TIPS FORUM 2022

TOWARDS A JUST TRANSITION
THE ROLE OF INDUSTRIAL POLICY

AN ANALYSIS OF THE SECUNDA COAL-TO-LIQUIDS FACILITY IN THE CONTEXT OF SOUTH AFRICA'S ENERGY TRANSITION

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Rationale and Preview

The path to a net zero future requires the transition away from fossil-derived liquid fuels, and associated industry products. South Africa has a globally unique interconnected crude oil refining, synthetic fossil fuel and petrochemical industry in South Africa. To plan for a transition, an understanding of the value chains and enabling policies, subsidisation and industry structures is necessary. There is thus a need for a consolidated synthesised overview of the South African fuels industry and its socioeconomic and environmental impacts, which also maps out the interconnected sectors likely to be impacted by a 'liquid fossil fuel transition'.

It is crucial to develop an in-depth understanding of the impacts of existing policy and regulations in the fuels industry (to assist with the context of a potential transition in the future). However, this first requires an unpacking of the local processes of liquid fossil fuel provision, more particularly the production of synthetic fuel from coal and its climate and environmental impacts and why Sasol is important to the South African economy.

In order to frame the liquid fuels industry 'status-quo' in the context of South Africa's climate ambition, an overview of Sasol in the chemical and oil industry will be presented. Fuel pricing, historic subsidisation, the regulatory landscape and economic impacts of the oil industry will also be discussed, and lastly the climate and environmental impacts of producing synthetic fuel and chemicals from coal will be reviewed. This paper aims to provide a case overview of Sasol (Secunda operations), a key contributor to the liquid fuel and chemicals industry in South Africa, and a major industrial greenhouse gas emitter.

In the context of South Africa's carbon emissions targets and the Paris Agreement, to achieve greater step changes in greenhouse gas mitigation does not simply entail shutting down carbon intensive industries. There are risks to both government and industry from minimal to non-transformation, and these should be analysed. A transition to a low-carbon economy requires a series of framework scenarios under which a 'best-case' mitigation action plan can be developed. In this setting, possible avenues for transformation in the liquid fuel sector necessitate greater detail into the interconnectedness of Sasol and the South African economy.

We argue that this transition is not a matter for government and industry to resolve alone. Labour must be and is part of such discussions. Additionally, a host of civil society and boundary organisations may add valuable perspectives to a green re-industrialisation compact - to replace the problematic legacy of a coal-based industrial complex built by the Apartheid State to counter sanctions with reduced dependence on imported oil and, at least in part, fuel its military ambitions.

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Climate Transparency

Abbreviations

AECI	African Explosives and Chemicals Industries
bbl	barrel
BFP	Basic Fuel Price
CAIA	Chemical & Allied Industries' Association
CO	Carbon monoxide
CO_2	Carbon dioxide
CH_4	Methane
CIT	Corporate Income tax
CTL	Coal to Liquid
DJP	Durban Johannesburg Pipeline
F-T	Fischer Tropsch
GHG	Greenhouse gas
H_2	Hydrogen
H_2S	Hydrogen sulphide
IDC	Industrial Development Corporation
mm	million
MMP	Multi Product Pipeline
PIC	Public Investment Corporation
PIT	Personal Income Tax
RAF	Road Accident Fund
SAA	South African Airways
SAF	Sustainable Aviation Fuel
SAPIA	South African Petroleum Industry Association
VAT	Value Added Tax

1. The South African Liquid Fuels Landscape

The South African liquid fuels industry is made up of the production of fuel from coal, gas, crude oil and the import and export of final product (Department of Energy, 2016).

Prior to the COVID-19 pandemic, in 2020, demand for petroleum products was approximately 35 billion litres per annum. The domestic market contributed 82% of demand (30 bn litres), with the remainder exported to neighbouring countries. Coal accounted for 21% of feedstock supply for the South African oil industry, and 57% was from crude oil imports. Imported finished petroleum product contributed an additional 22% to meeting South Africa's liquid fuel requirements (SAPIA, 2021).

As discussed later in this report, as the production of coal-derived synthetic liquid fuel from indirect coal liquefaction, and the refining of crude oil are two entirely different processes, the terminology of quoting crude nameplate capacity for synfuel in the South African liquid fuels industry is relatively meaningless or obfuscating. The white oil product (namely diesel, petrol and jet fuel) that can be produced from each facility is a better number to use in regards to the South African liquid fuels landscape. The following table presents the crude oil feedstock capacity of liquid fuel refining facilities in South Africa between 2010 and 2022, as typically stated.

Table 1 Processing nameplate capacities of South African liquid fuels producers (SAPIA, 2019)

Refinery (Location)	Ownership	Type	Capacity (barrels per day)			
			Years 2010 to 2015	Years 2016 to 2019	Years 2020 to 2022	Year 2022
Sapref (Durban)	Shell South Africa Refining (Pty) Ltd (50%) and BP Southern Africa (Pty) Ltd (50%)	Crude	180 000	180 000	180 000	0
Enref (Durban)	Engen Petroleum Ltd	Crude	120 000	135 000	0	0
Astron (previously Chevref) (Cape Town)	Off The Shelf Investments Fifty-Six (RF) (Pty) LTD	Crude	100 000	100 000	0	0
Natref (Sasolburg)	Sasol Oil (Pty) Ltd (63.6%) and Total South Africa (Pty) Ltd (36.4%)	Crude	108 000	108 000	108 000	108 000

Sasol (Secunda)	Sasol Synfuel (Pty) Ltd **	Coal-to-liquids	150 000	150 000	150 000	150 000
PetroSA (Mossel Bay)	The Petroleum Oil and Gas Corporation of SA (Pty) Ltd*	Gas-to-liquids	45 000	45 000	0	0
Total Refining Capacity			703 000	748 000	478 000	288 00

**PetroSA is a subsidiary of the Central Energy Fund (CEF), which is wholly owned by the State and reports to the Department of Energy.*

*** CTL capacity is the production of liquid fuels from coal.*

*Note: * /** These are equivalent crude oil capacities at average yield. 1 barrel = 159.0 l.*

Unique to South Africa, synthetic fuel production from coal is the single major contributor to (scope 1) greenhouse gas emissions in the liquid fuel supply industry. CTL (coal -to -liquids) production process includes the gasification of coal and Fischer-Tropsch processes, this differs from traditional crude refining in that CTL is seven times more energy intensive than conventional crude refining (Majozi & Veldhuizen, 2015). Notably, the two Sasol CTL plants (Sasol Synfuel) in Secunda South Africa encompass the single largest point source emission of CO_2 in the world (IISD, 2020). Sasol Secunda is also the hub of South Africa's chemical industry. The synfuels sector serves as the country's major source of chemicals feedstocks and intermediates (Majozi & Veldhuizen, 2015).

The liquid fuels industry needs to be viewed against the backdrop of the broader political economy of energy in South Africa, which has historically been characterised as the 'minerals-energy complex'. The energy sector heavily relies on coal and this dominance of fossil fuels has been explained through the historical co-evolution of state, business and mining interests (Fine & Rustomjee, 1996; Marquard, 2006; Baker, 2012). The unique politics of energy security and the country's international isolation during apartheid has inherently shaped the South Africa's carbon intensive energy sector, the most coal-dependent in the G20 (Climate Transparency, 2020a). The country's abundant supplies of low-grade coal, enabled the establishment of government initiated and funded synthetic fuel plants in the inland area adjacent to the coal fields. This together with South Africa's historic reliance on imported crude oil (from the strategic significance that fuel products assume in all countries) and the consequent establishment of refinery capacity at the coast, some considerable distance from the country's inland industrial hub and major market for fuel product, has given rise to a fuel industry characterised by complex locational economics. These, in turn, have given rise to a regulatory system and a logistical infrastructure that respond, in significant part, to these geographic features (Competition Tribunal, 2006).

Liquid fossil fuels currently make up 98% of the final energy consumed by the transport sector in South Africa, where electricity and biofuels make up only 2% of the energy mix in transport (Climate Transparency, 2020b). Legacy fossil fuel industry infrastructure for raw feedstock (crude, gas and coal), liquid fuel products (petrol, diesel and jet fuel, heavy fuel oil and marine fuel oil), wholesale storage, piping infrastructure and retail fuel outlets, inherently exist to provide security of supply of liquid hydrocarbon fuel for the current economy. As the demand for electric vehicles and low carbon transport increases, the decline in local demand for petrol and diesel will govern strategic investment decisions made on aging refining and liquid fuels infrastructure.

2. Background to Sasol / Industry Structure

The Sasol complex in Secunda, 120km South East of Johannesburg, operated by Sasol Synfuels (Pty) Ltd is the world's largest commercial Coal to Liquids (CTL) synthetic fuel facility to date. The Secunda facility converts ~40 Mt of coal per annum into ~150 000 bbl/day of liquid synthetic fuels, or approximately 5- 6 billion litres[1] of white product fuel per annum. Other products include inter alia pipeline gas, pitch, carbon products, solvents, polymers and other chemicals (Mangena, 2012).

Sasol had previously operated Sasol I, in Sasolburg, South Africa, which was also a coal-to-liquids facility. It used Lurgi Fixed Bed Dry Bottom gasifiers, and sub-bituminous coal to feed FT processes for liquid fuel and chemical production. In 2004 however, this facility retired the gasifiers in favour of natural gas autothermal reformers (National Energy Technology Laboratory, n.d.). The Sasolburg facility no longer produces liquid fuel, but a range of petrochemicals attributing to approximately 44% of Sasol's chemical production capacity (by mass) in the country.

Producing synthetic fuels from coal is one solution to meeting the energy needs of a country without solely depending on imported natural gas or crude oil. Coal-to-liquid technology has been in existence since the 1920s and was used extensively in Germany in 1944, producing around 90 percent of the national fuel needs at that time (Crimmins, 2011).The synthetic fuel industry in Germany developed (during time of war) was highly uneconomical, but provided fuel for tanks, trucks and planes (Anastasi, 1980). During the Second World War, the German military produced 90% of their jet fuel, and 50% of their diesel, through CTL. After World War II however the relative costs of oil and coal dictated the shutdown of German plants (Anastasi, 1980). Since then, the technology has been largely abandoned for the relatively cheaper crude oil of the Middle East. A notable exception is South Africa, where CTL conversion provides about 5.3 billion litres of locally produced transportation fuel (Competition Tribunal, 2004; Crimmins, 2011).

South Africa, with abundant low grade coal reserves, has historically been a strategic enabler of coal-to-liquid technology. Facing isolation during the apartheid era, South Africa turned to Fischer-Tropsch synthesis from coal gasification, to supply significant quantities of its hydrocarbon fuel and chemical needs (National Energy Technology Laboratory [NETL], n.d.). Following the 1927 White Paper, outlining processes for the production of oil from coal, pioneering work was done in the early 1930's. In 1935 Anglo Vaal (Anglo Transvaal Investment Company) acquired the rights of the German Fischer Tropsch process in South Africa. An American version of the Fischer-Tropsch process was also acquired by South African interests. Following preliminary coal tests, a complete specification for a suitable plant was drawn up in 1937, however progress on the project was interrupted by the outbreak of World War II in 1939. By 1946 negotiations started with the South African government for an agreement on the fiscal structures within which an oil-from-coal plant could be established. In 1947, the Liquid Fuel and Oil Act was passed and a Liquid Fuel Advisory Board was established with a licence finalised in 1949. Due to the vast capital outlay for the plant, Anglo Vaal approached the government for financial assistance, where a government financed company then proceeded with the venture. In

[1] At an average yield of 70% equivalent to coastal refineries

1950 an ordinary public company, with all shares owned by the Industrial Development Corporation, a government company with its own charter, was formed and incorporated as South African Coal, Oil and Gas Corporation Ltd (Sasol).

