THE JUST TRANSITION FOR THE REFINING AND LOGISTICS SECTORS OF THE SOUTH AFRICAN LIQUID FUELS INDUSTRY

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April 2022

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FOREWORD

Decarbonisation efforts in South Africa have focused on Eskom electricity generation and Sasol petrochemical production. However, given the absolute CO_2 emissions associated with these operations, as pressure increases to decarbonise all sectors of the economy to limit the global temperature increase to 1.5^{o}C by 2050, it will also be necessary for South Africa to decarbonise its transportation sector.

This in turn would have an impact on the jobs in the South African liquid fuels value chain. This paper develops a high-level overview of the impact on the jobs in the refining and logistics sectors, due to termination of operations in these sectors for economic and/or decarbonisation reasons.

Detailed job data for job numbers and skill levels for different categories of jobs in these sectors are not available in the public domain at this time; however, a study by FTI Consulting, *The economic contribution of the downstream oil industry to South Africa in 2019,* presents some high-level job data for the Industry. These data have been used in this study.

The research forms part of the Making Sense of Employment in South Africa's Just Energy Transition project. TIPS and WWF South Africa, with the support of GIZ, are implementing an initiative to support policymaking for South Africa's just transition. This focuses on employment and the relevant challenges and opportunities in the country's just energy transition.

Thanks are due to Gaylor Montmasson-Clair and Muhammad Patel of TIPS, Louise Scholtz and Farai Chireshe of WWF South Africa, and Tjasa Bole-Rentel previously of WWF South Africa and now with ENERTRAG SA, for their invaluable input and assistance in developing this report.

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ABBREVIATIONS

CF2	Clean Fuels Two fuel specifications
CO_2	Carbon dioxide
COP	Crude oil pipeline
EU	European Union
DSI	Department of Science and Innovation
F-T	Fischer Tropsch process
GTL	Gas to-liquids-plant
H_2	Hydrogen
IRP	Integrated Resource Plan
LOHC	Liquid organic hydrogen carrier
MPP	Multi-product pipeline
NATREF	National Petroleum Refiners of South Africa
ORTIA	Oliver Tambo International Airport
RWGS	Reverse water gas shift reaction
SAF	Sustainable aviation fuels
SA LFI	South African liquid fuel industry
SAPIA	South African Petroleum Industry Association
SAPREF	Shell and BP South African Petroleum Refineries
SBM	Single buoy mooring
VLCC	Very large crude carrier

EXECUTIVE SUMMARY

This report develops a high-level overview of the way in which the transition to a low-carbon economy may occur in the refining and logistics sectors of the South African Liquid Fuels Industry (SA LFI). The rate of transition, the number of jobs, and the associated skill levels are discussed and possible actions to reduce the impact on employment are presented.

From the study by FTI Consulting (2021) the total number of jobs (direct and indirect) in the refining and logistics sectors was 95 309 in 2019, with direct jobs estimated to be in the order of 4 000. Most of these jobs are classified as highly skilled and skilled. A more detailed breakdown of job numbers and skill levels for different categories of jobs in these sectors is not available in the public domain at this time.

The transition for the refining sector, which provided 64 121 jobs in total in 2019, is already underway. As of Q2 2022, two of the four oil refineries in South Africa have ceased operations due to economic reasons. The third refinery has been shut down since July 2022 and is anticipated to return to service in Q3 2022. The fourth refinery has reported that by Q3 2022 it will consider its future as investment to produce fuels to meet Cleaner Fuels Two (CF2) emission standards are not economically viable. The PetroSA GTL plant has ceased operations due to lack of gas feedstock. Jobs are currently being lost in the refining sector as shut downs occur for economic reasons, before any impact of the Net Zero carbon pathway has been considered.

Alternative manufacturing operations for these sites will be considered due the high cost of environmental rehabilitation that will otherwise be required.

Given the need to replace the products previously produced by refining crude oil, one of the options companies will consider for the dormant refinery sites is import terminals. As a result, not all refining jobs will be lost but the numbers retained will be a small fraction of those employed when the refineries were fully operational.

A number of new product production opportunities are possible. These include biorefining to produce sustainable fuels such as sustainable aviation fuels (SAF) and sustainable polymers. Green hydrogen production may also be a possibility. However, none of these opportunities are being implemented at present so the new jobs that would be created by these new operations will not provide an immediate solution for those refining employees who are currently losing their jobs.

The transition in the logistics sector will be different to that of the refining sector. It will be determined by the rate at which transportation moves away from fossil fuels to electric mobility and sustainable fuels. Current views are that e-mobility will not impact liquid fuel demand before 2035 (NBI, 2021). As a result there is still time to develop transition plans for the employees in the logistics sector.

There is a need to consider the development of a just transition plan for the majority of employees in the refining sector. However, there is more time to plan the transition for the employees in the logistics sector.

In order to develop the plan for the transition, the logistics sector will undergo, access to more granular job data will be needed.

The best solution to provide a just transition for employees in the refining and logistics sectors is a growing South African manufacturing sector.

