Opportunities for sustainable aviation fuel (SAF) production in South Africa

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The analysis presented here has been conducted by:

Techno-economic modelling of SAF production pathways: Prof. Johann Görgens, Dr. Abdul Petersen and Mr. Farai Chireshe, Stellenbosch University, Department of Chemical Engineering

IAP availability assessment: Prof. William Stafford, Prof. David Le Maitre, Mr. Greg Forsyth and Dr. Ryan Blanchard from the Centre of Industrial and Scientific Research (CSIR)

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The growing impact of aviation on the climate

The commercial aviation industry currently accounts for **2–3%** of global carbon dioxide (CO_2) emissions.

Without mitigation, this is expected to account for over 22% of all anthropogenic CO_2 emissions.

In South Africa, civil aviation related emissions account for more than **8%** of total transport CO_2 emissions.

Tourism could be impacted as more travellers become climate conscious.

Transport related emissions will reduce competitiveness of SA exports (EU's carbon boarder adjustment mechanism).

Sustainable aviation fuel (SAF) to play a key role in decarbonisation of aviation.

Why should SA pursue Sustainable Aviation Fuel (SAF)?

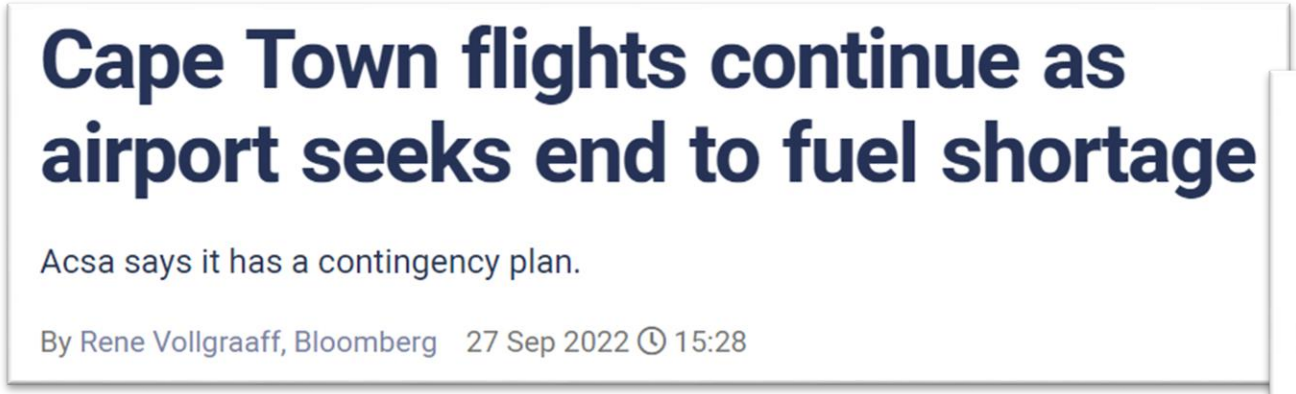
Excellent resource base

Long-standing experience with promising SAF production technologies (**Sasol** and **PetroSA**)

Need to start decarbonising own aviation sector

SAF represents an important export opportunity

SAF for security of jet fuel supply



Cape Town flights continue as airport seeks end to fuel shortage

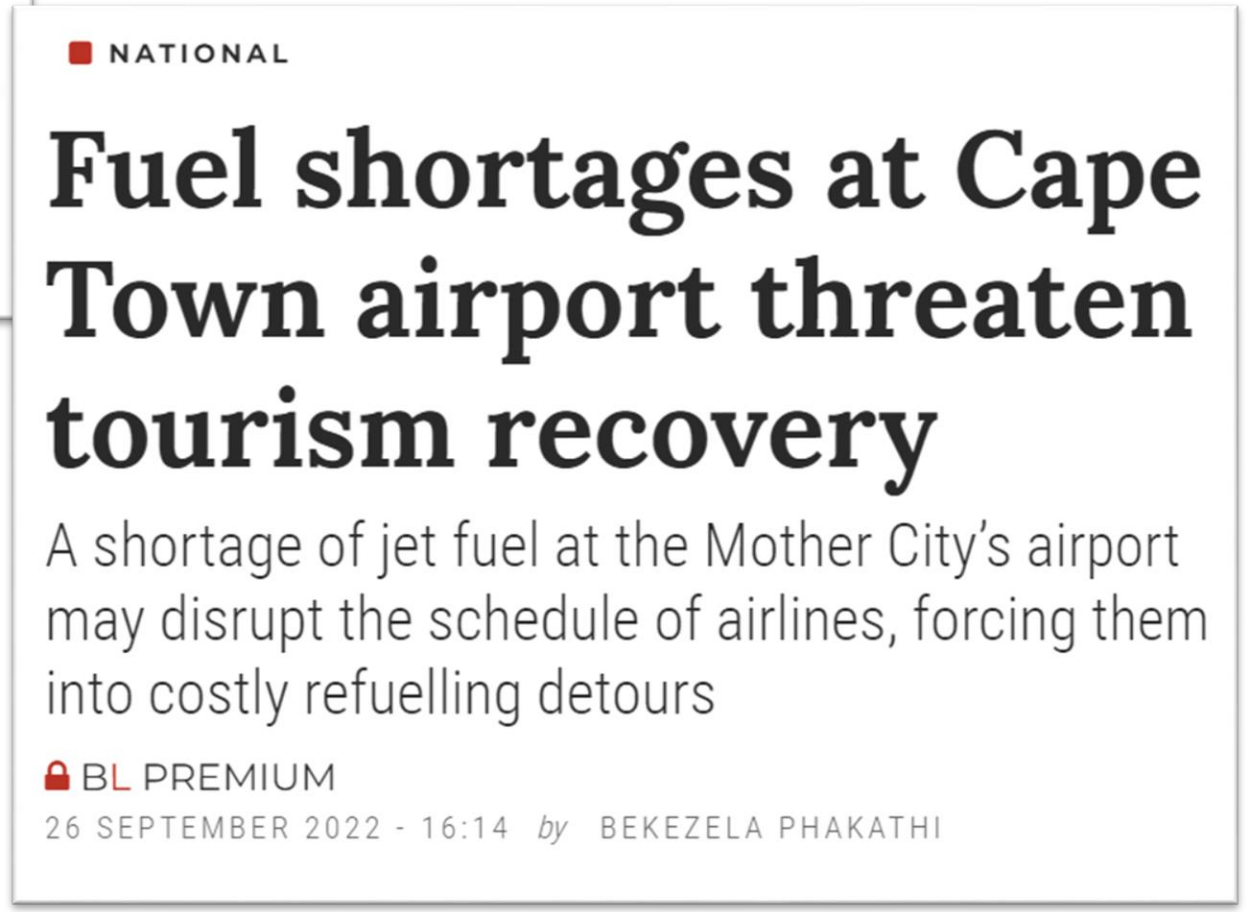
Acsa says it has a contingency plan.

By Rene Vollgraaff, Bloomberg 27 Sep 2022 15:28

27 Sep

Cape Town jet fuel crunch could worsen as shipment hits rough seas

news24 Carin Smith SHARE



NATIONAL

Fuel shortages at Cape Town airport threaten tourism recovery

A shortage of jet fuel at the Mother City's airport may disrupt the schedule of airlines, forcing them into costly refuelling detours

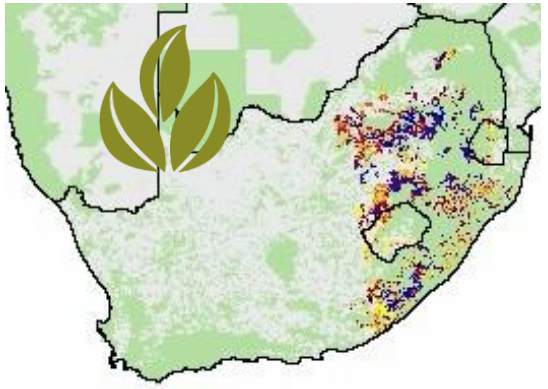
BL PREMIUM

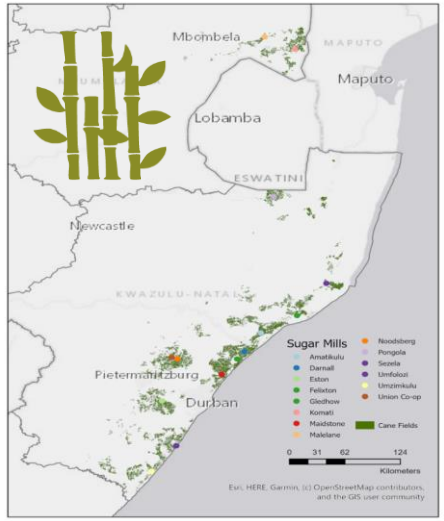
26 SEPTEMBER 2022 - 16:14 *by* BEKEZELA PHAKATHI