The total capital investment for Sasol I (Sasolburg) was $450 million (equivalent to $5.4 billion[2] in 2022), and at the time the only fully integrated commercial synthetic plant in the world (Anastasi, 1980). By 1955, the first synthetic motor fuel was used in South Africa. The oil companies were required to uplift Sasol's entire production according to market share at import parity pricing (Crompton et al., 2006).

Following the introduction of mandatory crude oil sanctions by the United Nations the government decided to further expand the production of synthetic fuels. The decision was taken to establish Sasol II at Secunda. The Iranian revolution two years later led to the accelerated decision for Sasol III, also in Secunda (Rustomjee et al., 2007). Sasol undertook its plant expansion in 1975 to help South Africa move towards greater independence from imported crude oil (Fluor, 2022a). By the early 1980s Sasol completed almost $7billion (equivalent to $18.9 billion[3] in 2022) worth of expansion of Sasol II and III. The three plants produced a total of 112,000 barrels of oil per day, about half of South Africa's needs at that time. Sasol's production costs for synfuel averaged $17 per barrel, below the 1979 OPEC price of more than $20 per barrel and the spot market price of $31 per barrel. South African motorists paid approximately $0.63/litre at the pump (Fluor, 2022b). Despite substantial additional volumes produced, the oil companies were again required to purchase all their production (to supplement their own use volumes) at import parity pricing. This created surplus crude based refined product capacity in the country and the multinational crude oil refiners (and Natref) had to mothball around 30% of their capacity for which they received some compensation in the form of a synlevy (Rustomjee et al., 2007).

When Sasol II and Sasol III were commissioned in the early 1980's, the coal mine was the largest in the world at the time, with production of four mineshaft systems dedicated to the two plants (Fluor, 2022b). Sasol III was a replica of Sasol II converting approximately 50,000 tons per day of low-grade bituminous coal into gasoline, diesel, and jet fuel and other petroleum products, as well as chemical products. Together Sasol II and III convert about 100,000 tons per day of low-grade bituminous coal into a variety of petroleum and chemical products, and cover an area of 15.5 million square meters (Fluor, 2022b). As mentioned earlier, Sasol I (~30 000 bbls/day) was eventually converted to a plant producing only chemicals feedstock (Rustomjee et al., 2007).

Today, Secunda Synfuels Operations (Sasol Synfuels (Pty) Ltd) operates the world's largest commercial coal-based synthetic fuels manufacturing facility, producing synthesis gas (syngas) through coal gasification and natural gas reforming (Sasol, 2022a). Sasol Ltd, an integrated energy and chemicals holding company, major shareholders include the South African Government Employees Pension Fund, and the Industrial Development Corporation of South Africa Limited, Investec Asset Management, Allan Gray Investment Council, Prudential Investment Managers and Old Mutual Limited (Sasol, 2021a).

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[2] *The dollar had an average inflation rate of 3.51% per year between 1950 and 2022 (Alioth Finance, n.d.).*

[3] *The dollar had an average inflation rate of 2.71% per year between 1985 and 2022 (Alioth Finance, n.d.).*

Table 2 Sasol Major Shareholders (Sasol, 2021a)

Fund manager	**% of total issued securities**
PIC Equities	13,99
Industrial Development Corporation of South Africa Limited	8,4
Ninety One SA (Pty) Ltd	5,57
Allan Gray Investment Counsel	5,53
Prudential Investment Managers	4,89
Old Mutual Limited	4,01
Black Rock Incorporated	3,29
The Vanguard Group Incorporated	3,17
Sanlam Investment Management	3,04

The South African government, through the IDC and PIC Equities, continues to hold a 22 per cent stake in Sasol, the world's largest producer of liquid fuels from coal (and a leading company in the development of gas-to-liquid technologies) (Caldecott et al., 2016; Sasol, 2021a). Subsequent to Sasol's privatisation, the IDC has remained a shareholder although its shareholding has been reduced from approximately 20% to about 8%. The dividends received by the IDC contribute to the funding that the IDC invests in new projects in fulfilling its development mandate.

Within the South African chemicals industry, including liquid fuel, Sasol is a large industrial employer. In 2021, South African Sasol Limited had more than 28 000 employees. The mining sector accounted for the largest portion of the company's employee numbers (around 7,800). The Sasol chemicals Africa sector followed with 7,414 employees, and its fuels sector with 4,688 employees (Galal, 2021).

The following section describes some of the economic impacts derived from the oil industry in South Africa, available employment data and contribution to GDP.

3. South African Oil Industry Economic Impact

The industry encompasses and wide range of public and private sector companies such as: refiners and manufacturers (crude and synthetic), blenders, suppliers, wholesalers, transporters, storage companies, traders, retail marketers and speciality marketing companies.

Figure 1 below shows the various segment contributions in the South African liquid fuels value chain. Note this information excludes any contribution from Sasol Synfuels.

Value chain segment	Head office	Feedstock and imports	Refining and Manufacturing	Distribution and storage	Wholesale	Retail	Total
GDP	R 9.3 bn 5.7%	R 2.5 bn 1.5%	R 63.3 bn 38.9%	R 12.1 bn 7.5%	R 51.6 bn 31.7%	R 23.7 bn 14.6%	R 163 bn 100%
Jobs	21,775 8.8%	4,167 1.7%	64,121 25.9%	27,021 10.9%	32,364 13.1%	98,324 39.7%	247,772 100%
Capital expenditure	R 21.6 bn 23.0%	R 3.3 bn 3.5%	R 32.1 bn 34.2%	R 18.1 bn 19.3%	R 13.9 bn 14.8%	R 5.0 bn 5.3%	R 94 bn 100%

Figure 1 Value Chain Segment Contributions, 2019 (SAPIA, 2021)

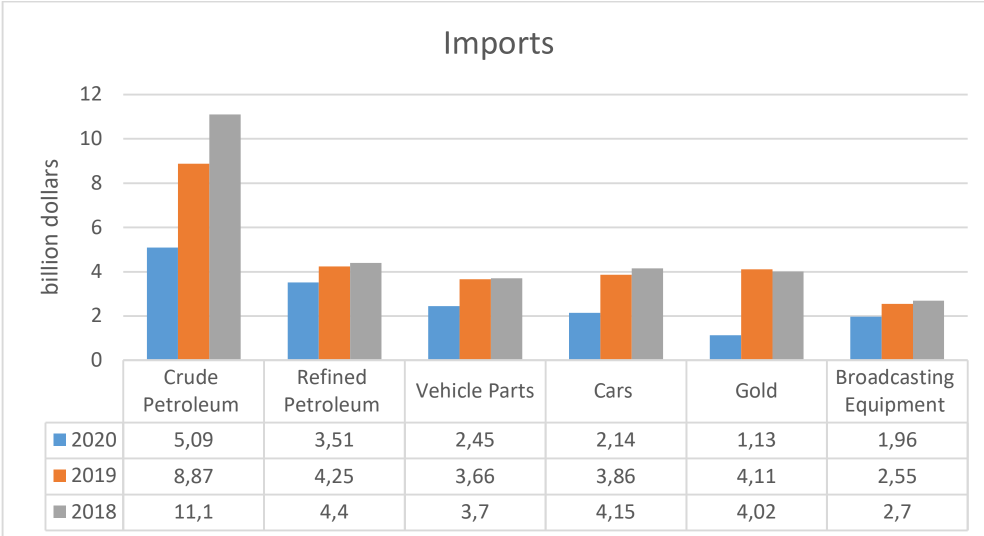
In 2019, the oil industry in South Africa supported 1.5% of country total employment (1.1% directly). SAPIA members directly employed 10,630 people[4] and supported another 160,728 direct jobs at their suppliers. The oil industry indirectly supports a further 76,415 jobs in the economy through second round suppliers (supplier's suppliers). And 139, 465 additional jobs are supported from the induced economic contribution from spending of workers linked to the industry.

Over 78% of oil industry jobs in South Africa are derived from three segments (Retail, Refining and Manufacturing, Wholesale). A higher proportion of jobs are created by forecourt attendants and convenience stores, operating refineries, and wholesalers moving product from the refinery to the market. However, forecourt attendants and employees in convenience stores are employed indirectly, i.e., they are not employees of the oil companies. It is also noted that the continued employment of pump attendants is protected by the Petroleum Products Amendment Act (Rustomjee et al., 2007).

In 2019, the South African oil industry directly contributed 2.7% of the country's GDP (R139 bn), and 0.5% indirectly (R24bn) (SAPIA, 2021). Over 70% of the oil industry's GDP is derived from two segments of the value chain, Refining and Manufacturing, and Wholesale. These segments comprise of six refineries and an extensive wholesaler network of operations. Seven integrated companies (companies operating refining facilities, as well as storage, distribution, wholesale and retail businesses across the country) create 92% of the oil industry's GDP (SAPIA, 2021). However, it is important to note that employment and GDP data is somewhat unclear as not all of South Africa's oil companies, and companies in product distribution, have subscribed to SAPIA membership. For example Sasol Synfuels is not a member of SAPIA (Competition Commission of SA, 2010). A consolidated transparent overview of employment data, and economic data, for the South African oil industry is needed. This may require different actors from government, academia, and private sector to work together to provide cohesive data.

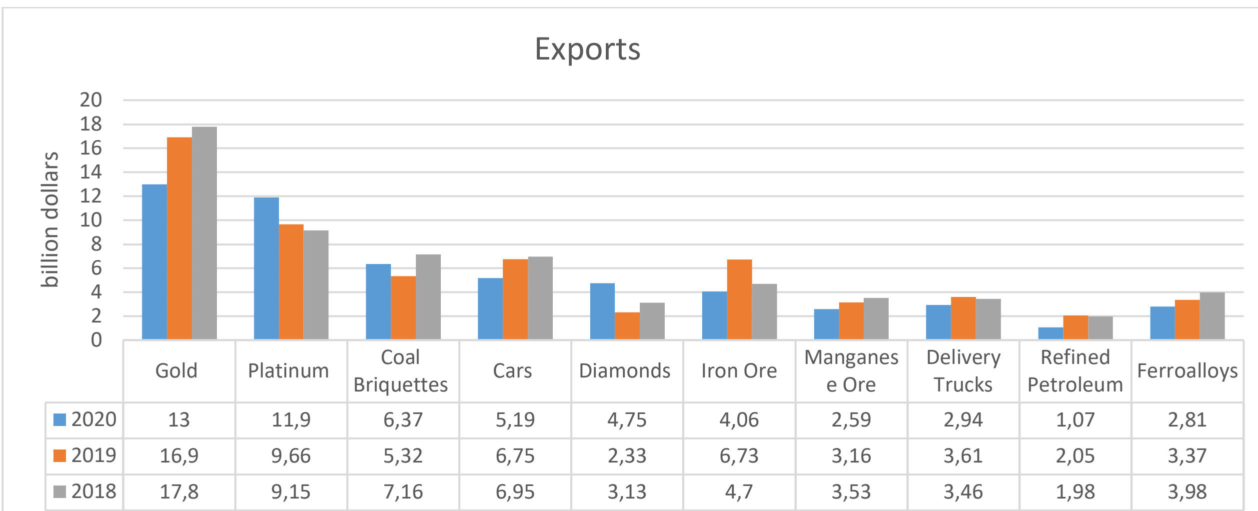
Figure 2 and 3 below show South Africa's top imports and exports by value between 2018 and 2020.