1. INTRODUCTION

Decarbonisation efforts in South Africa have focused on Eskom's electricity generation and Sasol's petrochemical production, given the absolute CO_2 emissions associated with these operations. However, as pressure increases to decarbonise all sectors of the economy in an attempt to limit the global temperature increase to 1.5°C by 2050 (compared to the pre-industrial era), it will also be necessary for South Africa to decarbonise its transportation sector. This in turn would have an impact on the jobs in the South African liquid fuels value chain.

This paper develops a high-level overview of the impact on the jobs in the refining and logistics sectors due to termination of operations in these sectors for economic and/or decarbonisation reasons.[1] It should be seen as the precursor to a more in-depth study to better understand the scope and extent of the impact on jobs and what actions can be taken to limit the negative impact on jobs in these sectors.

The refining sector processes crude oil or natural gas to produce finished products, such as petrol, diesel, jet fuel, illuminating kerosene and bunker fuel oil. The logistics sector is responsible for the acquisition of the crude for the refineries as well as the movement of the finished products from the refineries to the market. A group in the logistics sector is also responsible for the importation of finished products to balance local demand if refinery production is insufficient.

Publicly available data on jobs in the liquid fuels industry (LFI) are not readily available. An FTI Consulting 2021 report, *The economic contribution of the downstream oil industry to South Africa in 2019* commissioned by the South African Petrochemical Industry Association (SAPIA provides high-level job data for 2019, used as the basis for discussion in this report. Based on the FTI report, the total number of employees for SAPIA members was 10 630 in 2019.[2]

The oil refineries considered are the Astron Energy refinery (Glencore – main shareholder) in Cape Town (formerly Chevref refinery), the Engen (PETRONAS – main shareholder) and SAPREF (Shell and BP – main shareholders) refineries in Durban and NATREF (Sasol and TotalEnergies – main shareholders) in Sasolburg. The PetroSA GTL synfuel plant (South Africa Government – main shareholder) is also included in the discussion as it is a member of SAPIA. Importantly, the Sasol Secunda operation is not included in this report as it is linked to the coal value chain (its primary feedstock), rather than dynamics in the liquid fuel industry.

As of early 2022, both the Astron and Engen refineries are not operational following technical incidents at both facilities. The Astron refinery is planned to restart in the third quarter of 2022 (CITAC, 2022). In contrast, Engen has taken the decision, on economic grounds, not to restart the refinery but to convert it into an import terminal. A feasibility study to build a biorefinery on the site is also being undertaken. In addition, PetroSA ceased operations in 2021 due to lack of indigenous feed gas, and Shell and BP announced in February 2022 that they would freeze spending and pause operations at SAPREF from the end of March 2022. In its April 2022 Industry Insight, CITAC quotes the Sasol CFO as stating that the upgrades needed to produce higher quality fuel at NATREF are "sub-economical" and a decision on the refinery's future will be made by the end of the third quarter of 2022.

[1] The impact on the marketing sectors (retail and commercial segments) is not covered in this paper. See Maseko, 2022 for a discussion on petrol stations.

[2] According to Sasol Limited, 2021, the firm had 26 003 employees South Africa. It is reasonable to assume that only the Sasol Oil employee numbers are included in the Executive Summary of the FTI report (2021). Also Sasol Oil is the SAPIA member and not Sasol Synfuels.

It is clear that a transition has already begun in the refining sector of the SA LFI, primarily for economic reasons and not a result of the energy transition or move to Net Zero carbon emissions. Notwithstanding the reason for the transition or change, it still needs to be managed in a just manner. Given the need to reduce future CO_2 emissions from the transport sector, the energy transition will shape the transition in the logistics sector of the SA LFI.

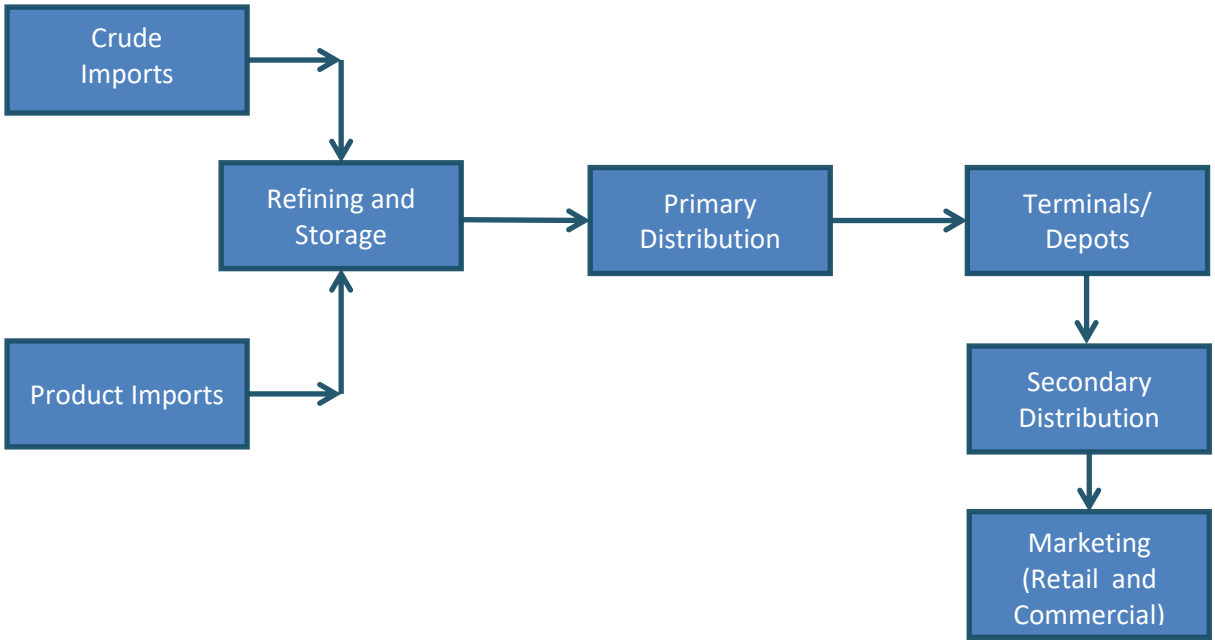
The following topics are addressed in this report:

- An outline of the South African liquid fuels value chain will be presented and explained;
- Jobs in the refining and logistics sectors will be identified by type and number;
- The timing for just transition actions and the impact on jobs will be discussed; and
- Possible options for the decarbonised Refinery and Logistics sectors will be considered.

2. AN OUTLINE OF THE SOUTH AFRICAN LIQUID FUELS VALUE CHAIN

As this report focusses on the Refining and Logistics sectors, it is important to contextualise where these sectors fit into the Liquid Fuels value chain. A simple representation of the Liquid Fuels value chain is shown in Figure 1. The role of the Refining and Logistics sectors in the value chain will be explained in the sections that follow Figure 1.

Figure 1: Overview of the South African Liquid Fuels value chain



Source: Author. *Note*: When in operation, the PetroSA synfuel plant sourced its gas feedstock locally. This was processed and the products were supplied to the market from the Primary Distribution point onwards, as shown in Figure 1.

2.1 Refining and storage

2.1.1 Refining Operations[3]

Imported crude oil is processed through the various oil refineries (when in operation) to produce a range of products, the bulk of which are petrol, diesel, jet fuel and illuminating kerosene. Each manufacturing operation has its own storage facilities that hold the finished product for dispatch to the market via various forms of distribution, outlined in Figure 1 and discussed in more detail in the report.

[3] See FTI Consulting, 2021: Refining and Manufacturing.

2.1.1 Crude Imports[4]

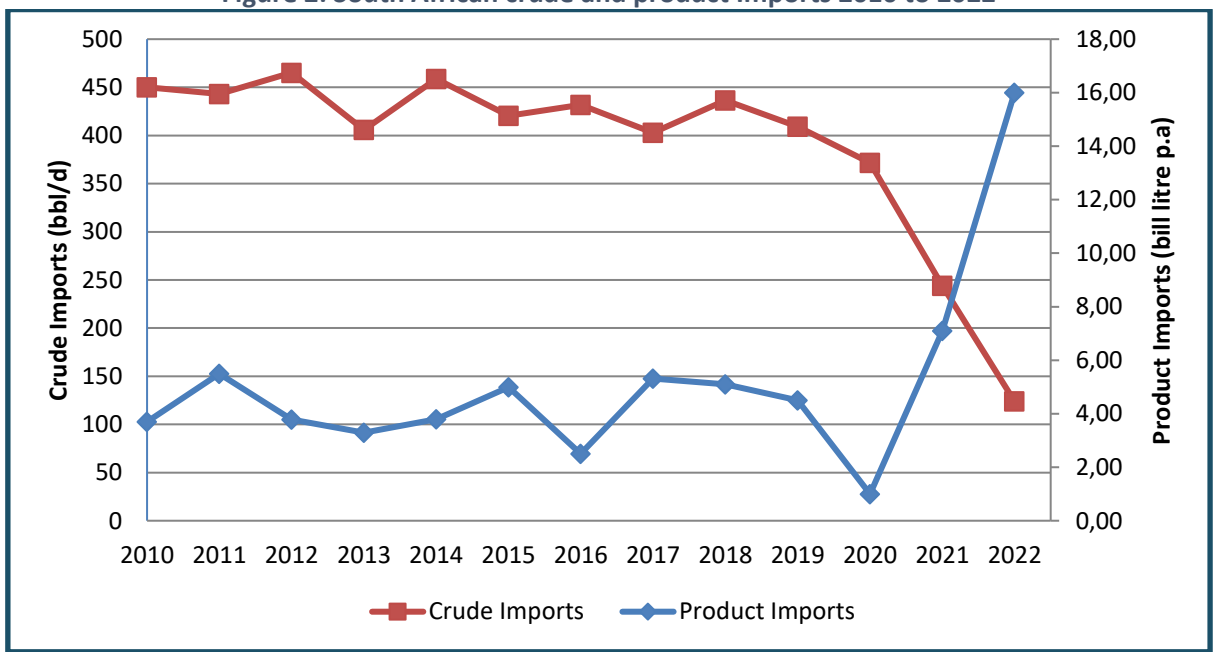
When in operation, all four crude oil refineries import their feedstock: Astron via Saldahna Bay and the others via the single buoy mooring (SBM) facility off Durban. Crude oil purchased from primarily the Middle East and West Africa is brought in by ship. Economies of scale benefit the cost of shipping so very large crude carriers (VLCCs) are used, as they can enter Saldanha bay and use the SBM in Durban but are too large to enter any other South African ports.