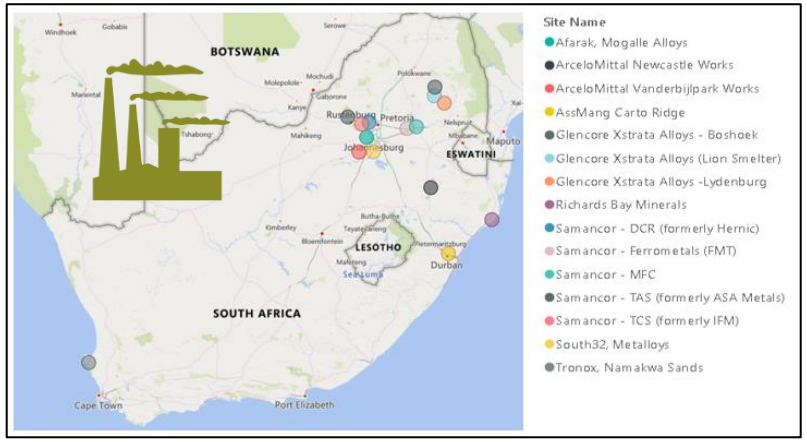
APPROACH TO ESTIMATING THE SAF OPPORTUNITY FOR SOUTH AFRICA

Feedstock availability

Feedstock	Potential availability
Solaris	5,2 million tonnes of seed per annum
A-molasses	165 000 tonnes per sugar mill per annum
Industrial off-gas	3,34 million tonnes per annum
Cleared IAPs	215 million oven-dry tonnes on less-than-35% slopes
Garden waste	170 000 tonnes per annum at two municipal depots (Johannesburg and Eden)







Invasive Alien Plants (IAPs): Ideal Feedstock for South Africa

IAPs are a threat to:

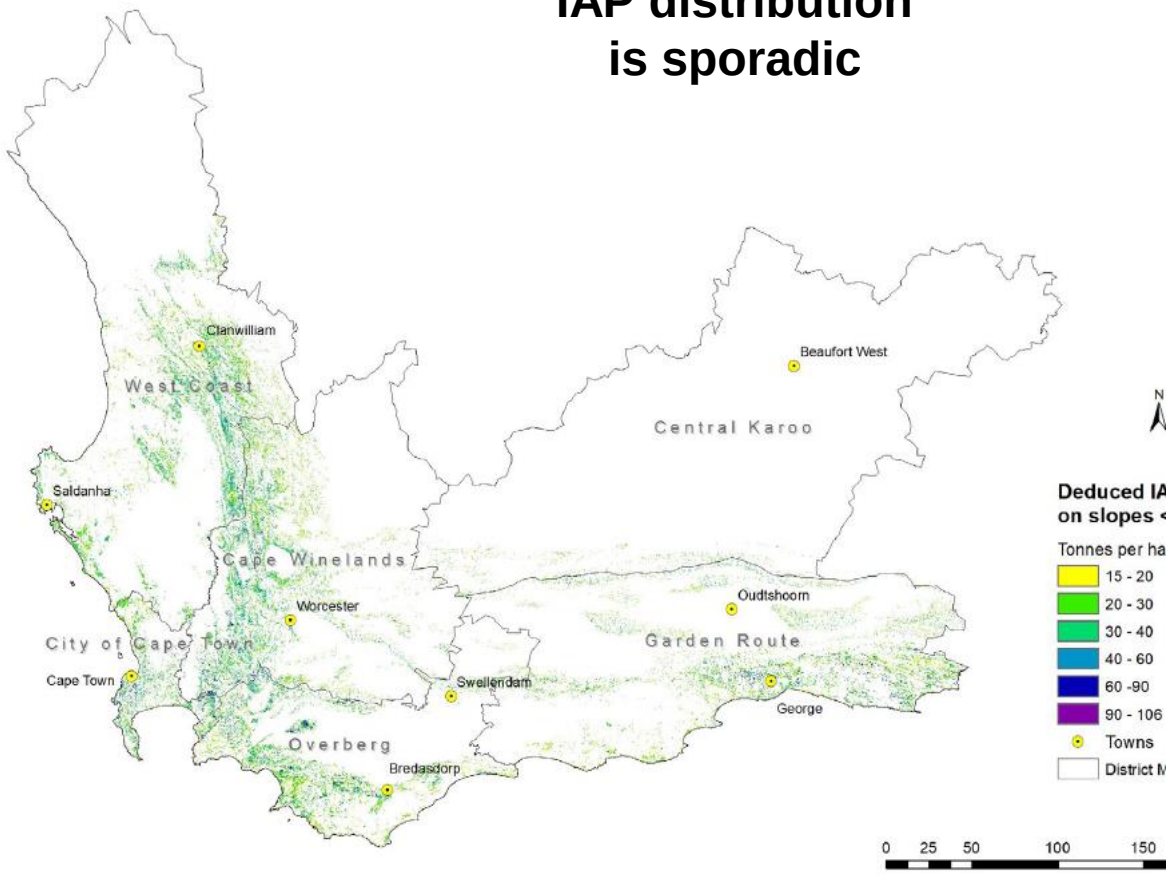
- Biodiversity
- Water security
- Productive use of land
- Ecological function of ecosystems

IAP removal is mandated by law

- Currently slow rate of clearing
- No large-scale removal of cleared biomass

IAP availability in Western Cape

IAP distribution is sporadic



Approach to assessing SAF production potential

FEEDSTOCK SELECTION

Solaris

A-molasses

Industrial off-gas

Cleared IAP & garden waste

SELECTION OF SAF PRODUCTION PROCESSES

Hydroprocessed esters and fatty acids (HEFA)

Alcohol (ethanol)-to-Jet (AtJ)

Fischer-Tropsch Synthetic Paraffinic Kerosene (FT-SPK)

Fischer-Tropsch Synthetic Paraffinic Kerosene plus Aromatics (FT-SPK/A)

Integrated hydropyrolysis and hydroconversion (IH^2)