[4] *SAPIA South African Petroleum Industry Association*



	Crude Petroleum	Refined Petroleum	Vehicle Parts	Cars	Gold	Broadcasting Equipment
2020	5,09	3,51	2,45	2,14	1,13	1,96
2019	8,87	4,25	3,66	3,86	4,11	2,55
2018	11,1	4,4	3,7	4,15	4,02	2,7

Figure 2 Top Imports for South Africa between 2018 to 2020(Observatory of Economic Complexity, 2021)



	Gold	Platinum	Coal Briquettes	Cars	Diamonds	Iron Ore	Manganes e Ore	Delivery Trucks	Refined Petroleum	Ferroalloys
2020	13	11,9	6,37	5,19	4,75	4,06	2,59	2,94	1,07	2,81
2019	16,9	9,66	5,32	6,75	2,33	6,73	3,16	3,61	2,05	3,37
2018	17,8	9,15	7,16	6,95	3,13	4,7	3,53	3,46	1,98	3,98

Figure 3 Top exports for South Africa between 2018 to 2020 (Observatory of Economic Complexity, 2021)

From this trade data it is clear that the liquid fuels, transportation/automotive and mining sectors have the largest effect on South African balance of payments, and a significant impact on foreign exchange.

From 2017 data of South African energy flow, about 78% of liquid fuels in South Africa are used for transport, 11% of liquid fuels are exported and the remainder is used by industry, commercial, residential and other (Department of Science and Innovation, 2021; Marquard et al., 2021). The price of fuel therefore has a direct influence on the cost base of the economy (Rustomjee et al., 2007).

To further understand the contributions of the oil industry value chain in South Africa, the next section discusses the fuel price structure, regulatory landscape and government revenue streams.

3.1 Fuel Price Structure and Government Revenue from Liquid Fuel

To get a holistic view of the structure of the liquid fuels industry in South Africa, one needs to understand the pricing mechanism that governs fuel prices. According to Rustomjee et al (2007), South Africa has a unique liquid fuel value chain with a legacy of very complex regulation (that has undergone some reform). This regulatory legacy is also interwoven with an existing complex fiscal regime.

The regulatory mandate/ policy instruments are:

- Energy White Paper on Energy Policy of November 1998
- Petroleum Products Act, 1977 (Act No.120 of 1977);
- Central Energy Fund Act, 1977 (Act No. 38 of 1977);
- Gas Act, 2001 (Act No. 48 of 2001);
- Petroleum Pipelines Act, 2003 (Act No.60 of 2003);
- Gas Regulator Levies Act, 2002 (Act No. 75 of 2002);
- Petroleum Pipelines Levies Act, 2004 (Act No. 28 of 2004);
- National Energy Regulator Act, 2004 (Act No. 40 of 2004); and
- National Energy Act, 2008 (Act No. 34 of 2008)

The price of fuel in South Africa is regulated using the basic fuel price (BFP) mechanism. The BFP is related to the costs of purchasing petroleum products from international markets, and the costs related to shipping these products to South Africa. This cost is therefore largely influenced by the international price of refined products and the R/$ exchange rate, and is based on an import parity principle[5](Department Statistics SA, 2021). All other elements making up the petrol price are local in nature. These include taxes, levies, margins, and storage and distribution costs (Figure 4).

The price for inland 95-octane petrol stood at R20,29 per litre (December 2021). Taxes and levies account for one-third of the total petrol price. According to the Department of Mineral Resources and Energy, the price consists of four broad elements: Basic fuel price: R9,74 (48%), Taxes and levies: R6,67 (33%), Retail and wholesale margins: R2,74 (14%), Storage and distribution costs: R1,14 (6%).

[5] *Import parity pricing principle i.e. what it would cost a South African importer of petrol to buy the petrol from an international refinery, transport the product from that refinery, insure the product against losses at sea and land the product on South African shores.*

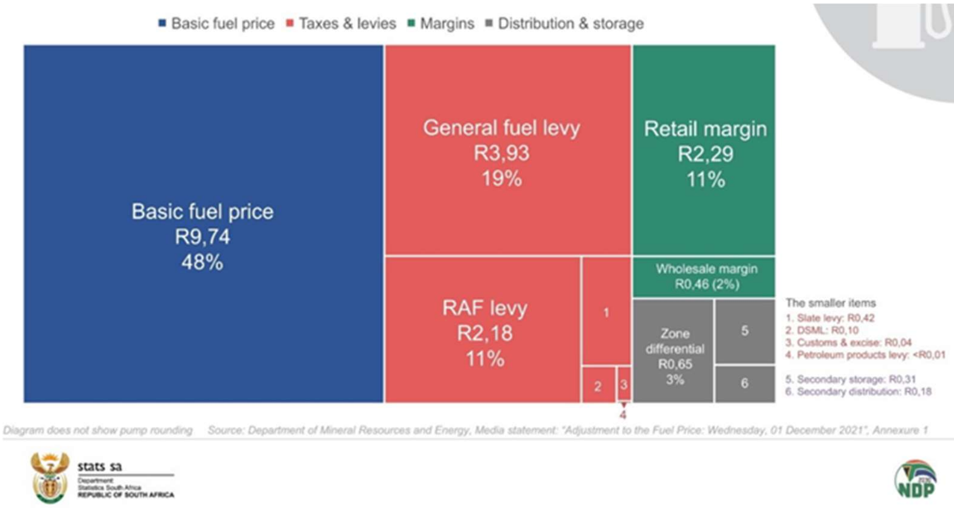


Figure 4 **Breakdown of the per litre price for inland 95-octane petrol, December 2021 (Total R20,29) (Department Statistics SA, 2021).**

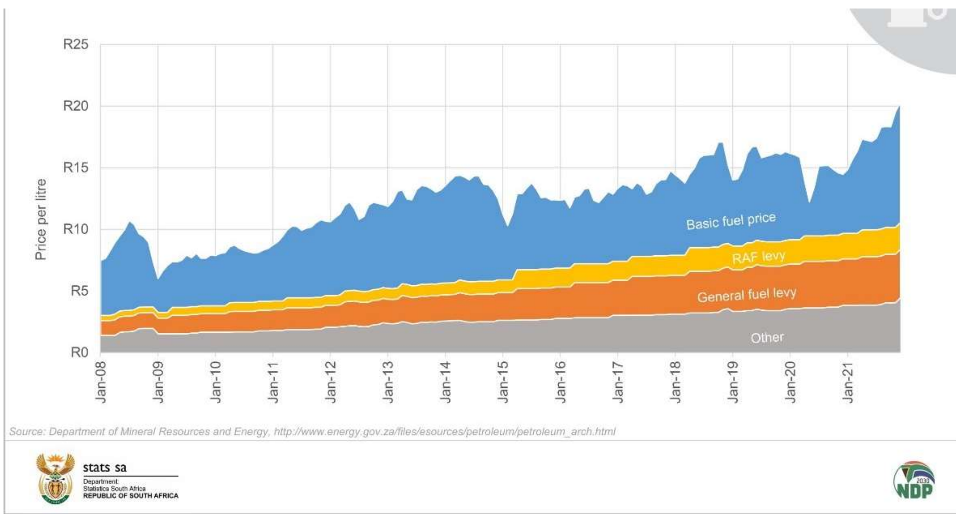


Figure 5 Breakdown of the monthly per litre price of inland 95-octane petrol (Department Statistics SA, 2021).

Figure 5 shows that components of the petrol price have risen over time. The Road Accident Fund (RAF) levy has increased by 425% since January 2008, outpacing the general fuel levy (up 225%) and the basic fuel price (up 119%).

The basic fuel price is set every month by the Department of Mineral Resources and Energy. Changes to the general fuel levy and RAF levy are usually announced once a year during the National Budget Speech. Figure 5 shows the basic fuel price (reflecting international product price and R/$ movements predominantly) fluctuates more than the general fuel levy and RAF levy.

In 2019 Finance Minister Tito Mboweni was quoted in stating that there might be significant increases in the fuel levy in order to look at the Road Accident Fund and liability, which was expected to nearly double in the following three years (SABC News, 2019). As of December 2021, The RAF levy was R2.18 per litre of petrol (11% of price of inland 95 octane petrol). In the 2019/20 fiscal year, the levy generated R41.2 billion for the RAF. According to the RAF's annual report, 93% of the income from the levy was used to pay claims. In 2019/20 the general levy generated R80 billion for the government, accounting for approximately 6% of total tax revenue. By no means the largest source of revenue for the government, but it brings in more money than either customs duties or alcohol and tobacco excise duties.

Money from the general fuel levy flows into the National Revenue Fund together with revenue from all other taxes. There is a portion of the general fuel levy that is specifically set aside and transferred to South Africa's eight metropolitan municipalities. In 2019/20, this amounted to R13.2 billion.

The bulk of the government tax revenue collected comes from Personal Income Tax (PIT), Corporate Income Tax (CIT), Value Added Tax (VAT), Fuel Levies and Customs Duties. The top four tax revenue sources for the South African government have not changed for a period of about 20 years, from 1999/2000 to 2022/2023 (South African Market Insights, 2020). Tax revenue data is presented in Table 3 below.

Table 3 Top four tax revenue sources for South African government (South African Market Insights, 2020)

	1999/2000		2022/2023	
Personal income tax	R 85.88 bn	(42.7 %)	R 621.6 bn	(38.6%)
Value-added tax	R 48.38 bn	(24.0 %)	R 405.6 bn	(25.2%)
Corporate income tax	R 20.97 bn	(10.4 %)	R 258.4 bn	(16.1%)
Fuel levies	R 14.29 bn	(7.10 %)	R 94.17 bn	(5.85%)

In 2019 SAPIA (South African Petroleum Industry Association) members generated and collected R121.3 billion in tax income for the government. There are three components of this tax generated and collected 1) Fuel Levy (R 75.4 billion) which is paid by consumers at point of purchase and passed to the government 2) Direct taxes (R 14.8 billion) paid by SAPIA members as company tax paid on profit, and 3) Indirect taxes (R 31.1 billion), which includes levies during the production process, customs and excise on imported inputs, VAT and other levies included in the fuel price. For the 2019/20 tax year, 9% of total government tax income was from the oil industry (SAPIA, 2021).

The liquid fuel price structure in South Africa is based on crude oil and crude oil derived petroleum products. And although 27% of feedstock for domestic liquid fuel demand (in 2019) was from coal, the basic fuel price does not consider South Africa's fundamentally different fuel production processes, with its associated environmental and climate impacts.

4. Sasol and Subsidies

Sasol's world-leading position in coal-to-liquids has been based on subsidies – both historic and current (Utilities Middle East, 2021). Technological lock-in resulting from subsidies received in the past, and continued subsidisation, continues to support Sasol. Carbon intensive processes, remaining from technologically locked in assets, continue to be utilised to produce liquid fuels and chemicals inland. Subsidies to Sasol arose from energy security concerns, heightened by trade embargoes imposed on South Africa during apartheid and to help insulate consumers from international oil price shocks (Lott, 2017).

The pricing mechanism, as previously explained is known as the Basic Fuel Price (BFP) and is based on an import parity price (which takes account of customs, freight and insurance costs). It is paid by consumers to producers or importers of petroleum and synthetic fuels (Pant, Mostafa & Bridle, 2020) and is based on international refined product prices.

Sasol's production cost is largely independent of international refined product prices even though the synthetic fuel manufacturer sells into this administered market at prices determined without reference to their production costs (Rustomjee et al., 2007).

Sasol estimates that the breakeven cost of producing synfuels from coal is approximately $35/barrel (Sasol, 2019). However, the data behind these figures are not publicly available and therefore cannot be critically reviewed (Pant, Mostafa & Bridle, 2020).

A study by Rustomjee et al (2007) considers possible reforms to the fiscal regime applicable to windfall profits in South Africa's liquid fuel sector, with particular reference to the synthetic fuel industry. It concludes, when oil prices are high, there is a structural propensity for synthetic fuel producers to continue to benefit from excessive economic rents, largely arising from: (a) the differing cost structures between fuels produced from crude oil and fuels produced from the synthetic fuel processes and (b) the import parity basis (BPF) on which fuel prices are set.