Crude is pumped into storage from the delivering ship, where it is stored until it is processed through the refinery. In the case of the Astron refinery, the crude is stored in the Saldanha Bay crude storage facility and pumped to the refinery as required. For the Engen and SAPREF refineries, the crude is pumped off the ships via the SBM to the tank farm situated to the south of SAPREF before being fed to the refineries as needed (and when in operation). In the case of the NATREF refinery, crude is pumped off the ships via the SBM to the NATCOS[5] tank farm (owned by Sasol Oil and TotalEnergies) before it is pumped to Sasolburg using the crude oil pipeline (COP) owned and operated by Transnet Pipelines.

2.1.2 Product Imports[6]

When the demand for petrol, diesel or jet fuel in South Africa exceeds the volume produced by the local refining sector, it is necessary for the volumes required to balance supply to be imported. With three refineries currently not in operation, the import volumes have increased significantly with the concomitant reduction in crude imports, as shown on Figure 2.

Figure 2: South African crude and product Imports 2010 to 2022



Source: Author based on data from South Africa Department of Minerals and Energy (product imports) and CEICdata.com (crude imports)

For Astron, the imports are landed in the Cape Town harbour and pumped to the refinery storage for onward distribution. For all the other oil companies, the primary import port is Durban. Given the

[4] See FTI Consulting, 2021: Feedstock and Product Imports.

[5] NATCOS – Company own jointly by Sasol and TotalEnergies that manages the storage and logistics facilities in the Durban harbour for their shareholder.

[6] See FTI Consulting, 2021: Feedstock and Product Imports.

available depth in South African ports, the ships used for product imports are smaller than those for crude imports. As import volumes are increasing, oil companies are also importing product directly into the ports of East London, Gqeberha, and Mossel Bay.

2.2 Primary distribution[7]

Primary distribution includes various modes that provide the initial movement of finished product from the refineries/GTL plant and harbour terminals to depots that serve the market. The various modes of transport include road, rail, coastal shipping and pipeline. The approximate share of volume transported at the primary distribution stage is shown in Table 1.

Table 1: Mode of Transport – Approximate share in 2019

MODE OF TRANSPORT	APPROXIMATE SHARE (IN VOLUME)
Road	31%
Rail	2%
Coastal shipping	4%
Pipeline	63%

Source: Author

2.2.1 Road

In primary distribution by road, tankers are used to move product over long distances (such as Durban to Johannesburg) from refinery storage facilities to storage facilities closer to retail and commercial markets. Normally, this is the most expensive mode and is used for emergencies or lower volume products, like illuminating kerosene, solvents and lubricating oils. More recently, as a result of increased pipeline tariffs,[8] more companies have used road transport to move product from the coast to the inland region (T.G. Johnston, 2022).

2.2.2 Rail

Rail transport is under-utilised in South Africa due to its inefficiency and unreliability. There is, however, a daily block-train that delivers jet fuel to the Oliver Tambo International Airport (ORTIA) near Johannesburg from the Durban refineries or harbour. This is a crucial aspect of ensuring an adequate supply of jet fuel to ORTIA.[9]

2.2.3 Coastal shipping

Product is also moved down the coast mainly from Durban to other ports on the South African East coast as well as to Namibia via Walvis Bay. With the volume of imports growing, and companies shipping these imports directly to the ports mentioned above, the volume of coastal shipping has, however, decreased.

[7] See FTI Consulting, 2021: Distribution and Storage

[8] A feature of the National Energy Regulator of South Africa (NERSA) pricing mechanism for the pipeline tariff is that as the volume pumped through the pipeline reduces, the tariff increases.

[9] As a result of the April 2022 floods, the mainline rail service was washed away. This prevented the operation of the daily jet block train service, which in turn caused supply shortages at ORTIA until an alternative supply system using the multi-product pipeline (MPP) was developed.

2.2.4 Pipeline

Transnet Pipelines owns and operates a network of pipelines in South Africa that ship crude, finished products and gas (Transnet, 2021).

The COP and the MPP provide the major transportation facilities to move crude and products from Durban to Gauteng. The crude oil fed to NATREF is transported through the COP, whereas two grades of petrol and two grades of diesel are shipped from the Durban harbour terminal (TM1) to the terminal at Jameson Park in Gauteng (TM2).

From TM2, product can be routed into the northern pipeline network that feeds a number of marketing depots (or storage facilities). In addition, this northern pipeline network links product from both the Secunda coal-to-liquids plant and NATREF into this distribution network. There is also a pipeline that transports jet fuel from NATREF to ORTIA to supplement the volume railed up from the coast.

In addition, a gas pipeline runs from Secunda to Empangeni and then down to Durban. Gas from the Secunda operation is shipped via this line to industries in Mpumalanga and KwaZulu-Natal.

2.3 Terminals/Depots[10]

As noted, there are storage facilities at various locations in South Africa that receive finished product via the different primary distribution modes. Traditionally, the storage facilities at the ports are referred to as terminals whereas the inland storage facilities are referred to as depots.

Both terminals and depots are a collection of large tanks in which finished product is stored, having been delivered by one of the primary distribution modes. It is stored in these tanks until it needs to be dispatched to retail sites (service stations) and commercial customers by secondary distribution.