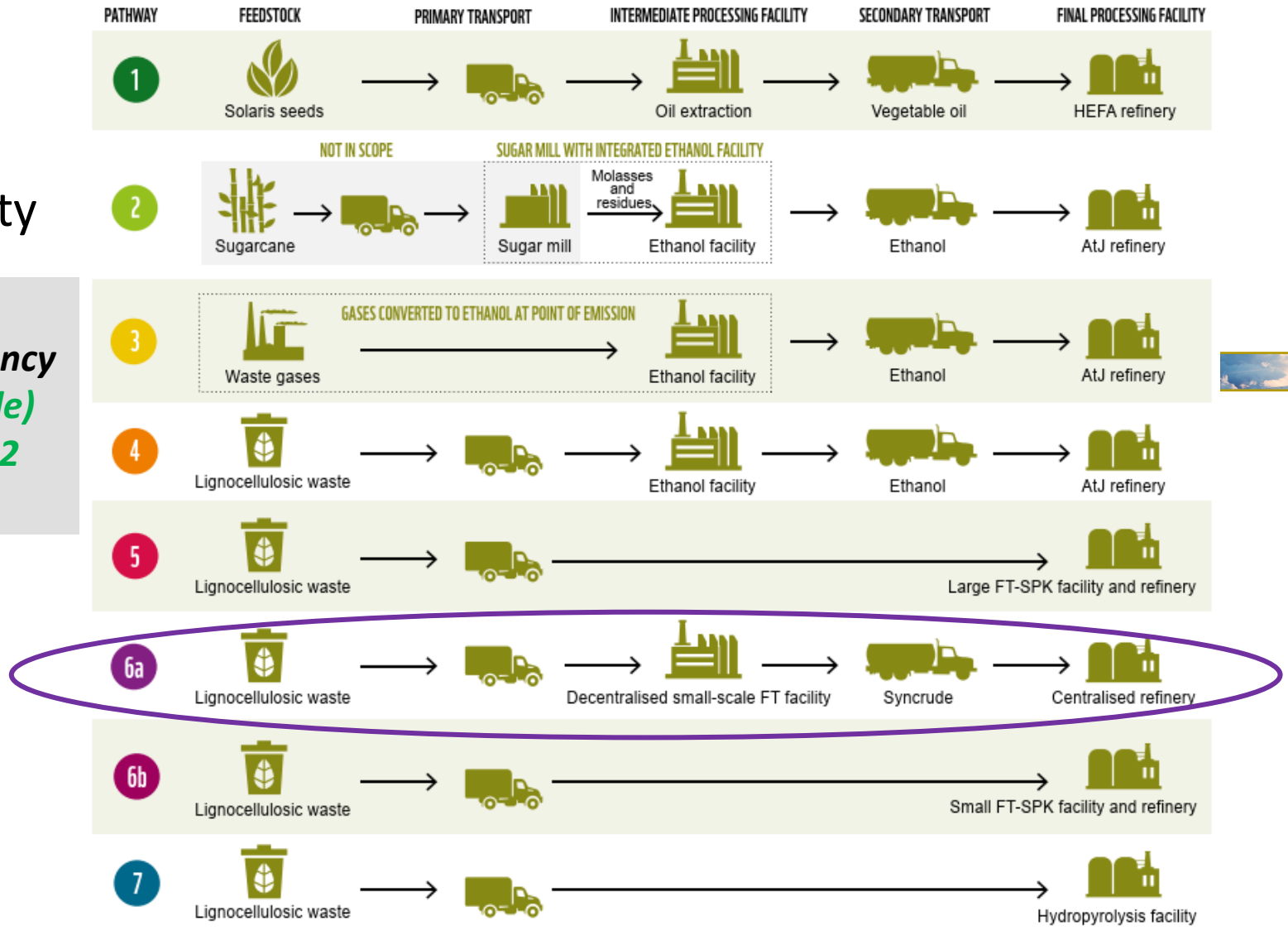
7 SAF PRODUCTION PATHWAYS

Approach to assessing SAF production potential

NETWORK OPTIMISATION
Centre of gravity

2 scenarios:
- ***Energy self-sufficiency***
- ***External (renewable) energy for green H2***

TRANSPORT COSTING

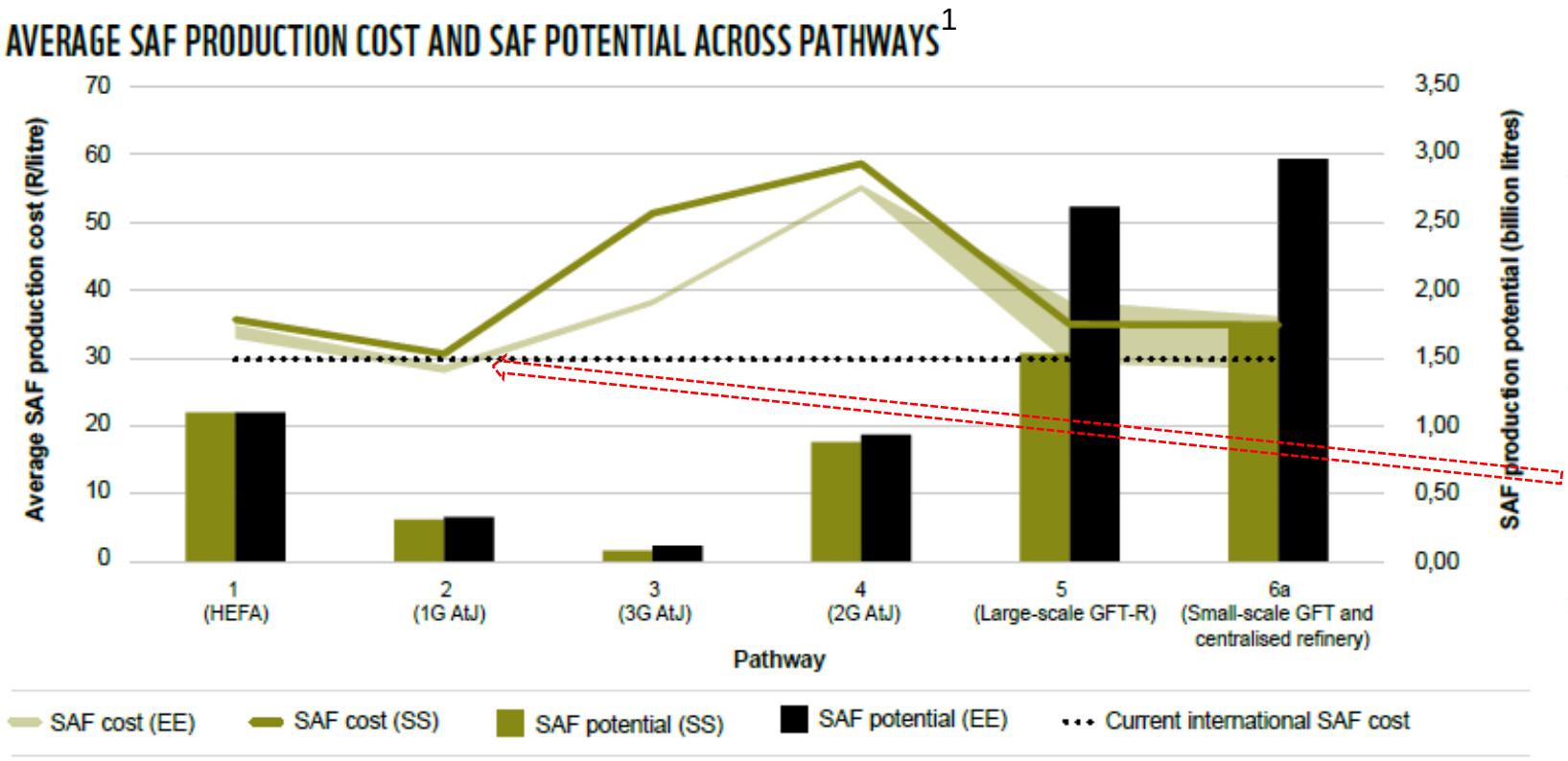


SAF PRODUCTION POTENTIAL & COST PER FACILITY

NATIONAL SAF PRODUCTION POTENTIAL

THE SAF OPPORTUNITY IN SOUTH AFRICA QUANTIFIED

Pathway Comparison



SS: Self-sufficiency **EE:** External Energy

Upper and lower parts of band in EE scenario represents green H2 costs of 4.4 and 2 $/kg respectively.

Generally, external energy scenario more cost-effective than self sufficiency scenario.

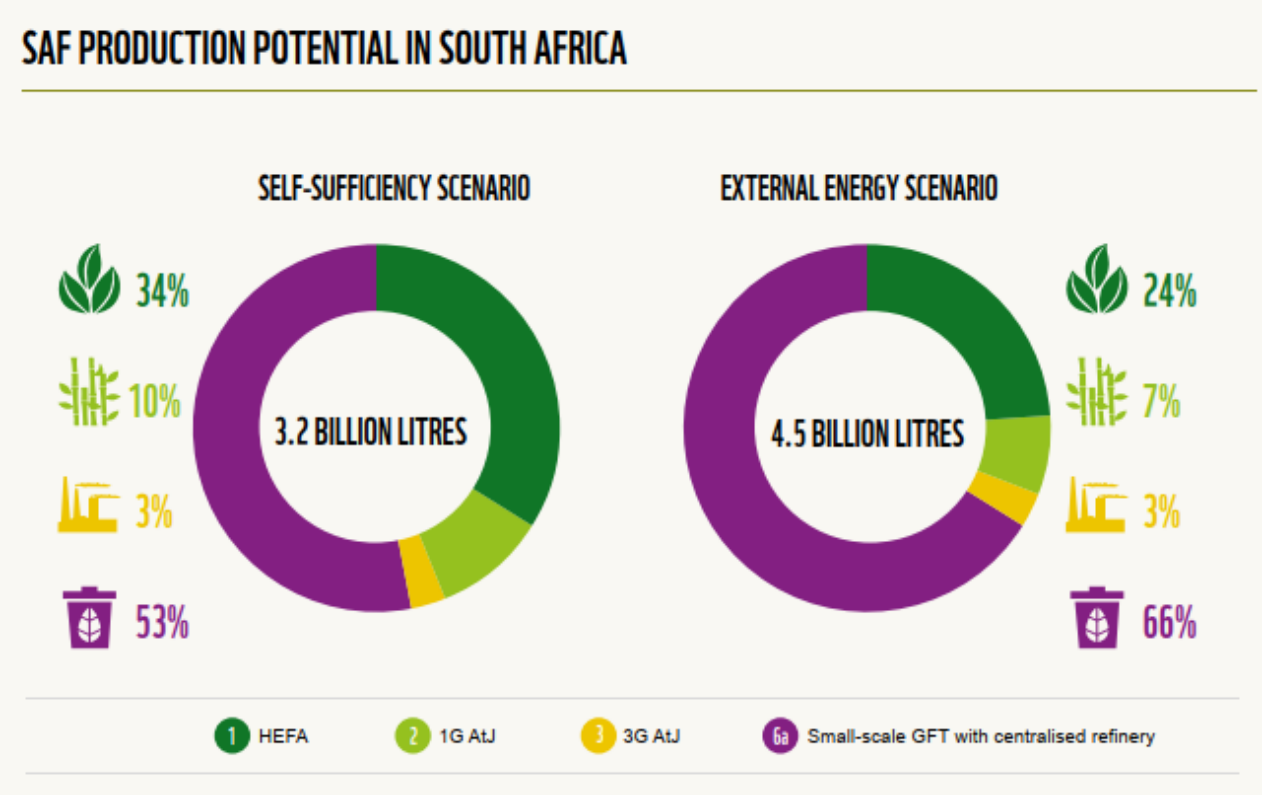
Pathway 2 cost-comparable with international SAF cost.