It can be argued that although the pricing mechanism generates windfall profits for Sasol in times of high oil prices, it has also led to massive losses in times of low oil prices (Pant, Mostafa & Bridle, 2020). However, precedents suggest that this leads to increased government subsidies for Sasol (Rustomjee et al., 2007). Although South Africa altered its fuel pricing regime in 2003 to more accurately reflect an import parity price, it is well documented[6] that this price remains above a competitive price and confers a benefit to liquid fuel producers through market price transfers(Competition Tribunal, 2006:148 ; Crompton et al., 2006). Sasol's own lobbying efforts are also important; the Competition Commission, for example, has noted Sasol's opposition to pricing reform (Burton, Lott & Rennkamp, 2018). In 2017, Sasol made it clear that new investments in coal- and gas-to-liquids projects were unappealing on both economic and environmental grounds due to volatile commodity markets, low returns and unacceptably high carbon emissions (Financial Times, 2017).

Subsidisation of fossil fuels in South Africa is discussed in a number of publications (Rustomjee et al., 2007; Burton, Lott & Rennkamp, 2018; Brindle & Geddes, 2019) but further transparency and clarity into the interconnected factors which exist to prop up fossil fuel industries in South Africa is still essential.

There is a difference between the production costs of coal and crude oil-based fuels, however transparent data into the production costs of liquid fuel producers is largely absent, in part due to competition regulations. Further work is needed to validate Sasol's production cost, which would shed further light on the extent to which coal-based fuels may be mispriced in South Africa (Brindle & Geddes, 2019).

The following section discusses the coal to liquids (CTL) production process used by Sasol at its Secunda site, where chemicals and synthetic liquid fuel are produced.

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[6] *BJM Report on Sasol (Jan 2002) quotes from Sasol Synfuels Division: "SSF commented that its cash cost is currently less than $10 per barrel of crude equivalent. Its objective is to attain $7 per barrel over the next five years".*

5. Sasol Coal-To-Liquid Process

Sasol uses proprietary technology to convert syngas into synthetic fuel components, pipeline gas and chemical feedstock for the downstream production of solvents, polymers, comonomers and other chemicals (Sasol, 2022b). Sasol utilises indirect liquefaction of coal (gasification and Fischer Tropsch) to produce this range of chemical products and synfuels at its Secunda based operation.

The Fischer Tropsch process uses hydrogen (H_2) and carbon monoxide (CO) to make different types of hydrocarbons with various H_2:CO ratios. In a CTL facility the H_2 and CO can be supplied from the coal gasifier (Bowen, Irwin & Canchi, 2007).

Sasol (Secunda) converts coal to liquids in two steps: the first step in the production of synthetic oil, is gasification of coal (1) the coal is gasified[7] with oxygen and steam under high pressure to yield a mixture of gases (mainly hydrogen, carbon monoxide and methane). Lurgi gasifiers using steam and oxygen, are able to process low grade, high ash coal available to Sasol. The synthesis gas is then fed to gas purification scrubbed with methanol to remove (chemical by-products) sulfur, carbon dioxide, tars, oil, phenols, ammonia, cyanide and other unwanted components. After being cleaned of impurities (2) the purified synthesis gas mixture is sent to the Water Gas Shift reactor where the H_2:CO ratio is adjusted to 2:1 (which is critical for the Fischer Tropsch system) by the production of H_2 and CO_2. This is where the bulk of the concentrated CO_2 stream is generated. Once the CO_2 has been removed, the syngas stream is passed over an iron-based catalyst in Fischer-Tropsch synthesis, combining hydrogen and carbon monoxide, to produce a range of hydrocarbons including motor fuels. The yield of products obtained can be altered by changing process operating variables (Anastasi, 1980).

From a CO_2 emissions perspective, it is this carbon monoxide to hydrogen ratio needed for Fischer Tropsch reactors that inherently governs the excess carbon dioxide emitted. The 'Water Gas Shift' reaction converts excess carbon monoxide to carbon dioxide, and in doing so increases the quantity of hydrogen needed for the CO:H_2 ratio (since coal has more carbon than hydrogen). Steam reforming can be used when natural gas is used as a feedstock for the production of syngas. Methane is converted to CO and H_2.

The gas purification step used is the Rectisol process and it separates out carbon dioxide from the feedstream to the Fischer Tropsch reactors(National Energy Technology Laboratory, n.d.). It is this concentrated stream of CO_2 removed by the Rectisol process, that is emitted to the atmosphere giving rise to the largest single point source of CO_2 in the world[8].

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[7] *Gasification: decomposition of coal under high pressure (and temperature) with oxygen and steam, to produce what Sasol calls its raw synthesis gas.*

[8] *In addition to carbon dioxide emitted from combustion for process heat requirements.*

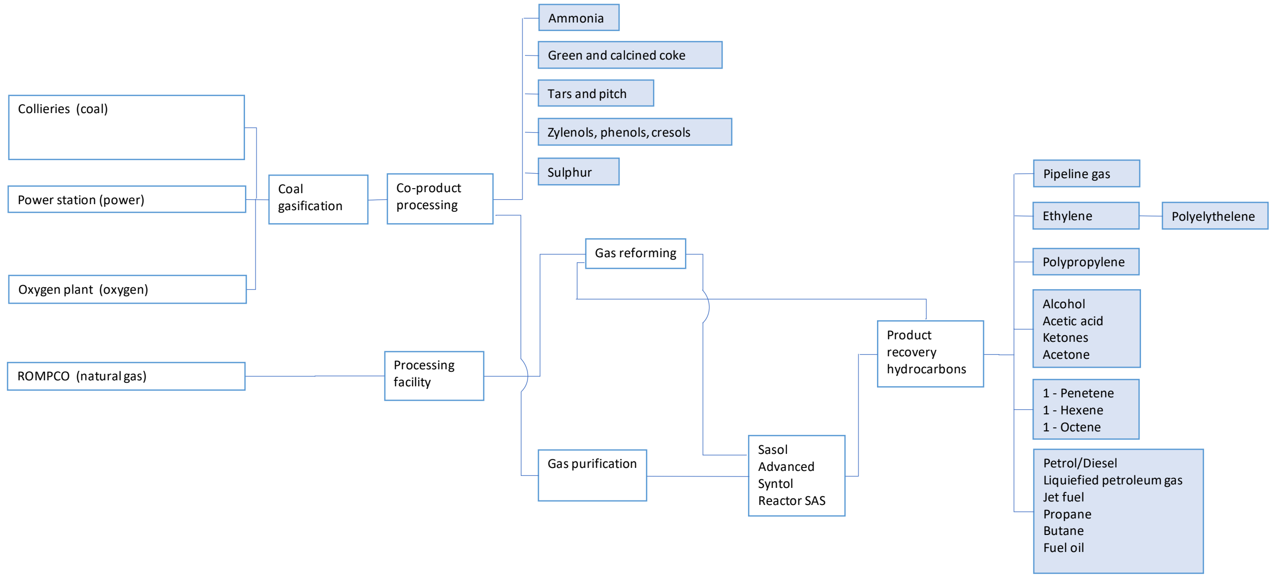

Figure 6 Overview of Sasol's processes in Secunda (National Energy Technology Laboratory, n.d.)

6. Sasol Contribution to Liquid Fuels and Chemicals in South Africa

6.1 Synfuel Relative to Chemicals Industry and Coal Usage in South Africa

South Africa is the world's sixth largest consumer of coal as well as the sixth largest exporter of coal. South Africa's coal consumption is dominated by the power sector, and in 2017 the South African synthetic fuel industry (Sasol Secunda CTL) consumed 23% of all coal consumed in the country.

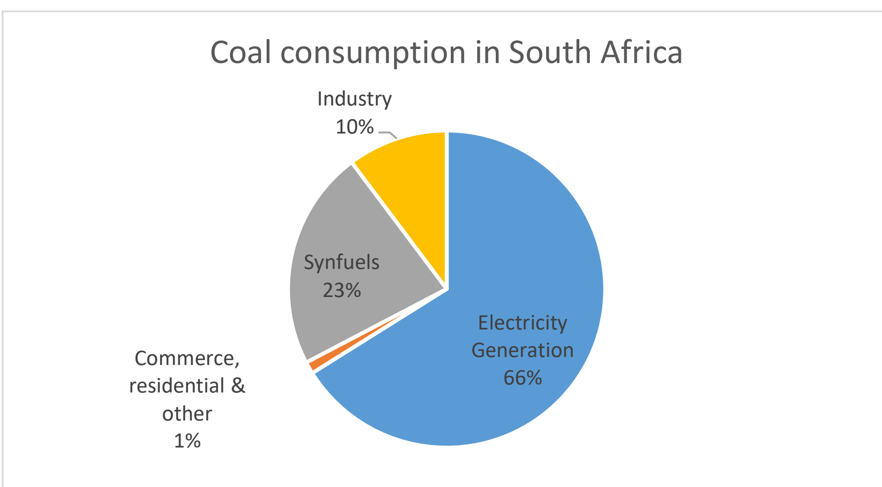

Figure 7 South African coal consumption in 2017 divided into parts (Department of Science and Innovation, 2021; Marquard et al., 2021)

The Sasol Secunda site consists of two CTL plants with a combined capacity of 5- 6 billion litres of white oil product and "more than 40 million tons of coal per year" is consumed (Höök & Kjell, 2010).

The synfuels sector serves as a source of liquid fuel, and is also the country's major source of chemical feedstocks and intermediates (Majozi & Veldhuizen, 2015). Sasol Synfuels produces most of South Africa's chemical building blocks, including ethylene, propylene, ammonia, phenolics and solvents (Competition Tribunal, 2004). Sasol is highly globalised, vertically integrated and diverse. It is South Africa's second largest industrial corporation (Galal, 2021). In 2014 it ranked as the 37th largest chemicals manufacturer globally by chemicals revenue ($10.3 billion) (Tullo, 2015). In comparison, South Africa's second largest chemicals manufacturer, AECI has total turnover of approximately only 7% of Sasol's chemicals revenue (R10 billion) (Barnes & White, 2017).

According to the Chemical and Allied Industries' Association, the upstream chemical sector is dominated by Sasol, AECI and Omnia (Tyrer, 2009). The upstream sector is highly concentrated, capital intensive and internationally competitive, with an export surplus existing for many upstream chemical products[9]. In contrast, the downstream sector is generally not very competitive, is more labour intensive and is undertaken by a large number of small companies (Tyrer, 2009). The chemicals sector has significant impacts on other sectors important to the South African economy including the automotive, textiles, plastics and agro-processing sectors (Department of Trade and Industry, n.d.).

The Department of Labour and Department of Trade and Industry include liquid fuels in the 'Chemicals' Sector. In 2017 the chemical sector (excluding plastics), contributed 2.92% to national GDP, 21.4% to manufacturing GDP and employed 105 690 people(Department of Trade Industry and Competition, n.d.). The liquid fuels sub-sector remains the largest contributor to the chemicals sector's output, followed by basic chemicals and then pharmaceuticals (Barnes & White, 2017).

South Africa comprises around 0.5% of global chemical production capacity with petrochemicals comprising about 55% of all chemicals produced locally. South Africa is home to Africa's most advanced and largest chemicals sector. The sector is diversified and highly mature, spanning fuel and plastics fabrication to pharmaceuticals and supplies a wide range of industries (InvestSA, 2022).

South Africa has a weak balance of payments position within the chemical sector. This is because the exports are predominantly low unit value commodity chemicals whereas imports are higher value fine and speciality chemicals. The deterioration of the country's chemicals trade balance is also due to annual growth in local chemicals sales substantially outpacing local production, leading to the need for increasing imports (Barnes & White, 2017).