2.4 Secondary Distribution[11]

The movement of finished product to customer sites (retail and commercial) is done primarily in road tankers and tank trailers. Typically, a road tanker carries 50 000 litres of finished product. Delivery of finished product to customers is planned and scheduled by systems usually operated by a group based in the company head office.

2.5 Head Office[12]

Oil companies generally have a function in their head offices associated with each sector of the value chain. These are mostly involved in long-term planning and oversight of operations. However, one group is operationally focussed. It is responsible for ordering both the crude oil processed in the refineries and the finished product imports. It also arranges for the export of any excess product from the refineries that the local market cannot absorb. This group also plans and co-ordinates the production, primary and secondary distribution operations centrally for maximum efficiency.

[10] See FTI Consulting, 2021: Distribution and Storage.

[11] See FTI Consulting, 2021: Distribution and Storage.

[12] See FTI Consulting, 2021: Head Office.

3. IDENTIFYING JOBS BY TYPE AND NUMBER

Planning for a just transition in the South African LFI requires a granular understanding of employment in the value chain. The sector is notoriously opaque when it comes to sharing or providing information, especially at any detailed level. Typical details for jobs that would be needed include: type of job, level in the organisation, number of positions existing, years of experience required, minimum qualification required, age of incumbent and salary. Unfortunately, this level of detail is not available. Based on FTI Consulting (2021), total jobs (direct and indirect) by segment in the value chain are shown in Table 2.

Table 2: Breakdown of jobs across the value chain

	TOTAL DIRECT AND INDIRECT JOBS (2019)	% OF TOTAL JOBS	ESTIMATE OF DIRECT JOBS (2019)
Head Office	21 775	9%	934
Feedstock and Import	4 167	2%	179
Refining and Manufacturing	64 121	26%	2 751
Distribution and Storage	27 021	10%	1 159
Wholesale*	32 364	13%	1 388
Retail*	98 324	40%	4 218
Total	**247 772**	**100%**	**10 630**

Source: Author, based on FTI Consulting, 2021.
Note: the data in the column "Estimate of Direct jobs" is derived by assuming the percentage of total jobs across the value chain applies to SAPIA employees. While this assumption may not be correct, it is the best that can be done in the light of no other data being available at this stage.
These numbers reflect the position before all the closures in 2021 and 2022 so current numbers may be different.
*See Maseko, 2022 for a discussion on retail and commercial sectors.

When, considered together, the refining (Refining and Manufacturing in Table 2) and logistics (Feedstock and Import plus Distribution and Storage in Table 2) sectors account for a more than a third of the employment in the value chain. The sectors employed a total of 95 309 people in 2019 (directly and indirectly), which constitutes 39% of the total number of jobs, with 4 089 of these estimated to be direct jobs.

In addition to the number of jobs, the skill level required for the jobs is also important. However, no detailed breakdown or definition of skill levels is readily available. Data from FTI Consulting (2021), which reported the data for 2019, are shown in Table 3. They state that skills levels in the South African oil industry are at a higher level than that in the overall South African labour force but without any indication of how this conclusion is reached. In any event, while most of the forecourt jobs in the retail sector would fall into the semi-skilled and unskilled category, the bulk of the jobs in the refining and logistics sectors would fall in the highly skilled and skilled categories.

Table 3: Employment skills levels 2019

	HIGHLY SKILLED AND SKILLED	SEMI-SKILLED AND UNSKILLED	INFORMAL
Oil Industry labour force	59%	24%	17%
South African labour force	20%	57%	24%

Source: FTI Consulting, 2021.

Although most of the jobs in the refining and logistics sectors are located in the highly skilled and skilled categories, differences exist. To understand what actions could be taken to ensure a just transition, the job categories in each sector of the value chain (i.e. management, professional, clerical, process operator, maintenance artisan and truck drivers) are considered separately.

- Head Office sector: jobs range across management, professional and clerical categories.
- Feedstock and Import sector: in addition to management, professional and clerical categories, there are also operational jobs, such as process operators and maintenance artisans to manage the physical process of loading and unloading ships that bring the feedstock and imported products to the ports.
- Refining and Manufacturing sector: the management, professional and clerical categories all exist in this sector as well but the skill level of process operators is more advanced than that required in any of the other sectors. Maintenance artisans are also required in this sector.
- Distribution and Storage sector: the bulk of the jobs in this sector fall into the process operator, maintenance artisan and truck driver categories. A small number of jobs are required in the management, professional and clerical categories.

There are some semi-skilled, unskilled and informal jobs in the refining and logistics sectors but their numbers are small and, if the positions are available, people with these skill levels can transfer relatively easily across different industries.

The Management category raises the least concern as oil companies transition. People with management skills developed in the oil industry should be able to apply these effectively in other industries in South Africa, and no specific plan needs to be developed. The same thinking applies to the Professional category, which should also not require any specific plan. Although no specific action plan may be needed for the Management and Professional categories, in the current economic climate where growth is low and jobs in general are scarce, it is highly likely that not everyone in these categories would find new positions easily or quickly.

For all the other categories, action plans are required to ensure a just transition. These are discussed below.