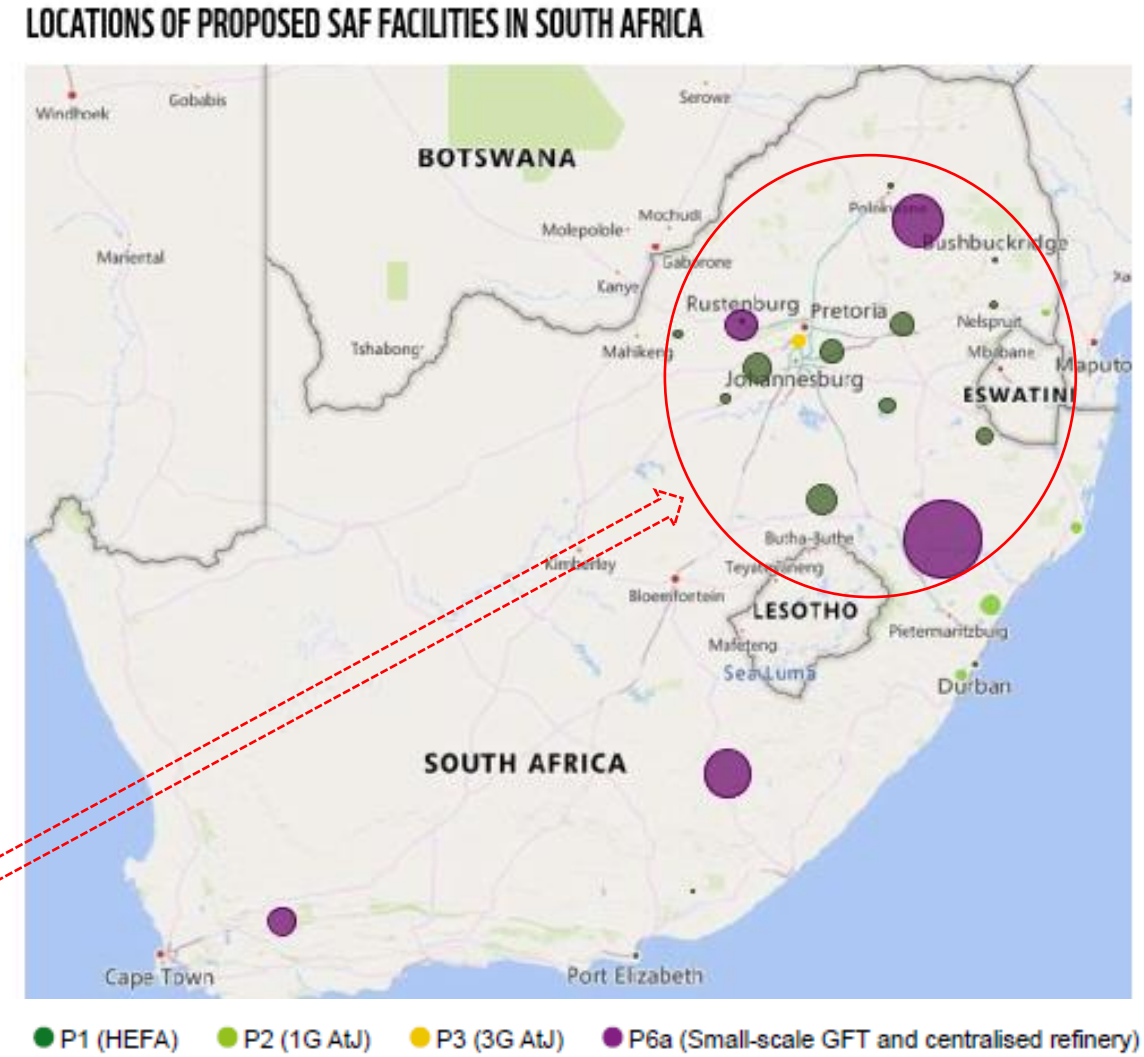
Cost-competitiveness of P5 and P6a in external energy scenario dependent on green H2 cost.

[1]P6b and 7 excluded as they were deemed least likely to be developed based on the results obtained in self-sufficiency scenario

Costs given for green field facilities; SAF production using brownfield sites (e.g., Sasol/PetroSA's existing Fischer-Tropsch facilities or petroleum refineries) is likely to be cheaper

South Africa's SAF Production Blueprint



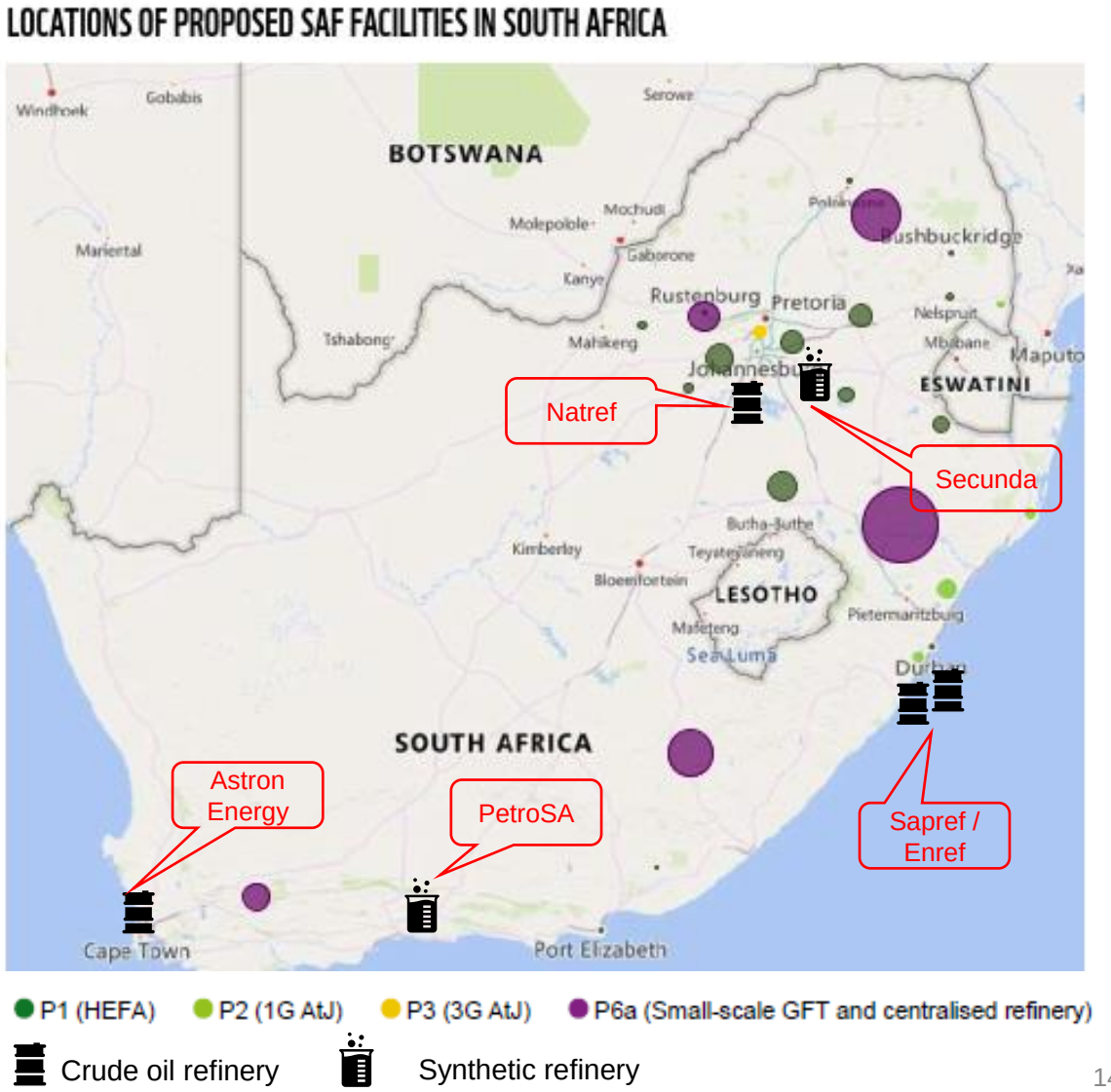


- Facilities in the north-east can supply OR Tambo
  - Approx. 65% of total jet consumption in SA

