EXPLORING ALTERNATIVE OPTIONS FOR COAL TRUCKERS IN A BIOMASS SUPPLY CHAIN

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EXECUTIVE SUMMARY

The energy transition will result in a decrease in the use of coal, and by implication a decrease in coal hauling jobs. About 4 000 people are employed as drivers of coal trucks in South Africa at present. Given the wide biomass feedstock base and similarities between the hauling practices of coal and biomass, there is an opportunity for coal truckers to find alternative livelihoods by transporting sustainable biomass for new green industries. There are many forms of biomass that can be used for a variety of energy uses. The job numbers presented in this report are based on the assessment of production potential for sustainable aviation fuel (SAF) in South Africa. Other final uses of biomass would, however, generate similar transport employment opportunities.

Sustainable biomass supply chains for SAF production in South Africa were modelled using a centre of gravity analysis to determine optimal locations for biomass processing facilities, based on the resource distribution. Trucking jobs required to service nationwide supply chains were then estimated. Only biomass trucking jobs within geographic proximity to coal mines were considered to have the potential to offset the losses in coal trucking jobs, as the home base for those drivers would remain the same.

The analysis shows that transporting lignocellulosic biomass, such as cleared invasive alien plants or garden waste, could create almost 3 000 jobs for drivers of side tipper trucks (used currently for coal transportation), meaning that almost 75% of the current coal jobs could be directly transitioned to biomass transport. Producing SAF from lignocellulosic biomass would provide the most employment opportunities for truck drivers due to its low bulk density and the need to be transported over long distances. Furthermore, developing domestic SAF production capabilities could create employment opportunities for over 550 drivers of super link trucks (large flatbed truck) for transporting Solaris tobacco seeds from the farming fields to oil extraction facilities and more than 300 tanker drivers for transporting vegetable oil, ethanol and syncrude to where they are further refined into SAF. In addition, about 400 support jobs could be created across all the supply chains, and most of the current employment in truck maintenance and refuelling would be preserved.

Biomass hauling represents a significant opportunity to offset a large part of jobs that will gradually be lost in the coal trucking sector. Tipper truck drivers would be required in their thousands, making this an important part of the just transition for workers dependent on the coal value chain, thus ensuring that South Africa's move to a low-emissions economy is inclusive and equitable, and protects communities and workers so they are not left worse off. Capturing the additional employment opportunity for super link drivers would require the conversion of some of the current coal trucks into flatbeds, which would require additional investment.

Some training may be necessary to allow coal truckers to transition to tanker jobs. These tanker jobs could also be taken up by drivers currently being used in the petroleum products value chain, which is also expected to shrink in the longer term as South Africa decarbonises its transport sector.

Critically, to realise this potential and provide a source of sustainable livelihood to coal truck drivers, South Africa must embrace the role of the bio-based and circular economy in its just transition and implement it in conjunction with other low-carbon freight solutions.

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ABBREVIATIONS

1G	First Generation
2G	Second Generation
3G	Third Generation
CSIR	Centre for Scientific and Industrial Research
GFT	Gasification and Fischer-Tropsch
GHG	Greenhouse Gas
GIS	Geographic Information System
COG	Centre of Gravity
IAPs	Invasive Alien Plants
SAF	Sustainable Aviation Fuel

1. INTRODUCTION

The energy transition will see a decline in the use of coal, which coincides with a reduction in coal trucking jobs. About 4 000 people are employed as coal truckers in South Africa at present (Makgetla et al, 2019). Considering the extremely high unemployment rate in the country, any additional job losses should be avoided or compensated with transferable employment opportunities.

Because of similarities in transport method (similar truck type) and some geographical overlap, sustainable biomass supply chains can provide alternative business and employment opportunities for coal truckers, if the bio-economy takes off in South Africa. Therefore, its role in the just transition should be given due consideration.

This study has been conducted on the back of WWF South Africa's assessment of the sustainable aviation fuel (SAF) production potential in South Africa (WWF South Africa, 2022), but provides an indication of the job creation potential associated with biomass transportation overall. Indeed, while some of the trucking jobs identified in this study are specifically related to establishing domestic SAF production capabilities, a large number of the employment opportunities identified would materialise even if the biomass is used for other purposes.

The report is structured as follows: Section 2 describes the approach and methodology followed to estimate the biomass trucking jobs. Section 3 breaks down the trucking job potential from the different SAF production pathways evaluated. The key conclusions are summarised in Section 4 and Appendix A gives further details on the trucker jobs modelling and assumptions.