Process operators are responsible for the day-to-day operation of the plant. Although no definitive number is available at present, the number of process operators is estimated at about 1 000. They are the most highly skilled people (in the direct job categories under consideration) other than the management and professional categories. Yet, they could be the most at risk due to the termination of operations in the value chain. It takes years of on-plant experience and exposure to develop an effective and competent process operator to run a section of a refinery or tank farm effectively and safely.

Process operators have specialised skills. They could be retained if the oil companies invested in new processing operations other than oil refining. Possible alternatives are discussed in Section 5. Most of these alternatives would need skilled process operators although perhaps not in the same numbers. Given their level of expertise and competence, they should be able to retrain for other jobs. They could transition to the chemical industry as well as other processing industries. There would be some scope for process operators in the operation of renewable energy facilities, but as these facilities are located away from the current refinery locations the opportunities may not be seen as attractive.

Maintenance artisans also have skills that can be readily transferred to other industries. Maintenance artisans in the oil industry do very similar work to maintenance artisans in other

industries and sectors. Provided there are positions in other sectors, maintenance artisans could move to them without significant retraining.

Similarly, truck drivers hold skills that are easily transferred to other sectors without much retraining (Chireshe and Bole-Rental, 2022). Again, however, job availability will be the critical issue.

As with the two previous categories (i.e. maintenance artisans and truck drivers), those employed in clerical positions should also find it relatively easy to move away from the oil industry to other sectors, again subject to the availability of positions.

As jobs in the South African LFI are seen as mostly highly skilled and skilled, a growing economy that results in the creation of new industries and the expansion of existing industries would be the best avenue to enable a just transition as the oil industry reduces its role in society.

4. TIMING FOR JUST TRANSITION ACTIONS AND THE IMPACT ON JOBS

An important consideration for a just transition for oil industry employees is that the timing and phasing will be quite different from that expected for the coal industry.

According to the 2019 Integrated Resource Plan (IRP), 15% of the coal-fired generation capacity should be decommissioned by 2023. For the oil industry, the timing is different – four production facilities are already not in operation (Astron, Engen, SAPREF and PetroSA) with NATREF indicating possible closure before the third quarter of 2023. Jobs are already being reduced and lost in the refining sector of the value chain. While these job reductions and losses are a response to economic issues (related to the conversion of facilities to produce CF2 quality fuels or the lack of feedstock) and not the energy transition, there is an immediate need for a just transition in this sector.

Not all the refining jobs will be lost – the three coastal facilities (Astron, Engen and SAPREF) may be converted to import terminals (and perhaps other operations) which will need staff to operate them. However, the number of jobs will be fewer than that needed to run a refinery.

Jobs in the logistics sector will be impacted by the manner in which the demand for finished product changes in South Africa. As demand reduces, so the logistical infrastructure required to handle the volumes required by the market will be reduced (for economic reasons). Consequently, the job losses in the logistics sector will be slower and more incremental as the final product demand reduces.

Decline in liquid fuel demand is anticipated to be gradual over the next 15 to 20 years (depending on the availability and price of liquid fuels). As it stands, the shift to electric vehicles is expected to be relatively slow. Reasons for this are the low number of hybrid and electric passenger vehicles currently on South African roads and the absence of any policy incentive to support the market transition. In addition, the current average life of a passenger vehicle is of the order of 12 years. In addition, the development of electric powered commercial vehicles is slower than that for passenger or light vehicles, so the demand for diesel in the commercial sector is likely to last longer than that for petrol.

In summary, jobs are already being lost in the refining sector with some being retained for the operation of import terminals and/or new operations on existing refinery sites. However, jobs in the logistics sector will reduce progressively over the next 15 to 20 years as the demand for liquid fuels declines.

5. POSSIBLE OPTIONS TO MAINTAIN EMPLOYMENT IN DECARBONISED REFINING AND LOGISTICS SECTORS

Even though oil companies have stopped, or may stop or reduce operations at their refining / manufacturing / terminal / depot sites, they will be reluctant to vacate the sites entirely. This is primarily due to the environmental clean-up and rehabilitation costs that would be incurred on completely vacating the sites. As a result, companies will likely explore all alternatives to continue operating on these sites, but with reduced headcount. This applies to the refinery/manufacturing sites especially, as the clean-up costs would be significantly higher than for terminals/depots, i.e. smaller sites (by area) would cost less to clean-up and so would close first. This could reduce the rate of job losses for the South African LFI.

On refining/manufacturing sites, the focus to continue operations would be on alternative operations with lower direct (Scope 1) GHG emissions, producing sustainable products.

Decarbonised refining implies the production of fuels that can be used in ICE vehicles from biogenic feedstocks as well as from CO_2 via direct/indirect capture. The advantage of producing these liquid biofuels is that much of the existing storage and distribution infrastructure could continue to be used. Sustainable processes that could be considered for refinery sites are:

- Biorefining
- Conversion of CO_2 to products
- Production of green hydrogen

5.1 Biorefining

Biorefining involves the production of products from biogenic feedstocks like crops, crop residues, wastes or algae. Alternative liquid fuels and other bio-based products that substitute for the fossil derived products are produced (Demirbas, 2009; Rasool and Hemalatha, 2016).