Annual jet fuel consumption in SA was 2.5 billion litres pre-Covid-19 pandemic
SAF meets sustainability requirements of the Roundtable on Sustainable Biomaterials (RSB)

Making use of existing refineries

- Utilising brownfield facilities can reduce SAF production costs.
- **Secunda**: lignocellulosic biomass (invasive alien plants)
- **Natref**: lipid-based feedstocks
- **Sanref** and **Enref** : sugarcane-based ethanol
- **PetroSA**: lignocellulose-based ethanol, syngas from lignocelluloses

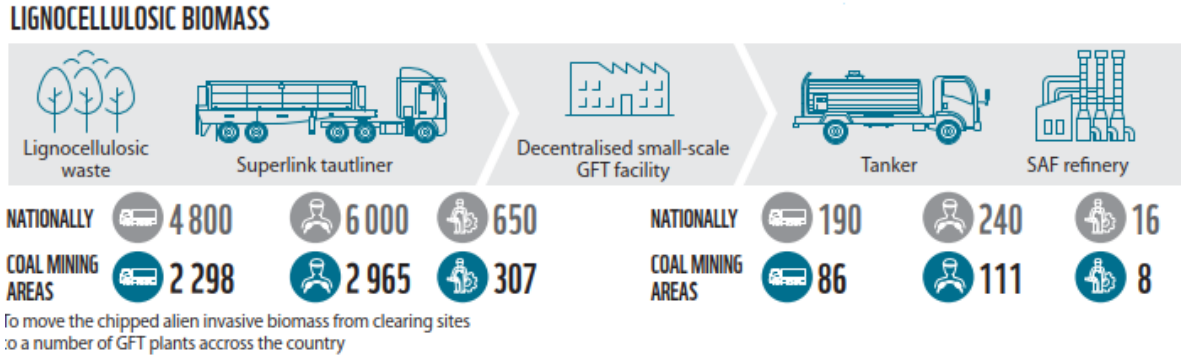


Socio-economic impacts of a domestic SAF industry

IF AS MUCH AS POSSIBLE OF THE CONSTRUCTION MATERIALS AND EQUIPMENT IS MANUFACTURED IN SOUTH AFRICA, THE CONSTRUCTION PHASE ALONE COULD CREATE ALMOST 40 000 DIRECT JOBS

GROWING SOLARIS IS LABOUR INTENSIVE AND COULD RESULT IN THE CREATION OF OVER 19 700 PERMANENT AGRICULTURE JOBS

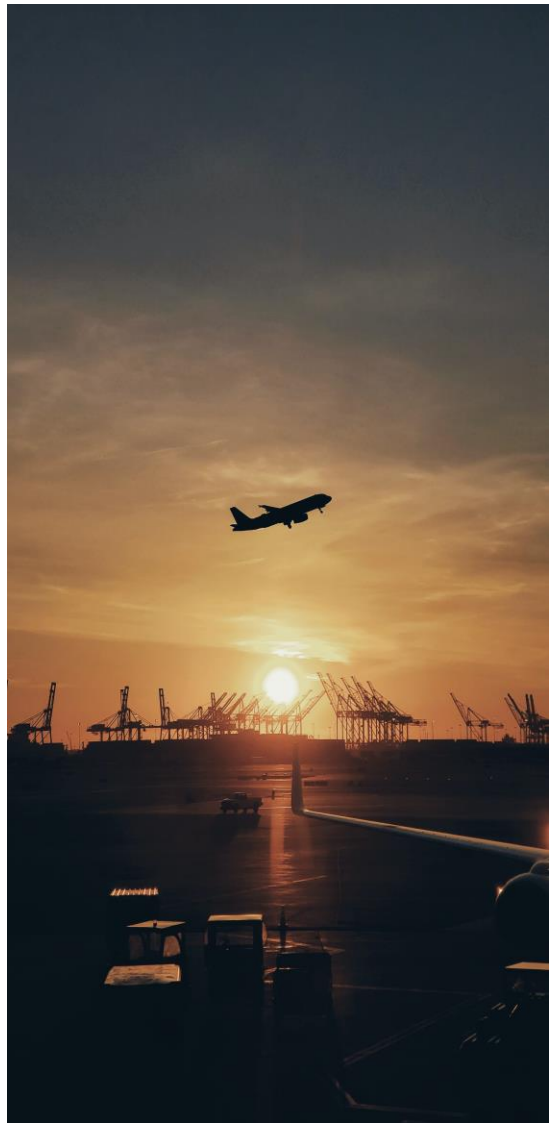
A DOMESTIC SAF SECTOR HAS THE POTENTIAL TO CREATE 90 000+ GREEN JOBS* IN SOUTH AFRICA



*Direct Jobs

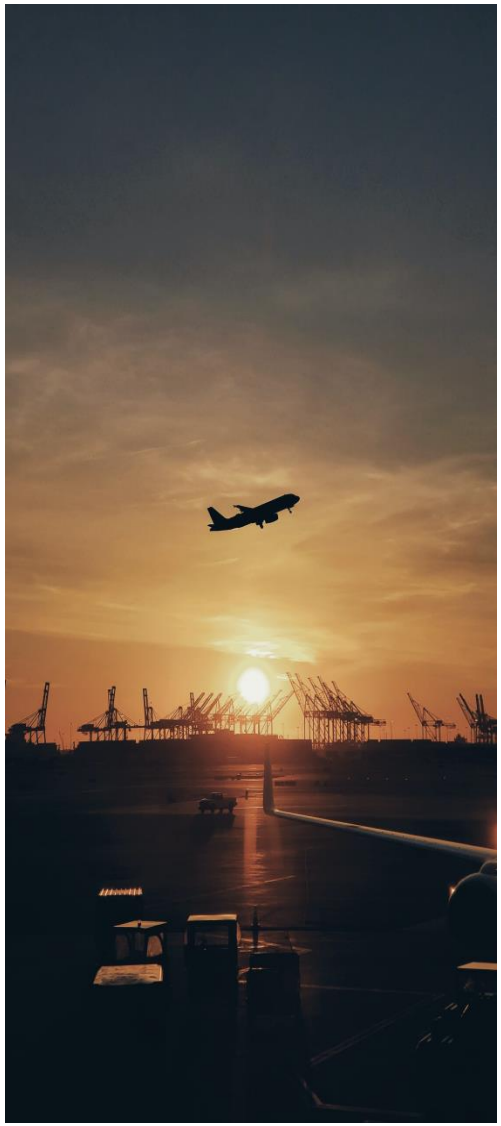
Key takeaways

- A domestic SAF industry could be a pillar of South Africa (SA)'s low-carbon economy, playing a key role in the just transition process by creating over **90 000** green jobs.
- Feedstock production could provide employment to **7 500** truck drivers, **20 000** farm workers and possibly even bigger numbers of IAP harvesters and preserve at-risk jobs in sugarcane production.
- SAF industry can catalyse growth of South Africa's **green hydrogen economy**.
- Immediate technical potential: **3,2 – 4,5 billion** litres of SAF annually.
  - Export potential: **2–3,3 billion litres**.
- SAF export can improve SA's trade balance by **5.4 – 11.4 billion USD** per annum.



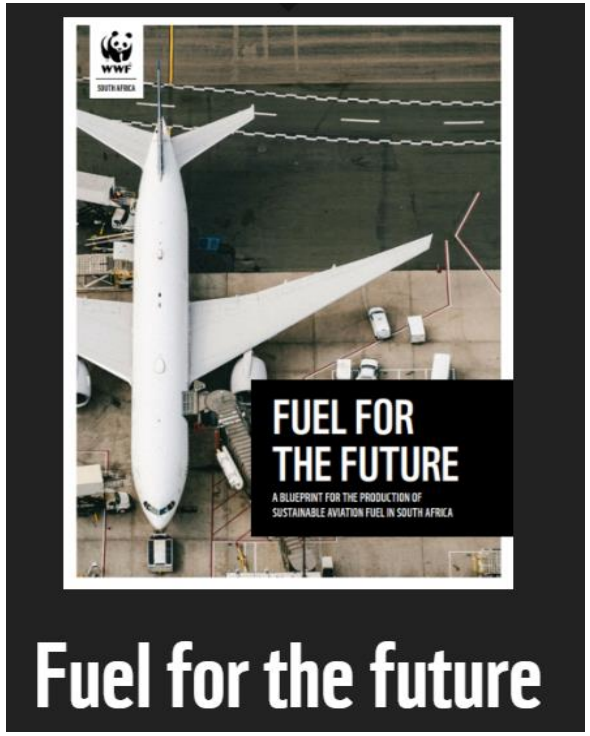
Recommendations to facilitate SAF development in SA

- **Policy certainty** key to develop a SAF industry in South Africa. Development of a **roadmap** for SAF production in the country is a critical step towards this.
  - Need for various stakeholders (e.g., Government departments, feedstock producers, fuel producers, airlines, airports, civil society, tourism bodies) to work together.
- Some of the assessed pathways already cost competitive with international SAF prices; several more could become competitive with relatively minor **policy support**.
  - Farmer support mechanisms to lower feedstock costs.
  - Implement measures to lower cost of capital e.g., subsidies, concessional finance.
- Ensure strict **sustainability principles** are incorporated to ensure environmental benefits are realised.
- **Demonstrate** feasibility of complex invasive alien plant-to-SAF supply chains.
  - Link existing alien clearing activities to SAF value chains.
- Make use of **existing refinery infrastructure** for SAF production.
- Grow bio-economy **alongside** green H2/PtX economy.
  - Synergies between the two can lead to reduced product costs.