A comprehensive list of chemicals produced at the Sasol Secunda and Sasolburg sites, and their use, is presented in the Appendix. The capacity of chemical production from each facility is also presented.

6.2 Synfuel Relative to Domestic Liquid Fuel Demand and Supply

The demand and supply dynamics of the liquid fuel industry are important to understand, both inland[10] and at the coast. South Africa has three conventional crude oil refineries situated at the coast, and one that is situated inland. Two coastal refineries, Enref and Sapref have closed, leaving Astron

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[9] eg. propylene polymers, acyclic hydrocarbons, reaction and catalytic products (Observatory of Economic Complexity, 2021)

[10] The inland region of South Africa includes the provinces of Gauteng, North West, Limpopo, Free State and Northern Cape.

(offline for refurbishment) as the remaining coastal refinery in the country (Enerdata, 2022; Parker, 2022). Sasol Synfuel in Secunda and Natref in Sasolburg are two refining facilities located inland and supply 100% of their output to meet inland fuel needs, including those of Gauteng Province, the country's biggest contributor to GDP (Davie, 2020). Based inland, these facilities have more efficient logistical capacity to convey refined product to inland clients than the coastal facilities, a critical component of coastal refiners' operational requirements (Competition Tribunal, 2006). Sasol benefits from its inland locational advantage being paid the full cost of transport from the coast to market through the BFP price whereas product is transported only from Secunda or Natref to market (Rustomjee et al., 2007).

To serve the inland fuel market and export to neighbouring regions, the Transnet MMP (Multi-Product Pipeline) replaced the 45-year-old DJP (Durban-Johannesburg Pipeline) in 2015. It enables increased capacity to transport liquid fuel from Durban to Gauteng, and supplements the inland liquid fuel market after off-take supply from Sasol Oil (TRANSNET, n.d.). Conveyance of liquid fuel by road and rail (fuel tankers and rail wagons) are other options to distribute liquid fuel from coastal refineries inland, however a higher cost of distribution is incurred.

While currently meeting only 23% of the country's petrol and diesel needs (when all domestic refining facilities are operational) Sasol Secunda's emissions-intensive coal-to-liquids conversion process accounts for 7.7% of national emissions (Department of Environmental Affairs, 2013).

Table 4 below presents the local available refining and white oil supply capacity in 2019, with all domestic facilities operational.

Table 4 Estimate of white oil production capabilities of South African liquid fuels producers in 2019

		Crude Equivalent Nameplate Capacity		White Oil Product			
Refinery	**Type**	**bbl/d**	**% Utilisation**	**Yield**	**bbl/d**	**billion litre/annum**	**% Total**
Astron	Crude	100 000	80%	70%	56 000	3,2	13,5
Engen	Crude	120 000	80%	70%	67 200	3,9	16,2
Natref	Crude	108 000	90%	90%	87 480	5,1	21,1
Sapref	Crude	180 000	80%	70%	100 800	5,8	24,3
PetroSA	GTL	45 000	30%	70%	9 450	0,5	2,3
Secunda	CTL	150 000	90%	70%	94 500	5,5	22,7
Total		703 000			415 430	24,1	100

With only Natref and Sasol Secunda operational in 2022, the share of the country's domestic production of diesel, petrol and jet fuel (white oil) needs met by Sasol Secunda increase to roughly 52% or 5.5 billion litres/annum.

Table 5 below presents the local available refining and white oil supply capacity in 2022.

Table 5 Estimate of white oil production capabilities of South African liquid fuels producers in 2022

		Crude Equivalent Nameplate Capacity		White Oil Product			
Refinery	**Type**	**bbl/d**	**% Utilisation**	**Yield**	**bbl/d**	**billion litre/annum**	**% Total**
Astron	Crude	-	-	-	-	0,0	0,0
Engen	Crude	-	-	-	-	0,0	0,0
Natref	Crude	108 000	90%	90%	87 480	5,1	48,1
Sapref	Crude	-	-	-	-	0,0	0,0
PetroSA	GTL	-	-	-	-	0,0	0,0
Secunda	CTL	150 000	90%	70%	94 500	5,5	51,9
Total		258 000			181 980	10,6	100

Figure 8 shows the Sasol liquid fuel volumes from Natref (crude refining), Secunda (synfuel refining) and fuel imports (petrol, diesel, jet fuel). It can be seen that Secunda Synfuels operations produces liquid fuel volumes roughly double that of Sasol's share of Natref production.

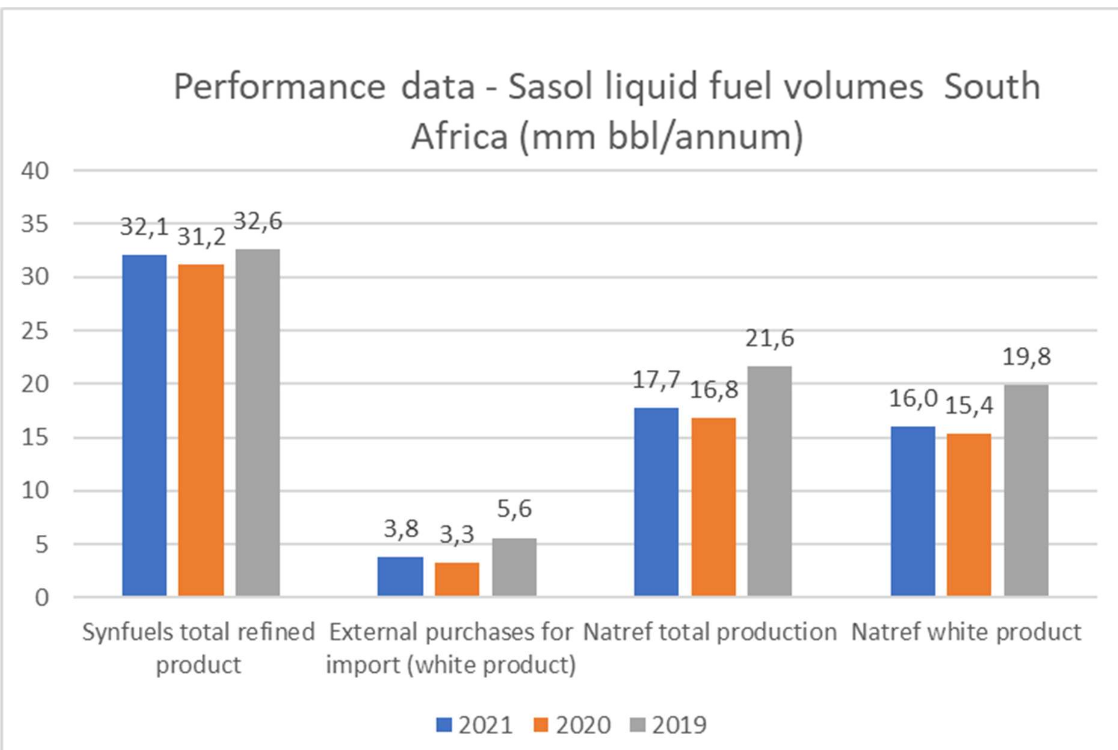

Figure 8 Sasol synfuel liquid fuel production for 2019-2021 (Sasol, 2021d)

According to South African Airways (SAA), approximately 90% of domestic "jet fuel uplift" is at OR Tambo International Airport, amounting to about R10-billion per annum) (Maqutu, 2015). The major supply of jet fuel to OR Tambo is from the Natref inland refinery and Sasol Secunda, as traditional crude-derived jet fuel can be blended with coal-derived synthetic jet fuel (synjet)[11] (A significant volume of jet fuel was railed up from Durban prior to 2022 floods in Kwa-Zulu Natal(Businesstech, 2022; Smith, 2022)). Natref also blends petrol with Sasol Secunda for octane enhancement. Further synergies include no sulphur diesel from Sasol Secunda that is blended with diesel from Natref. Sasol is a majority shareholder of Natref and as a result it has been able to introduce important operational synergies between its synfuels operations and Natref operations (Rustomjee et al., 2007).

All Sasol's liquid fuel business is housed in Sasol Oil (Competition Tribunal, 2004). The Sasol Oil (Pty) Ltd company markets fuels which are refined 1) through its 63,6% share in Natref[12] oil refinery at Sasolburg and 2) its Sasol Synfuel[13] facility at Secunda. Conventional crude oil-derived fuels are blended with coal-derived synthetic fuels. Sasol Oil will also import fuels to balance its product slate and meet contractual commitments when necessary. Sasol Oil also exports fuels into Southern Africa(Sasol, 2010).

Figure 9 illustrates the diesel/petrol/jetfuel and kerosene split of liquid fuel demand for South Africa in 2021, with diesel having the highest demand at 43% and 12.9 billion litres per annum. South Africa's mining industry, which contributes the bulk of the country's export revenues, is a key consumer of diesel.

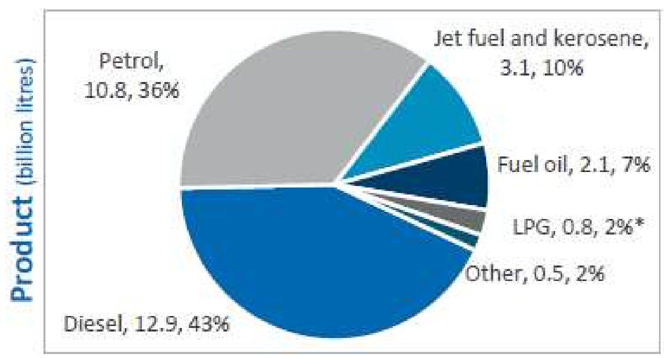

Figure 9 Liquid fuel product demand (billion litres) (SAPIA, 2021)

Figure 10 below presents the liquid fuel demand by sector in the country. 81% of liquid fuels are consumed by transport followed by industrial use at 7% (SAPIA, 2021).

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[11] Strictly speaking, the synthetic refineries do not produce jet fuel. Secunda produces a jet fuel component that needs to be blended 50% with crude oil derived jet fuel (Competition Tribunal, 2006).

[12] Natref in Sasolburg is a deep conversion refinery that is designed to upgrade heavy, sour crude oil with a high sulphur content and yields about 91% white petroleum products. Natref production split is approximately 29 – 32%, petrol, 31 – 37% diesel, 9 – 21% jet fuel and 5 – 8% black products (Sasol, 2021f).

[13] Sasol Synfuel in Secunda is a coal-to-liquid facility with final product (coal derived) made up of 40% petrol-blend components, 20% diesel-blend components and 40% chemical feedstock(Sasol, 2010).

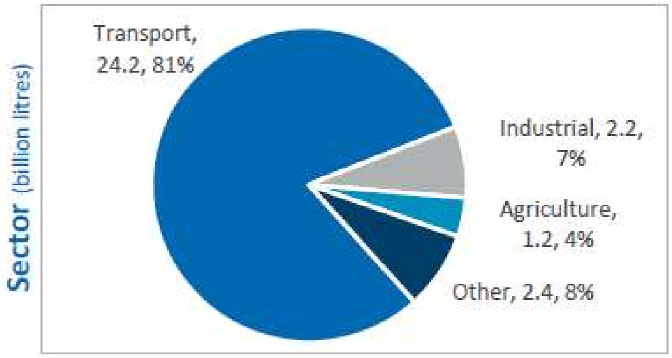

Figure 10 Liquid fuel demand by sector (billion litres) (SAPIA, 2021)

Figure 11 shows more than 60% of the South African liquid fuel demand is spatially concentrated in three provinces, Gauteng, Kwa-Zulu Natal and the Western Cape. Gauteng and Kwa-Zulu Natal have the highest liquid fuel demand at 31% and 20% respectively. Gauteng is the largest liquid fuel consumer at 9.3 billion litres per annum. The liquid fuels industry tends to refer to its demand sectors for fuel in terms of its coastal[14] and inland[15] areas, mainly as a result in which supply to these areas is managed i.e. Inland is supplied from Secunda, Natref and the Transnet pipeline. Coastal areas are supplied by road and coastal shipping from the coastal refineries or import terminals.