Ethanol production from sugar cane molasses and/or bagasse via thermo-chemical and/or bio-chemical processes is one example of a biorefining process. Similarly, the extraction of plant oils from crops, such as Solaris seed, sunflower, rape seed or Jatropha, and the conversion of these oils to biodiesel is another example. Animal fats can also be converted to diesel in a similar process.

The processes involved are proven at an industrial scale. This is borne out in the number of biorefineries already in South Africa (Montmasson-Clair, Wood and Deonarain, 2019). However, the cost of ethanol and biodiesel produced is typically higher than the cost of fossil-based fuels.

Biorefineries are usually smaller in capacity than those of crude refineries by an order of magnitude. As a result, to produce the volume of fuel required, more biorefineries would be needed. Since it makes economic sense to place these biorefineries close to the source of their feedstock, they are likely to be closer to rural communities and be a benefit to them.

In addition, the recent study by WWF South Africa on the production of SAF from various feedstocks indicates where these biorefineries could be located and provides estimates of the job creation potential (Bole-Rentel, Chireshe and Reeler, 2022).

All the existing crude refinery sites could be considered as locations for biorefineries. Both KwaZulu-Natal refinery sites are well located to use sugar cane as a feedstock for a biorefinery – it is understood that Engen is considering a biorefinery at its Durban refinery site as part of the Sugar Master Plan. NATREF could also be a good location for a biorefinery, given its proximity to Solaris

feedstock. Constructing a biorefinery on an existing oil refinery site will require technical modifications which will come at a cost.

The algae feedstock processes are still in the development phase but tend to require a large land footprint for the processing plant, due to the slow reaction rates involved in the conversion reactions.

Besides being used as a fuel for ICE vehicles, bioethanol can be used as a feedstock to produce a range of other products including sustainable aviation fuel (SAF) and biopolymers.

The gasification of biomass to produce a synthesis gas (carbon monoxide and hydrogen) which, together with green hydrogen, can be fed into a Fischer-Tropsch (F-T) reactor to produce sustainable fuels, such as green petrol, green diesel and SAF, is another process that could be considered. Again, the scale of operation would be much smaller than a traditional F-T plant due to the low energy density of the feedstock, but as there could be multiple facilities this could offset the job requirements.

5.2 Conversion of CO_2

In principle, the conversion of CO_2 involves a process known as the reverse water gas shift reaction (RWGS). CO_2 in the presence of a catalyst reacts with hydrogen to produce carbon monoxide and water. When this reaction occurs in the opposite direction, i.e. carbon monoxide and water reacting to form hydrogen and CO_2, it is the basis of producing either hydrogen or synthesis gas (syngas) from fossil fuels. The carbon monoxide produced by the RWGS reaction can then be combined with green hydrogen to produce syngas, which can be turned into sustainable products via the F-T process.

A challenge for this process is a readily available source of concentrated stream of CO_2. Usually, the feed stream of CO_2 needs to be concentrated from a dilute source which adds to the cost of operations.

SAF, sustainable diesel and sustainable polymers could be produced once the RWGS reaction can be carried out successfully at scale using the F-T process and syngas produced from CO_2.

Recently, LanzaTech (Biofuels Central, 2021) announced technology developed together with the United States Department of Energy's Argonne National Laboratory to produce SAF. The technology uses CO_2 and green hydrogen to produce ethanol, which in turn is converted to SAF and other hydrocarbons. LanzaTech is building a plant in Georgia in the US, which is due to start production of about 40 million litres per annum (10 million US gallons p.a.) in 2023 (Hydrocarbon Processing, 2022). In addition, the company is in discussions with various European and Chinese partners for the implementation of its technology. The company also has a partner in South Africa that is developing the first industrial waste gas-based plant.

5.3 Production of Green Hydrogen

In February 2022, the Department of Science and Innovation (DSI) released the Hydrogen Society Roadmap which identifies four catalytic projects: the Hydrogen Valley Initiative, the CoalCO_2-X project, the Boegoebaai SEZ, and the Sustainable Aviation Fuels Project.

The DSI has also proposed establishing a Hydrogen Valley that envisages three hubs:

- Johannesburg;
- Durban/Richards Bay; and
- Mogalakwena/Limpopo.

Expected demand in these hubs is anticipated to be up to 185 kilotonnes of H_2 by 2030, arising from a mix of chemicals production, iron and steel, heavy- and medium-duty trucks, oil refining and exports. The SAF biorefineries will also add to the demand for green hydrogen. The Hydrogen Valley is estimated to create between 14 000 and 30 000 jobs a year.

There is also interest in using the ports (e.g. Saldanha Bay, Coega, Richard's Bay) to serve the export market – proximal demand from the European Union (EU), Japan, and South Korea for green H_2 and green H_2 beneficiated products that are less costly to transport (e.g. liquid organic hydrogen carriers, green ammonia, green iron and steel).