Relevant Publications

For more information on SAF visit: https://www.wwf.org.za/our_work/initiatives/sustainable_aviation_fuel/



https://www.wwf.org.za/our_research/publications/?39122/fuel-for-the-future

https://www.wwf.org.za/our_research/publications/?26941/taking-off-understanding-the-sustainable-aviation-biofuel-potential-in-sub-saharan-africa

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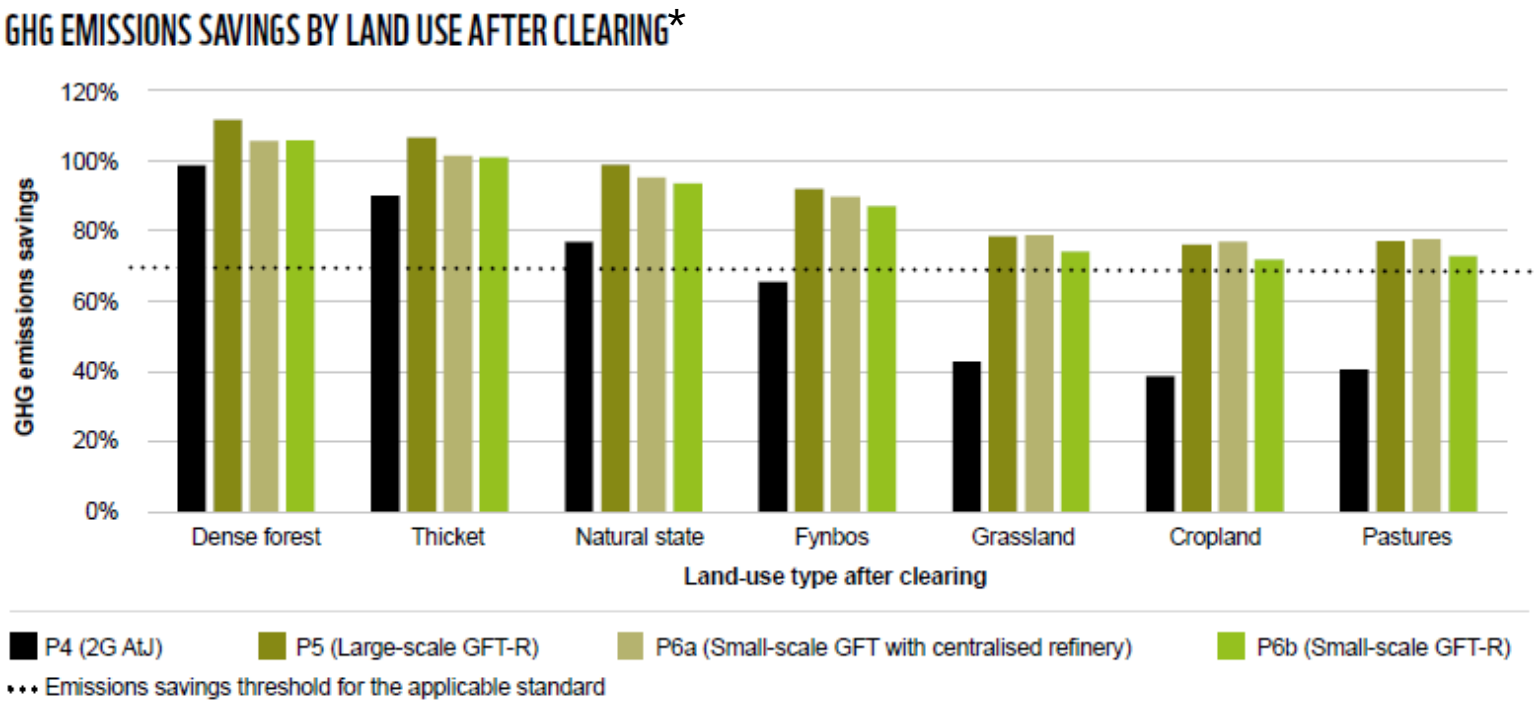
EXTRA SLIDES / ADDITIONAL INFO

GHG analysis

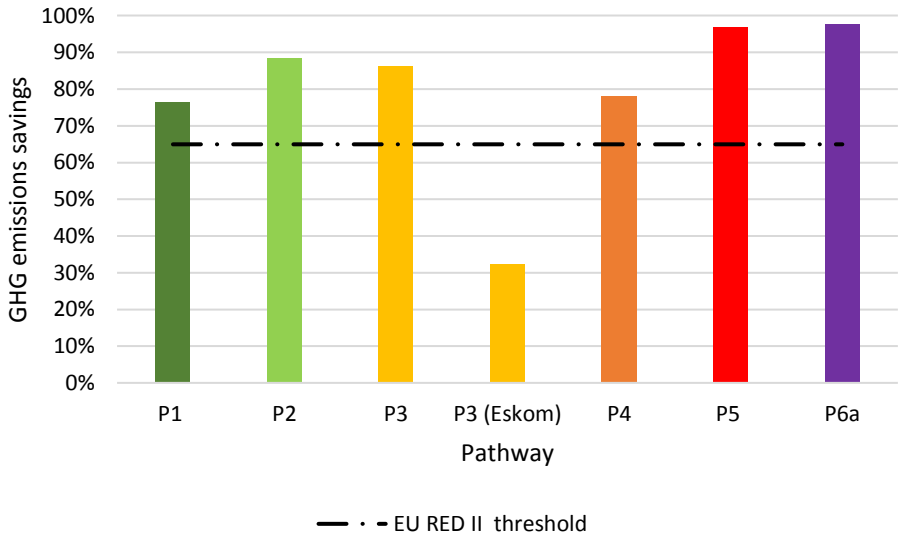


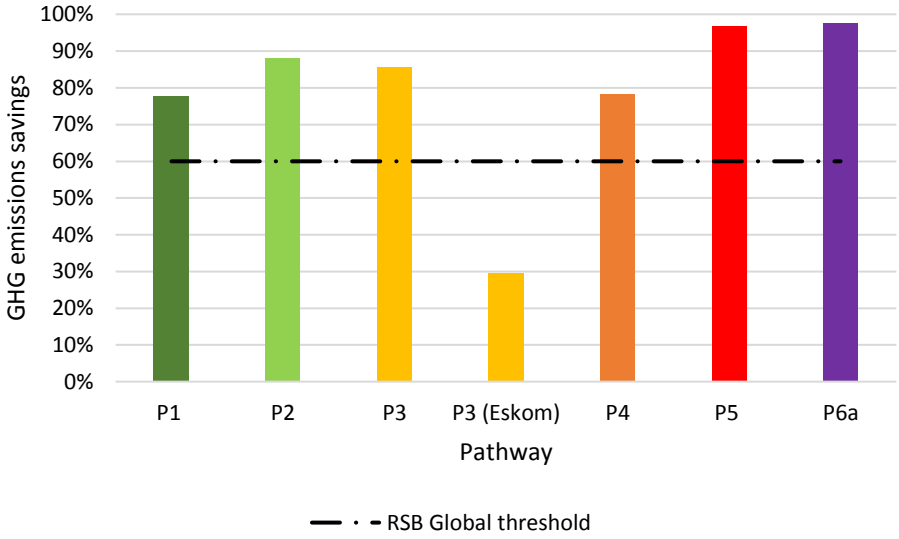
Overall GHG emissions savings by land-use type after clearing, for the EU RED II standard