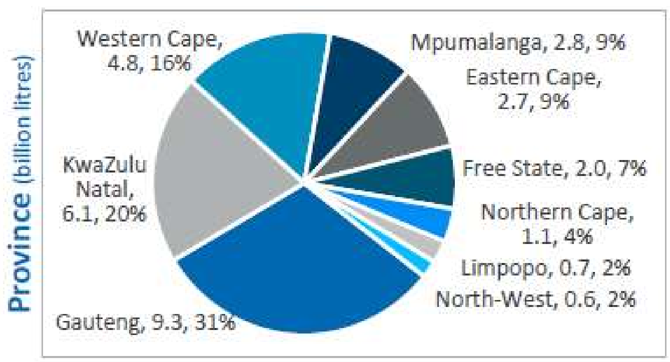

Figure 11 Liquid fuel demand by province (billion litres) (SAPIA, 2021)

7. Sasol Greenhouse Gas Emissions and Environmental Impacts

Sasol's GHG emissions profile is largely associated with operations in South Africa - more than 95% of its emissions. Today, Sasol Secunda operations is the world's largest producer of grey hydrogen from coal-based feedstocks. It is this hydrogen-producing process that is responsible for around half of their GHG emissions (Sasol, 2019). Sasol's Secunda complex, the largest coal-to-liquids plant in the world, is also the largest single-site carbon-dioxide emitter in the world (Bloomberg, 2020). Furthermore, Sasol is the second biggest contributor, behind state-owned electricity utility Eskom, to air pollution problems in Mpumalanga province, South Africa, a region which is amongst the worst in the world

[14] Kwa-Zulu Natal, Western Cape and Eastern Cape

[15] Gauteng, Mpumalanga, Free State, Limpopo, North West and Northern Cape

(News24, 2019). Sasol's greenhouse gas emission profile is dominated by emissions from their CTL based operations in Secunda. These account for approximately 85% of their global Scope 1 and 2 emissions (Sasol, 2019).

Emitting approximately 57 Mt CO2e emissions, using 89 Mt of water, consuming 288 PJ of carbon-intensive energy, and generating 242 kt of hazardous waste, Sasol Secunda has significant environmental externalities that negatively impact the South African ecosystems in general and local communities' health in particular (Sasol, 2019). Indirect coal liquefaction technology (i.e. gasification) generates approximately 80-110% more CO_2 emissions compared to conventional fuels, if the CO_2 is vented[16]. Well-to-wheel analysis has shown that (even with Carbon Capture and Storage) CTL production chain emissions are higher than for crude-derived fuels (Höök & Kjell, 2010). Thus, from an environmental and climate perspective, CTL synfuel production is much less desirable than crude oil refining. Furthermore, supplying close to 22% of South Africa's annual transport fuel in 2021, Sasol's CTL facility is responsible for a much higher carbon footprint in the South African fuel supply chain when compared to Europe, as shown in Table 6 below (Ahjum et al., 2020).

Table 6 Comparison of embedded CO_2eq for diesel and petrol for South Africa and Europe (Ahjum et al., 2020)

Fuel	Region	Well-to-Tank	Well-to-Wheel
		kg CO_2/litre	
Diesel	South Africa	1.5	4.3
	Europe	0.6	3.2
Petrol	South Africa	2.6	5.2
	Europe	0.5	2.9

It is worth noting that shutting down (retiring) the CTL facility in the liquid fuels supply sector has a mitigation impact comparable to the decarbonisation of the entire transport sector (Ahjum et al., 2020). But this would have a disastrous effect on the current supply to the chemicals sector, as the sector has a reliance upon coal for petrochemicals as outlined earlier. The establishment of the Sasol synfuels plants has resulted in the beneficiation of large quantities of low-grade coal reserves. The same facility that produces synfuel from coal, produces the bulk of the basic organic chemicals that are utilised in the downstream chemical and allied industries, as well as a significant proportion of South Africa's chemical exports (Rustomjee et al., 2007).

The following figures (12 and 13) highlight the resource intensity of the chemical and liquid synfuel production process at the Sasol Secunda facility.

[16] *There are system configurations where H_2S+CO_2 co-capture/co-storage can reduce emissions.*

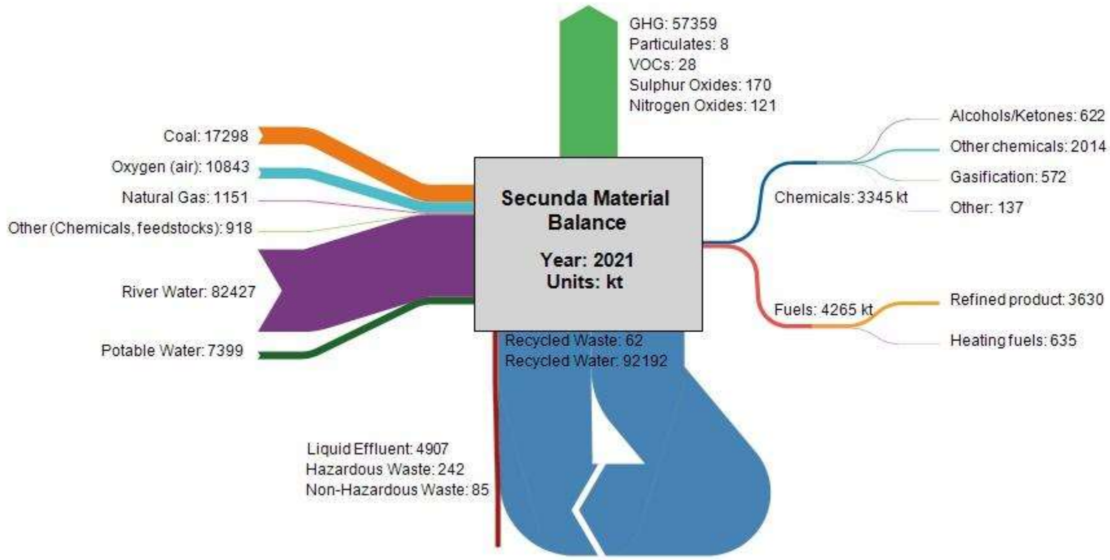

Figure 12 Overview Sasol Secunda chemicals vs fuel production 2021(Sasol, 2021b; Sasol, 2021d)

**Note: Coal feedstock of 17Mt /annum (2021) is reported as dry, ash-free basis in Sasol Sustainability Report 2021(Sasol, 2021c). Total coal consumption (including ash and water) is approximately 40Mt/ annum (Höök & Kjell, 2010). It is also noted that burning 17Mt of coal will not result in 57Mt of CO_2, the data source does not include the mass of coal for 'energy'. Therefore, the data reported at source is incomplete.*

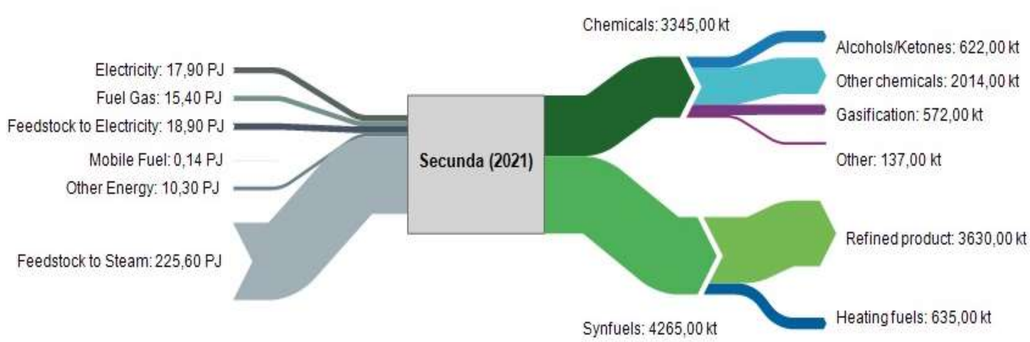

Figure 13 Overview energy use in Sasol Secunda chemicals vs fuel production 2021 (Sasol, 2021b; Sasol, 2021d)

**Note: Feedstock is coal*

As the largest commercial synthetic liquid fuel production facility in the world, Sasol Secunda would be well positioned if it could transition to green synthetic production processes. Its own internal analysis identifies scale cost advantage compared with constructing new greenfield facilities (Sasol, 2021e). Sasol has presented the benefits of green hydrogen and Power-to-X technology in their 2021 Climate Change Report, with Fischer Tropsch technology at the core of Power-to-X (Sasol, 2021e).

South Africa with an endowment of renewable resources, has the potential to create further cost advantages to producing green- hydrogen enabled products (Sasol, 2021e).

The following figure presents a general overview of the technology pathways involved in the green hydrogen and Power-to- X value chain.

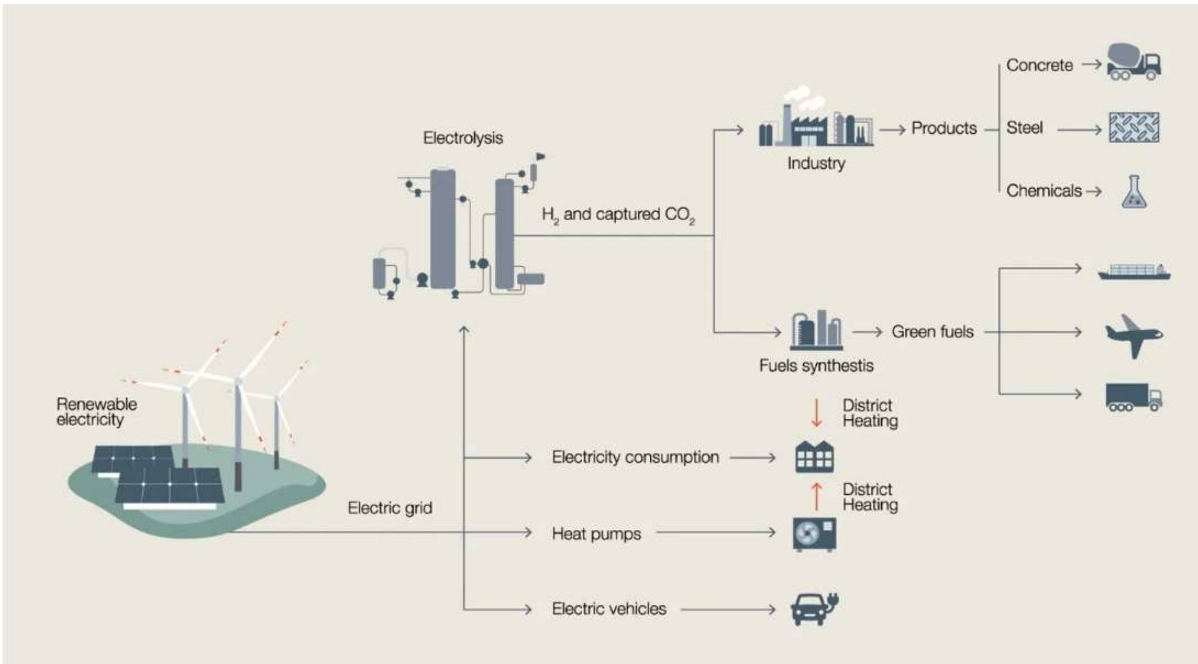

Figure 14 An overview of technology pathways involved in green hydrogen and Power-to-X value chain (Ironside, 2022)

Sasol was the first company worldwide to receive international approval for its 100% synthetic jet fuel produced by its proprietary Coal to Liquids (CTL) process. It was the first fully synthetic fuel to be approved for use in commercial airliners by global aviation fuel specification authorities. Sasol Synfuels wholly synthetic jet fuel was approved for commercial use in all types of turbine aircraft as Jet A-1 fuel. The production in Secunda holds broader implications for the alternative fuel mix as it paves the way for future global production and the use of synthetic fuels for use in transportation (Sasol, 2008). Sustainable aviation fuel is a viable option for future low carbon air transport, and Sasol has already had success in commercialising the world's first internationally approved 100% synthetic jet fuel.

