and proximity to export terminals. The case illustrates the long-term potential of third-generation feedstocks and the challenges of scaling them into a reliable, cost-competitive SAF supply.

Refinery Size and Feedstock Requirements

Target SAF Production:
100,000 tonnes/year (modular and scalable)

Algal Oil Requirement:
Assuming ~20% oil content, this requires ~500,000 tonnes of dry algal biomass per year

Land Footprint:
Estimated at 3,000–5,000 hectares for open-pond systems; smaller for
Photobioreactors

Oil Yield Targets:
10–30 tonnes oil/ha/year depending on strain, technology, and operating conditions

Required Infrastructure and Primary Processing

What Exists:
- Access to saline water (coastal site)
- Industrial land zoned for bioenergy, with utilities and port access
- Proximity to power, hydrogen, and CO_2 sources

What's Needed:
- Capital investment in algal cultivation infrastructure
- Drying and lipid extraction systems
- Pre-treatment and upgrading to meet HEFA requirements
- A colocated or nearby HEFA refinery, or integration with an existing one (e.g. Gladstone BioHub)

Feedstock and Project Challenges

- Scale and Consistency: Delivering 500,000+ tonnes of algal biomass with consistent oil content is unprecedented globally
- High Capex and Opex: Cultivation, harvesting, and lipid extraction are capital- and energy-intensive
- Water and Land Use Concerns: Despite using non-arable land, algae systems require substantial saline water and nutrients, which may face environmental or community scrutiny
- Lack of Commercial Precedents: No algae-to-SAF plant has reached full commercial scale globally, making financing risky
- Process Efficiency: Lipid extraction, dewatering, and upgrading need to be significantly improved for economic viability

Opportunities and Enablers

High Productivity Potential: Microalgae can produce 10x more oil per hectare than conventional oilseeds

Non-Land Competition: Uses non-arable land, saline/brackish water, and non-food biomass - attractive for sustainability credentials

Industrial Symbiosis: Can co-locate with industrial sites to use waste CO_2, nutrient streams, and waste heat

Biotech Innovation: Australia has strong algal R&D capabilities (e.g., CSIRO, University of Queensland) to enhance strain development

Carbon Policy Alignment: High carbon abatement potential positions algae to benefit from future carbon pricing or CI-based incentives

Modular Growth: Can scale gradually via modular pond or reactor systems to reduce risk

Source: 'Sustainable Aviation Fuel Roadmap' CSIRO / Boeing (2023); 'Green dreams: algae emerge as a game-changer in the fight against climate change' CSIRO (2023); 'Production of Biofuel from Microalgae' ARENA; 'Biofuel from Microalgae: Efficient Separation, Processing and Utilisation of Algal Biomass' ARENA; 'Advancing Marine Microalgae Biofuel to Commercialisation' ARENA; 'Marine and Aquaculture Research Facility (MARF)' James Cook University; 'Algae turns heavy metals green' James Cook University (2017); 'Bioinnovation Research Facility (incl. Mackay Renewable Biocommodities Pilot Plant / QUT Pioneer BioPilot)' Queensland University of Technology; 'From macroalgae to liquid fuel: Via waste-water remediation, hydrothermal upgrading, CO_2 hydrogenation and hydrotreating' University of the Sunshine Coast (2016)

GrainCorp