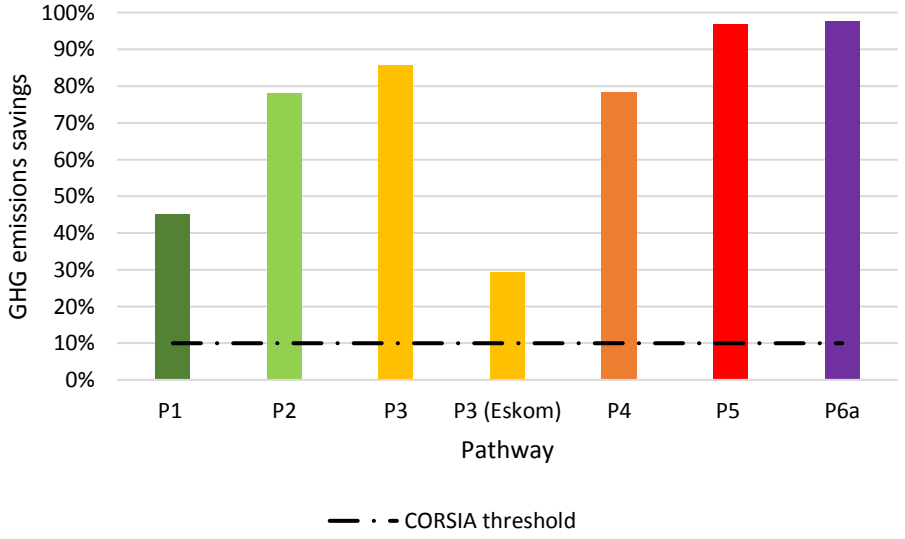
To maximise GHG savings from IAPs, clearing should be followed by rehabilitation of indigenous vegetation to restock carbon in the landscape

*Evaluated for a specific site in the Eastern Cape

GHG analysis - LCA





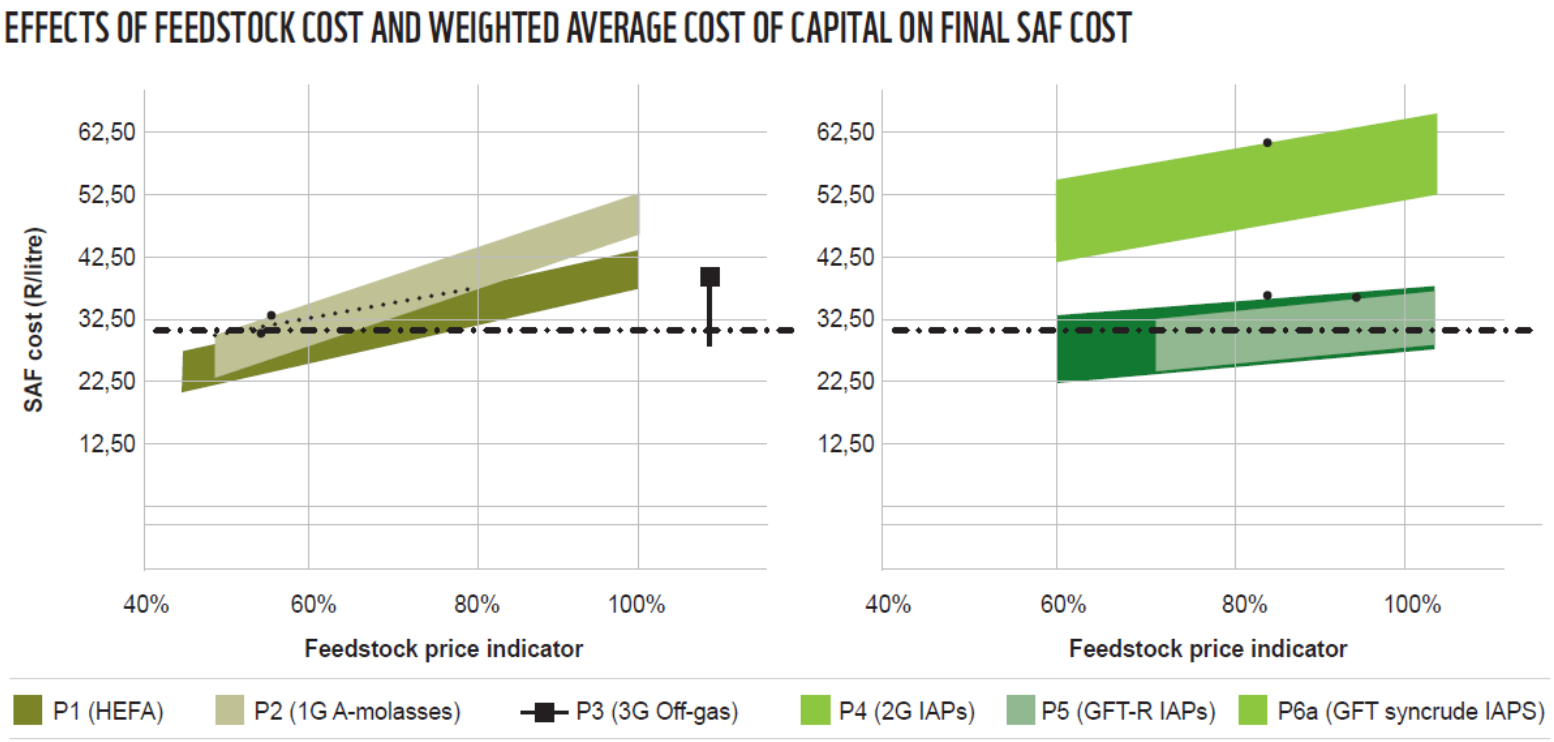


Most pathways achieved at least a 70% emissions reduction compared to conventional fossil-based jet-fuel

P1 (HEFA) achieves a 45% GHG saving if land use change is considered (CORSIA)

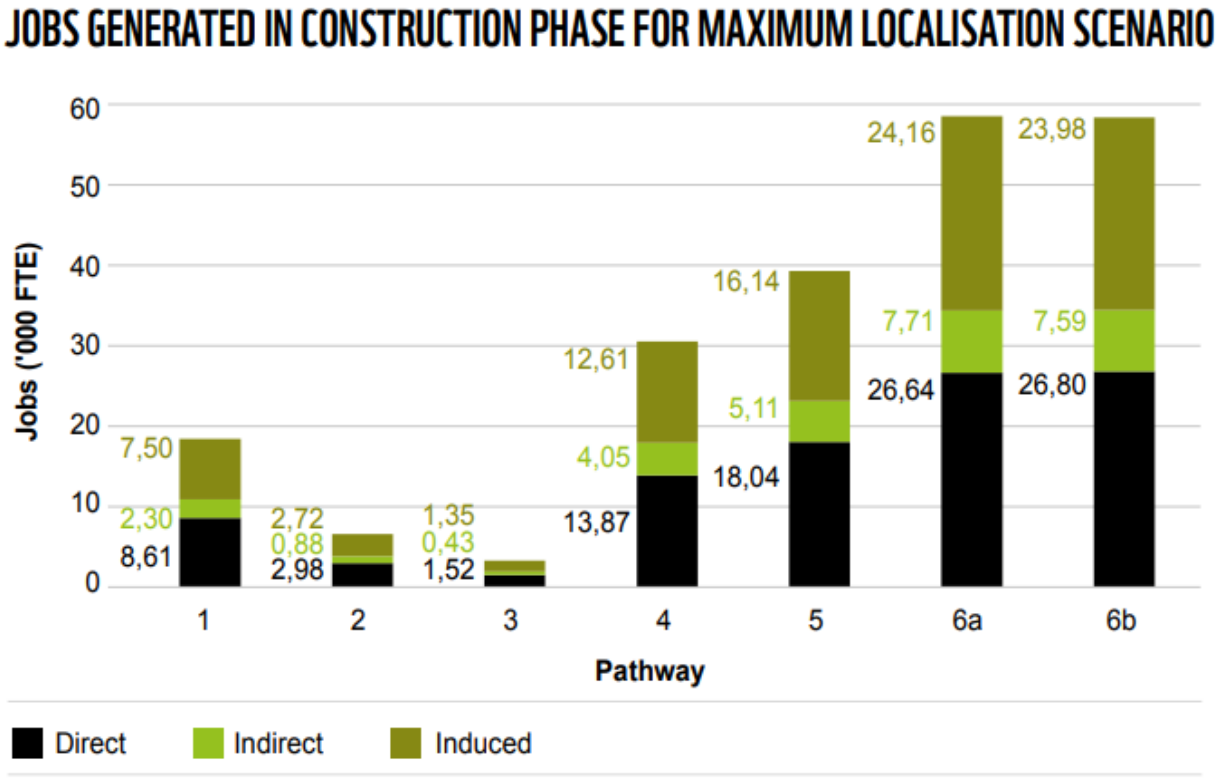
P3 (3G AtJ) achieves a 29% GHG saving when Eskom grid electricity is used