A number of green hydrogen initiatives are under consideration in the country, including:

- Various initiatives considering the manufacturing of green H_2 with support from the state – HyPlat, Isondo Precious Metals, Hydrox holdings, Bambili Energy, Chem Energy SA, and Mitochondria Energy.
- Eskom is exploring green H_2 production as part of the repurposing of existing coal-fired power stations– H_2 is currently used at power stations for cooling but not produced on site. Eskom is also deciding on which markets to enter.
- Sasol has announced several green H_2 projects, such as:
    - A partnership with Toyota to assess the feasibility of developing a green hydrogen mobility ecosystem in South Africa;
    - A collaboration between Sasol, Linde (Afrox's parent company), Enertrag and Navitas to bid for the production of SAF at Secunda for export to Germany.
    - A partnership with the Industrial Development Corporation for developing the green hydrogen value chain, which consists of developing upstream and downstream markets; and
    - A Memorandum of Agreement with the Northern Cape Economic Development Trade and Investment Promotion Agency to assess the feasibility of exporting green hydrogen and ammonia from the Boegoebaai port.
- Impala Platinum and Anglo Platinum are developing fuel cell mobility solutions for heavy duty forklifts and mining vehicles.
- Linde and Hive Hydrogen have embarked on the development of a R75 billion green ammonia export plant in Nelson Mandela Bay, which is anticipated to create 100 000 jobs. The first project is anticipated to begin operation in 2025 (Parker, 2022).

From this list, it is clear that not all the refinery sites are well-placed to be considered for green hydrogen production. Astron, PetroSA and NATREF would have some locational advantage with access to renewable energy for green hydrogen production. However, the Durban-based facilities face more significant challenges. As a result, it is unlikely that the Durban-based sites would be first choice candidates.

5.4 Summary of options

As outlined in the preceding sections, there are no obvious options immediately available that would address the loss of employment due to the closure of refineries. This can be seen in Table 4, which summarises the participants together with the costs and benefits (in a qualitative sense).

Table 4: Summary of options

OPTION	PARTICIPANTS	COSTS	BENEFITS
Closure	• Oil companies that own refineries	• Employment losses	• Emissions from oil refineries stop
Import terminals	• Oil companies that own refineries	• Supply risk increased due to increased imported product volumes	• Retention of some refinery jobs
Biorefinery	• Government (Department of Mineral Resources and Energy, DSI, Department of Environment, Forestry and Fisheries, Department of Agriculture, Land Reform and Rural Development, Newcos, oil companies	• Timing mismatch between closure of oil refineries and start-up of biorefineries • Small-scale • Other than molasses fed plants, nothing built yet • Product cost currently higher than fossil fuel products	• New employment opportunities created • Established technology • Possible use of existing oil refinery sites • Sites geographically dispersed • SAF production for local use and exports
Conversion of CO_2	• Sasol, Newcos	• New technology, in early stages of commercial operation • Not all existing refinery sites suitable	• Employment retention/creation • Feedstock for green hydrocarbon products (e.g. plastics, polymers fertilisers)
Green hydrogen	• Various Industry players (as shown in section 5.3)	• Current cost of production from renewable energy is higher than fossil feedstock • Crowded space	• Creates new employment opportunities • Use of some existing refinery sites possible • Strong global interest & future demand – support new exports which will contribute positively to the South African balance of payments

Note: The term Newcos is used to signify companies that are not yet operating in an option or are still to be formed to do so.

6. CONCLUSION

This report provided a preliminary analysis of the employment impact of the current and forthcoming transformation of the liquid fuel refining and logistics value chain in South Africa

From the data available (FTI Consulting, 2021), in 2019, there were 95 309 total jobs (direct and indirect) involved in Feedstock and Imports, Refining and Manufacturing and Distribution and Storage. Of these, it is estimated that a total of 4 089 were direct jobs in the sectors mentioned, indicating that more indirect jobs are at risk (compared to direct jobs. This may make it more difficult to access more granular data that is needed for planning a just transition.

In the refining sector, which is already experiencing changes in operations, the 64 121 jobs reported in 2019 are at risk. Of the total jobs, it is estimated that 2 751 were direct jobs. As many of the refining sites will continue to operate as import terminals, not all these jobs will be lost, however, only a low percentage of the total will continue to have jobs. As result, this sector of the value chain needs immediate attention if a just transition is to be achieved.

New or alternative technologies and processes that can use the skills of employees from the refining sector include the development of biorefineries, the conversion of CO_2 and the production of green hydrogen, but the implementation of these technologies or processes has not yet started locally. Consequently, these would not address the immediate loss of jobs in the refining sector. However, in the future, as these initiatives develop, there should be new job opportunities.

Further work, together with studies already conducted (Bole-Rentel, Chireshe and Reeler, 2022) would provide a better understanding of the types and numbers of new jobs that would become available as well as where they are located.

In the logistics sector, the loss of jobs will not be immediate but employment will reduce over time since the demand for liquid fuels will reduce as the transport sector moves away from fossil fuels to electric mobility and sustainable fuels. Initial estimates (NBI, 2022) are that the demand reduction will start to impact from 2035 (NBI, 2021). Consequently, the just transition related to these jobs can be better planned if work is initiated promptly.

However, to produce a meaningful plan to ensure a just transition for those employed in these sectors, greater granularity is required about both direct and indirect jobs, i.e. type of job, level in the organisation, number of positions existing, years of experience required, minimum qualification required, age of incumbent and salary. To access this level of information, South African oil companies and their service organisations would need to be prepared to share the data required.

Ultimately, it is vigorous growth of the South African manufacturing sector that would enable a just transition for employees of the local LFI by offering an increased number of opportunities for all job categories.

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