"We see the biggest opportunities for our Energy Business in green hydrogen for road transportation (heavy duty trucking and commercial vehicles), renewable energy, SAF (sustainable aviation fuel) and sustainable chemicals. These opportunities, which are directly tied to our own decarbonisation, will be more aggressively pursued closer to the 2030-time horizon. In the interim, we are advancing proof-of-concept projects through partnerships to stimulate demand, assess viability and accelerate growth"(Sasol, 2021e).

8. Conclusion

In summary, the apartheid regime created Sasol to produce CTL fuels domestically and, thereby, increase the fuel security of South Africa under the regime at the time. This was driven by sanctions against South Africa during the 1970s oil embargo (Mondliwa & Roberts, 2019). Since then, government policies and regulatory mechanisms have cultivated Sasol and CTL fuels in South Africa (Brindle & Geddes, 2019). Various authors have argued the history and structure of the regulatory framework makes continued state support to Sasol highly resistant to change (Marquard, 2006). Large sunk costs and demonstrated financial benefits to Sasol, since its inception, have enabled the continuation of synfuels operations. Approximately $19 billion (in 2022 monetary value) was invested into Sasol II and III (Secunda) in the early 1980's. Although a variety of policy issues such as historical subsidies and supply agreements have been addressed over the years, continued state support largely through the mechanisms of setting the fuel price (based on internationally traded refined product) further enables the carbon lock-in of CTL fuel production.

Although historical subsidies to Sasol have been justified on the grounds of ensuring domestic security of supply (Lott, 2017), the pricing mechanism is unable to insulate South African consumers from oil price shocks. Rather, fuel prices are administratively determined in South Africa, effectively reproducing an import parity price that takes into account international refined product price movements, transport and the Rand/US dollar exchange rate. The fuel price and tax elements apply to liquid fuel (petrol and diesel), derived from imported crude oil, imported refined product and synthetically produced product. Synthetic fuel manufacturers sell into this administered market at prices determined without reference to their production costs (Rustomjee et al., 2007). In addition to its coal-derived production, Sasol benefits from its inland locational advantage being paid the full cost of transport from the coast to market through the BFP price whereas product is transported only from Secunda or Natref to market (Crompton et al., 2006; Rustomjee et al., 2007).

The cost of production of synfuels (and therefore the profitability of the South African synfuels producers) bears no direct relationship to the production costs of the crude oil refiners, yet they are price takers of prices set according to international crude refining economics. This means that they are likely to experience very high profits at times of high refined product prices and profit squeezes at times of lower refined product prices. In the case of Sasol, the production costs of coal, its base input into the Secunda coal to liquids process (CTL), and the operating costs of its CTL process, are key to the calculation of its breakeven costs. The price realised for Sasol Secunda fuel products are external to its cost base (Rustomjee et al., 2007). However, the price of fuel has a direct influence on the cost base of the country's economy.

To summarise and revisit the complexity of Sasol Secunda operations: CTL is an energy-intensive, multi-step process that converts coal to liquid fuels and chemical feedstocks. In a typical CTL process, coal is first gasified to produce synthesis gas, which is subsequently converted to liquid and gas hydrocarbons in a catalytic Fischer Tropsch reaction. The process requires a significant portion of carbon from the feedstock coal to produce hydrogen and generate electricity. Therefore, as long as coal is utilised as a feedstock, the CTL process will remain fundamentally carbon-intensive[17]. Because of production process related limitations, further significant improvements in the Secunda GHG emissions profile will require the introduction of lower or low-carbon energy feedstock (Sasol, 2019).

If the liquid fuel production chain/network is analysed, synfuel produced by CTL technology is

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[17] *The Fischer-Tropsch process requires stochiometric H_2:CO ratio of 2:1. Coal has a high carbon to hydrogen ratio. To give the required H_2:CO ratio requires the production of more hydrogen. With the result that using coal as a feedstock to Fischer-Tropsch requires the rejection of carbon, and this is done in the form of emitting large amounts of CO_2. Switching to natural gas/CH_4 improves the H_2:CO ratio with the concomitant reduction in CO_2.*

inherently worse for the environment and climate than conventional crude oil refined fuel (Höök & Kjell, 2010). The effects of carbon-intensive production technologies extend into scope three emissions for linked value chains/networks in South Africa.

Given that the synthesis technology used is CCU (Carbon Capture and Utilisation) compatible, it is conceivable that the complex can be transitioned into a fossil-fuel free future. But this will require analyses beyond replacing the high energy demand of this process from its current coal-based supply to renewables; the source of carbon itself will have to be reconsidered.

Sasol Secunda produces both synthetic fuel and chemicals from coal feedstock. Their final product is approximately 60% synfuel and 40% chemicals(Sasol, 2010). A further complexity in the case of the production of synthetic fuels is attributing the correct costs to the various fuel and petrochemical feedstock streams that emerge from the reactors, as some of the co-products are produced whether desired or not(Rustomjee et al., 2007). Furthermore, the logistical benefit of producing at the country's inland economic, industrial and mining hub (as opposed to the coast, or import) applies to the chemicals business. The importance of the Sasol Secunda CTL facility to the South African chemicals sector must not be downplayed. Many of the co-products produced are valuable chemical feedstocks. Sasol Secunda supplies a significant amount of base chemicals that are utilised in the downstream chemical and allied industries, as well as a significant proportion of South Africa's chemical exports. With its dominance in the South African chemicals sector, retiring the Sasol Secunda CTL facility means shutting down the chemicals sector to a large extent. The import parity price of imported chemicals (international market price) plus the logistical cost of conveying the product inland will significantly increase the price of chemical final product to the inland industrial, chemical, manufacturing and mining sectors.

9. Next Steps/ Further Research:

The aim of this paper is to give context to the international climate mitigation audience regarding Sasol's contribution in the South African liquid fuel and chemical industry. Further quantitative analyses framing the existing provisions by the liquid fuel, automotive and chemical industries could assist in identifying and defining just transition pathways for decarbonisation. Forward looking strategies for clean energy transition needs to factor in socioeconomic considerations (such as competitiveness, tax revenues, business cycles, infrastructure lock-ins, technology development and implementation, trade dynamics, employment and skills).

Quantifying the scale and extent of support that Sasol enjoys is an important first step towards reform of production subsidies (Rentschler & Bazilian, 2017). The basic fuel price mechanism supports the liquid fuels industry, but consequently also supports the single biggest point source carbon emitter in the world, Sasol Secunda. At the same time the State wants to implement a carbon tax, but the State is also a significant shareholder of Sasol.

There is a need for the basic fuel price to be reviewed, owing to the differing cost structures between fuels produced from crude oil and fuels produced from the synthetic fuel processes. Building on previous work, this review may require the firms concerned to provide commercially confidential information, and it may be appropriate to involve several relevant arms of Government.

The recommended fiscal mechanism presented by the Task Team of a report by Rustomjee et al (2007) include: 1) that National Treasury consider a pure fiscal option of an additional special fuel levy on existing synfuel producer's volumes at a level commensurate with the level of permanent structural increase of oil commodity prices and triggered at an appropriate threshold/trigger price. A study in 1995 recommended an oil price threshold/ trigger price of $28.7/bbl. Rustomjee et al (2007) recommended an equivalent price (adjusted for inflation and exchange rate differences and other relevant factors since the 1995 study) should form the oil price threshold, above which rents accruing would be regarded as excessive. And 2) In addition, to cater for the volatility exhibited by oil prices, the Task Team also recommended that, the concept of a progressive sliding rate of taxation apply, according to a formula linked to the oil price. This specific fiscal response recommendation, to rents/excessive economic profits being generated by existing synfuel producers, is largely within the fiscal jurisdiction of the National Treasury and is implementable in its own right.

Rustomjee et al 2007 also state, "All indications from the material available to us, are that Sasol's synthetic fuels operations as well as the Sasol Group have moved to maturity and are no longer in the need of "incubator" assistance". Careful consideration needs to be given to the long-term prospects of this industry, the design of appropriate fiscal measures and the evolution of the relevant environmental and industrial regulatory arrangements.

The downstream refined product market has gradually shifted from a net export market to net imports. South Africa has a trade deficit in petrol and diesel, accentuated by demand for diesel from Eskom's open cycle gas turbines, and demand from strategic sectors. South Africa is expected to become more dependent on liquid fuel product imports (Businesswire, 2021). As of April 2022, four out of the six South African refining facilities are closed, leaving Natref and Sasol Secunda to meet domestic demand and the balance is imported fuel. Clean Fuel II requirements[18] will require crude oil refiners to upgrade their facilities or import fuel to meet new specifications. Rather than invest in ageing refineries with no cost benefit to the producer, Clean Fuel II requirements could place further weight on the closure of refineries, the logistics of importing liquid fuel and the South African balance of trade. Furthermore, looking towards future technology change (EVs, increased efficiency ICE etc) the tax collected from liquid fossil fuel will decline, which may put pressure on the State to look for alternate revenue streams. Other streams of government revenue should be explored, to balance any future diminishing revenue from fuel levy taxes. The interconnectedness of our liquid fuel and chemical industry prompts further detailed quantitative analysis, where this research should also tie in with interlinkages with the automotive manufacturing industry and South African industrial policy.

With the backdrop of the 'Minerals-Energy Complex', finding an optimal transition pathway to decarbonising liquid fuels, transport and chemical industries is not an easy one. The country's economy was built on the backbone of cheap abundant energy and feedstock – coal. Our overreliance on coal extends, from power production, to coal processing technology in the form of synthetically derived hydrocarbon (fuel and chemical) products. A value 'chain' may better be described as an intricate and interconnected 'web' or 'network', as the linkages are non-linear and complex (Zou & Purdom, 2022). The South African liquid fuel and chemical industrial value network is reinforced with synthetic (carbon intensive) hydrocarbon products which have socioeconomic value for the South African economy, however current production processes are highly carbon intensive. Deep decarbonisation is required in these sectors to align with South Africa's climate ambition (Paris Agreement) and nationally determined greenhouse gas emission contribution targets (NDC's). Repositioning Sasol technology and production towards a net zero future, as it has started to outline

[18] The tightening of fuel specifications by further reducing the levels of sulphur in both petrol and diesel (500 ppm to 10 ppm) as well as the reduction of benzene (5% to 1%) and aromatic (50% to 35%) levels in petrol to levels equivalent to the Euro 5 emissions standard.

in its 2021 Climate Change Report, could be a more beneficial mitigation pathway than simply shutting it down (loss of operating license). Sasol has stepped up its 2030 scope 1 and 2 greenhouse gas (GHG) emission reduction target, from an initial 10% for its South African operations, to 30% for its Energy and Chemicals businesses, off a 2017 baseline. However, the continued subsidisation of the single largest point source greenhouse gas emitter in the world has to be questioned in light of alignment with South African greenhouse gas mitigation goals and commitments.

Recommendations for further quantitative research:

- The collection of transparent and comprehensive employment and economic data for the South African oil (and gas) industry.
- Transition pathways for Sasol, moving to sustainable fuels and feedstock, and what its transition impact would necessitate of other South African economy sectors in the long term and at an accelerated pace.
- An analysis of the socioeconomic value chain of the South African ICE (internal combustion engine) automotive assembly and manufacturing industry, and the drivers, barriers and opportunities for a transition to locally assembled electric vehicles.
- Interlinkages between South African mining and chemicals industry: determining the key chemical requirements in the refining of South African mined minerals and metals (eg. gold and platinum group metals) and its associated economic advantages for export value.