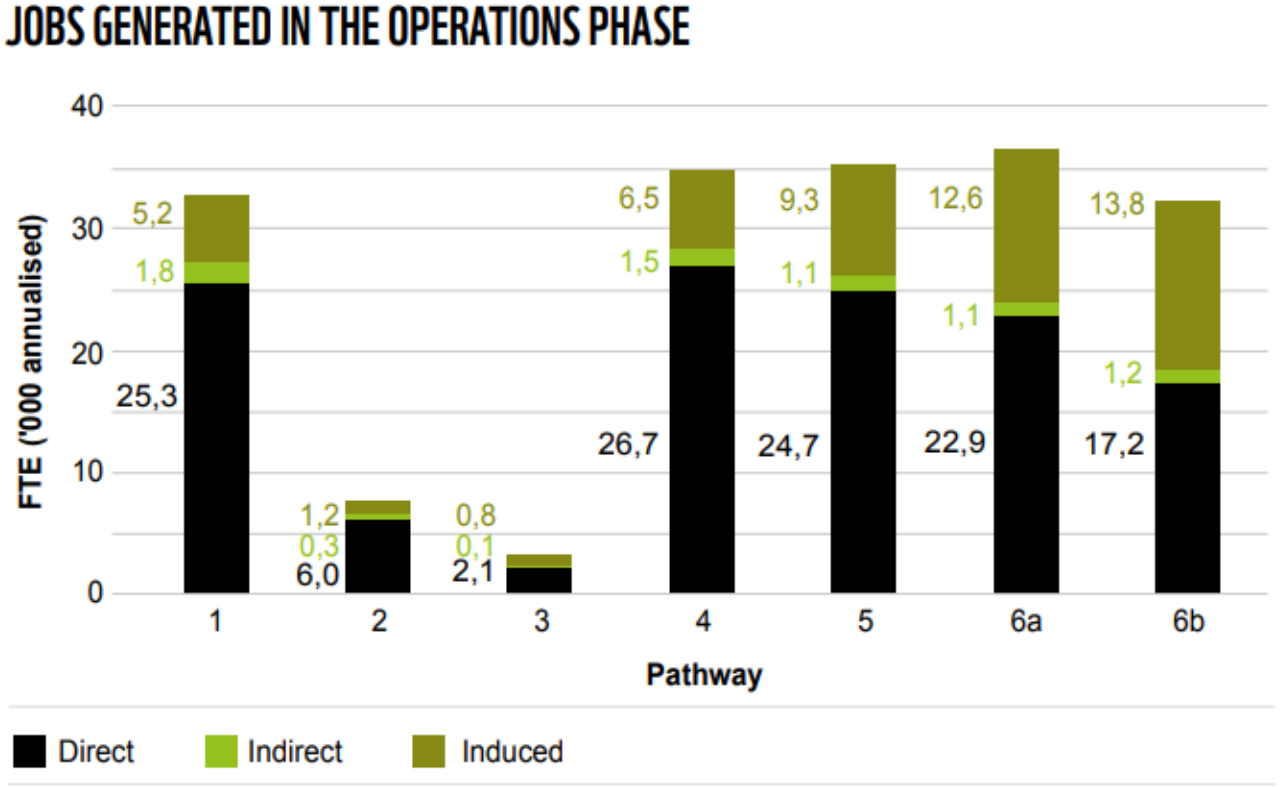
Sensitivity analysis



- Breadth of the band shows lower and upper WACC considered (10% and 20%)
- Slope of band shows effect of normalised feedstock prices
- Marked points show reference values considered in pathway analysis
- Effect of feedstock price variation most significant for P1 & P2
- Effect of WACC most prominent for P3, P4, P5 & P6a
- Premiums for green co-products can also be considered to lower SAF costs

Socio-economic impacts of a domestic SAF industry





THE MAJORITY OF DIRECT JOBS IN THE OPERATIONS PHASE ARE IN FEEDSTOCK SOURCING AND MOSTLY LOCATED IN RURAL AREAS

Transport employment opportunities of a domestic SAF industry

OVERVIEW OF BIOMASS-TO-SAF SUPPLY CHAINS ANALYSED FOR POSSIBLE JOB TRANSFERS

Primary transport | Secondary transport

Raw feedstock | Truck type | Intermediate processing facility | Truck type | Final processing facility

SOLARIS TABACCO

Solaris seeds → Superlink tautliner → Oil extraction → Tanker → SAF refinery

NATIONALLY	649	837	100	NATIONALLY	133	172	25
COAL MINING AREAS	427	551	68	COAL MINING AREAS	87	112	16

To move the Solaris seeds from the fields to the extraction facility.

A-MOLASSES

A-molasses → Sugar mill with integrated ethanol facility → Tanker → SAF refinery

NATIONALLY	100	130	16	COAL MINING AREAS	37	48	6

Only the secondary leg is considered here since the supply chain for the primary leg (plantation to sugar mill) already exists

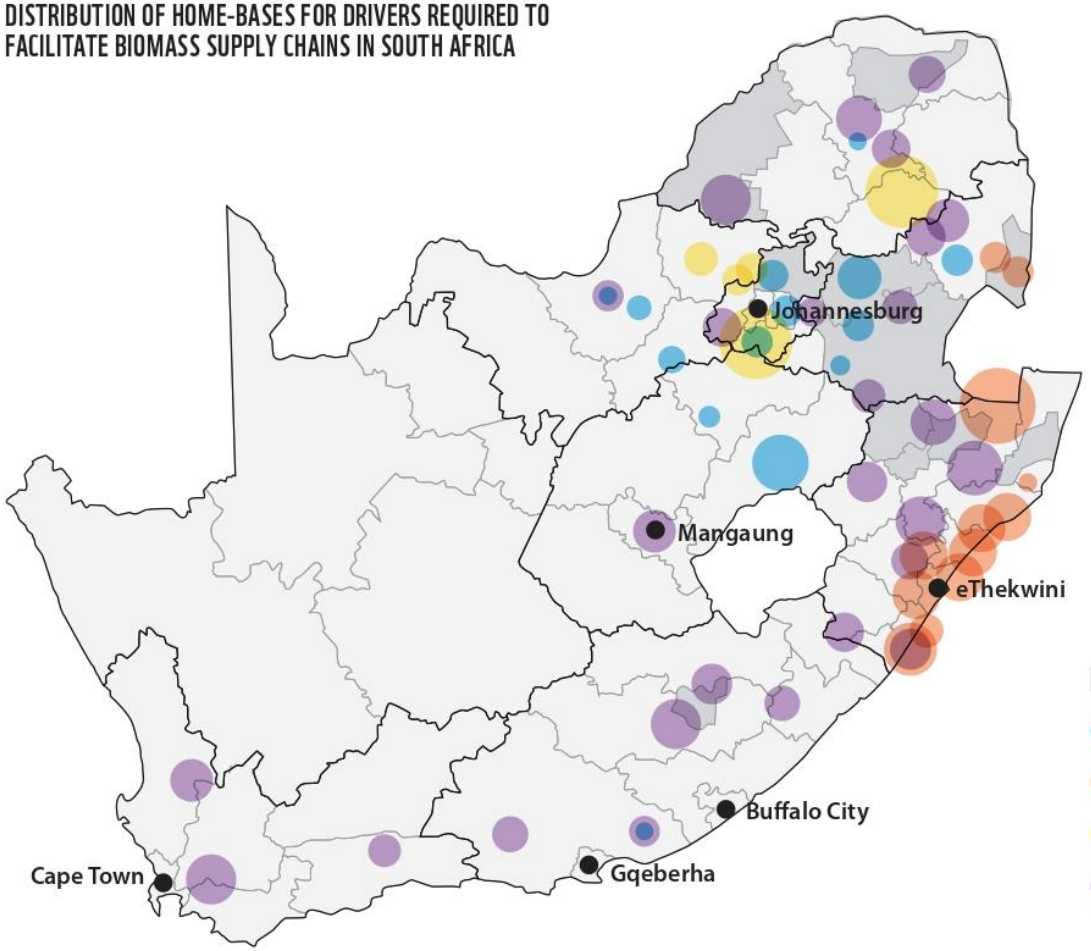
LIGNOCELLULOSIC BIOMASS

Lignocellulosic waste → Superlink tautliner → Decentralised small-scale GFT facility → Tanker → SAF refinery

NATIONALLY	4 800	6 000	650	NATIONALLY	190	240	16
COAL MINING AREAS	2 298	2 965	307	COAL MINING AREAS	86	111	8

To move the chipped alien invasive biomass from clearing sites to a number of GFT plants accross the country

DISTRIBUTION OF HOME-BASES FOR DRIVERS REQUIRED TO FACILITATE BIOMASS SUPPLY CHAINS IN SOUTH AFRICA



APPROXIMATELY <u>7500</u> TRUCKING JOBS NATIONALLY

Transport employment opportunities of a domestic SAF industry

Almost 75% of the current coal hauling jobs **(~ 3500 jobs)** could be directly transitioned to biomass transport because of overlap in coal and biomass supply chains and usage of the same truck types.