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Appendix

Table I Sasol Secunda liquid fuels production (Sasol, 2021d)

Liquid fuels production (synfuel)	year	2021	2020	2019
Synfuels total refined product	mm bbl	32,1	31,2	32,6
Refined product	kiloton	3 630	3 541	3 699
Heating fuels	kiloton	635	651	665

Table II Sasol Secunda other products from synfuel process (Sasol, 2021d)

Synfuels production process include chemicals	year	2021	2020	2019
Alcohols/ketones	kiloton	622	597	623
Other chemicals	kiloton	2 014	1 887	1 910
Gasification	kiloton	572	571	590
Other	kiloton	137	126	132
Total	kiloton	3345	3181	3255

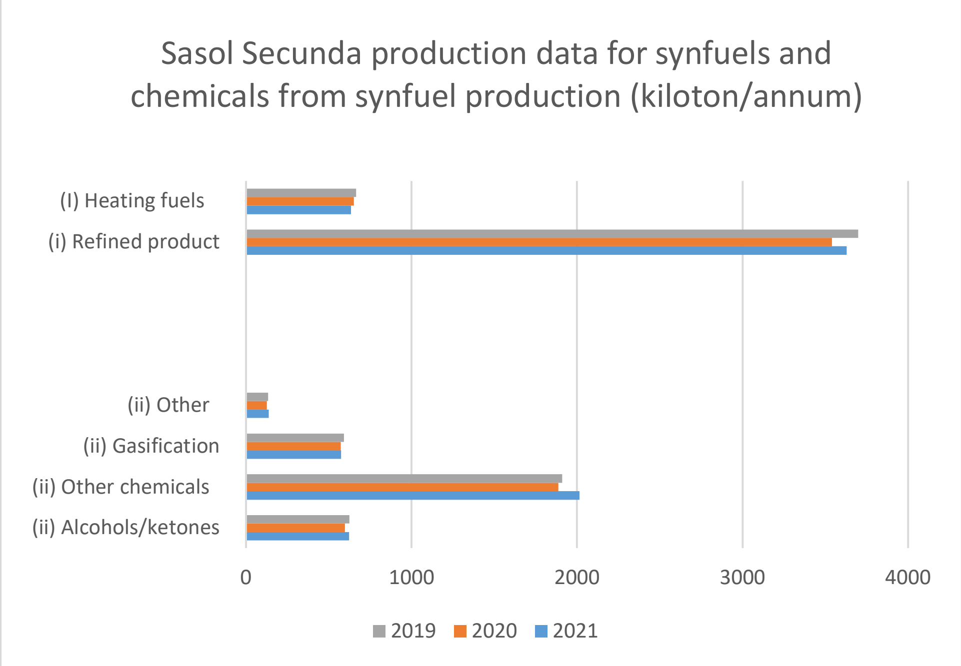

Figure I Sasol Secunda synfuels production metrics (Sasol, 2021d)

Note. (i) Secunda production synfuels (ii) Secunda chemicals products under synfuels

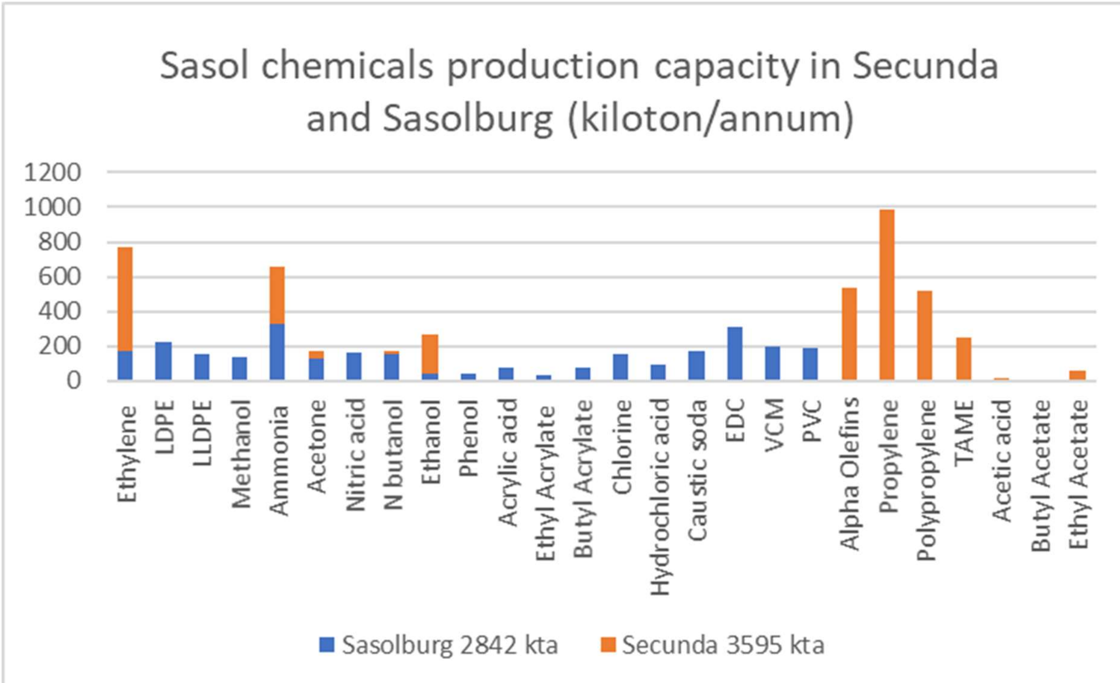

Figure II. Sasol primary feedstock chemical production capacity (IHS Markit, 2021)

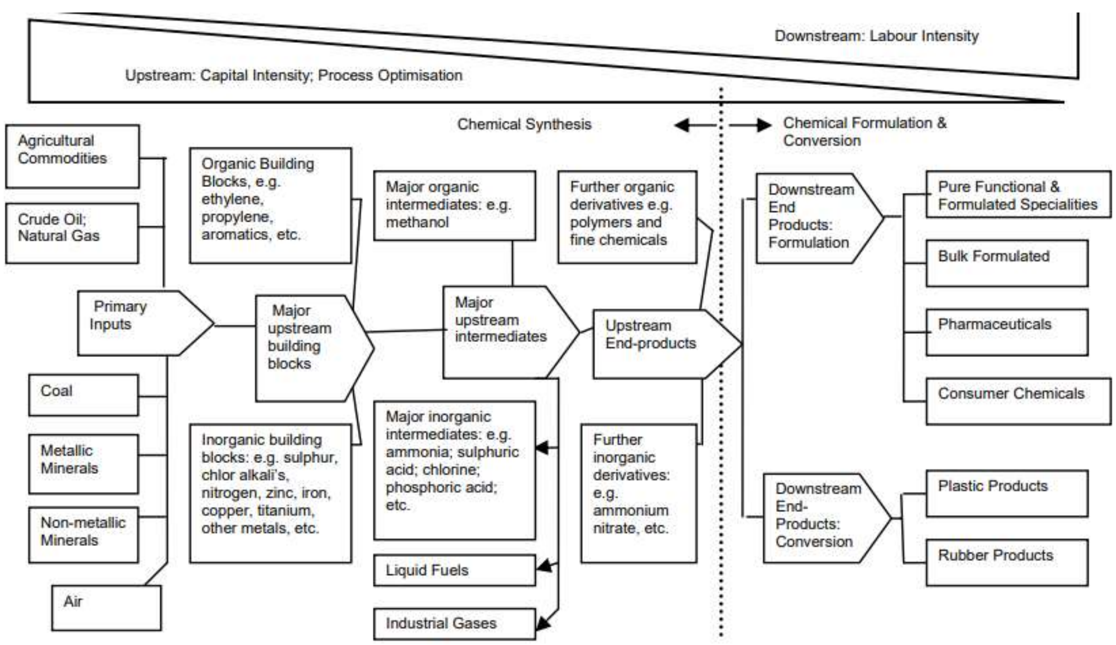

Figure III. Upstream and downstream elements of the chemical sector (Zyl et al., 2008)

Sasol Chemicals SA (kta)	Sasolburg	Secunda	Total capacity	Products chemical is used in (fertilizers, detergents, plastics, dyes etc) and description of what that product is
	2842 kta	3595 kta	kta	
Ethylene	168	600	768	Basic building block for polyethylene. Also, together with benzene , it is a basic component of styrene used to make rubber and polystyrene.
LDPE	220		220	Base chemical product. Used in the plastics industry, specifically the production of plastic shopping bags, bread bags and shrink wrapping.
LLDPE	150		150	Base chemical product. Used in heavy duty films, containers, lids and rotomoulded products such as water and fuel tanks.
Methanol	140		140	Building block for many everyday products such as plastics, paints, car parts and construction materials. Used as an industrial solvent to create inks, resins, adhesives and dyes. Clean energy resource used to fuel transportation vehicles.
Ammonia	330	330	660	Used in the production of fertilizer and nitric acid.
Acetone	125	50	175	Used both as a solvent and as an intermediate in the production of other products such as perspex and epoxy resins.
Nitric acid	160		160	Used in the preparation of a wide variety of industrial products, including explosives and fertilizers.
N butanol	150	18	168	Industrial solvent. Present in numerous beverages and food. Used as a solvent in the production of inks.
Ethanol	40	226	266	Key ingredient in household methylated spirits. Solvent used extensively in inks and paints. Also used as a solvent in the production of pharmaceuticals and cosmetics.
Phenol	40		40	Forms the disinfectant, carbonic acid when dissolved in water. Used in the plastics industry.
Acrylic acid	80		80	Industrial solvent used in the production of inks, adhesives, polymers etc.
Ethyl Acrylate	35		35	Primarily used in the production of emulsion-base polymers. Used in the production of water-based latex paints and adhesives, textile and paper coating, leather finish resins and in the production of acrylic fibbers.
Butyl Acrylate	80		80	Raw material used in the production of acrylic, vinyl acrylic and styrene acrylic copolymers. Also used in adhesives, fibber processing agents, acrylic rubber and emulsions.
Chlorine	158		158	Used in the sanitisation of water as well as the production of paper products, plastics, dyes, textiles, solvents etc.
Hydrochloric acid	96		96	Building block of VCM as well as other chemicals. Used in disinfectants, pool maintenance, food production and steel manufacture (removes rust and other impurities).
Caustic soda	173		173	Used in pulp and paper production, minerals beneficiation, aluminium, commercial drain and oven cleaners, soap and detergents.
EDC	312		312	Used primarily as a raw material in the production of VCM.
VCM	195		195	Chemical intermediate used to produce PVC.
PVC	190		190	Versatile material commonly used in the building and construction industry to produce door and window frames, pipes, wire insulation etc.
Alpha Olefins		536	536	polymerised with polyethylene starting point for producing detergent alcohols, synthetic lubricants, lubricating oil additives and surfactant. widely in industry, from mining to textiles. (comonomers 1- pentene, 1-octene, 1- hexene) heavier alpha olefins produce surfactants that, in turn, are used in shampoos, soap powders and other detergent
Propylene		990	990	Used to produce polypropylene.
Polypropylene		520	520	Base chemical used to produce automotive parts, luggage, pipes, bottles, house wares, toys, woven sacks and flooring.
TAME		250	250	Ether used as a fuel oxygenate.
Acetic acid		16	16	Food acidifier (vinegar), chemical intermediate to make esters, vinyl acetate, acetic anhydride etc.
Butyl Acetate		4	4	Solvent used in paint, inks, adhesives and coatings.
Ethyl Acetate		55	55	Solvent used in paint, inks, adhesives and coatings. Used in photographic film, nail polish removers, lacquers, perfumes, oils and resins.
Total	2842	3595	6437	

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