2. APPROACH

The analysis of the number of trucking jobs in biomass supply chains that could offset the loss of coal trucking jobs is simple but builds on a complex analysis undertaken to assess the SAF production potential in South Africa (WWF South Africa, 2022), and the modelling of its possible supply chains, which has been undertaken in collaboration with a logistics service provider.[1] WWF South Africa's assessment evaluated the total production potential of SAF in South Africa from several feedstocks (Solaris tobacco, A-molasses, industrial off-gases and lignocellulosic wastes). This analysis included an evaluation of several SAF production pathways on a techno-economic basis and the potential to reduce greenhouse gas emissions. For pathways that competed for the same feedstock, the one that was most cost-effective and produced the most amount of SAF, while meeting the minimum greenhouse gas (GHG) reduction criteria required for sustainability certification, was chosen as desirable. In total, the potential to produce over three billion litres of SAF has been identified for South Africa.

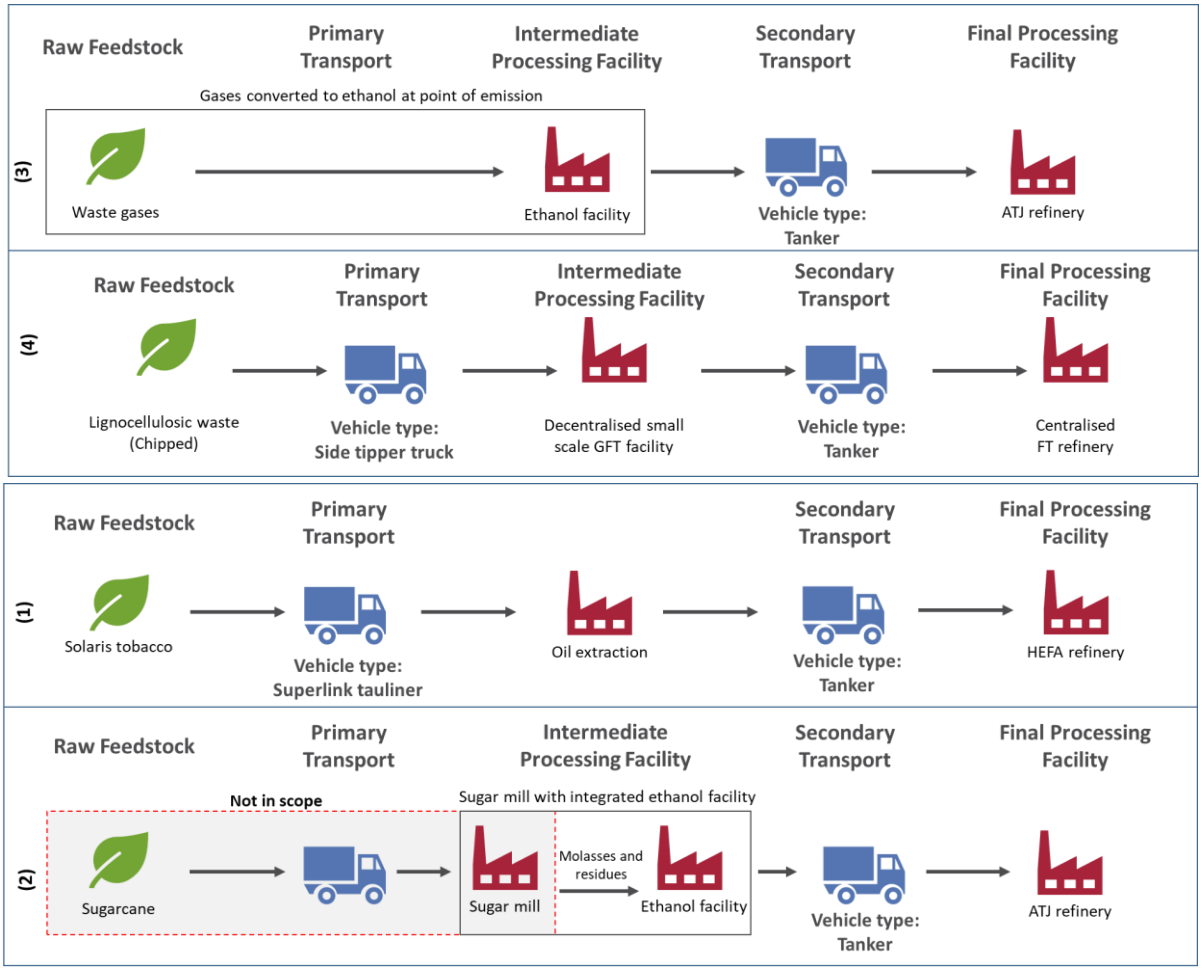
The transport job analysis starts with the selection of the identified feedstocks, the modelling of their location-dependent supply chains, and an estimation of the number of trips required to transport the biomass from its point of origin to the processing plants, which depend on the distance, truck capacity and shift type. From this, the number of biomass trucking jobs was estimated in consultation with logistics companies and based on industry standards. Biomass hauling and the associated jobs are disaggregated into "primary transport" which refers to moving the biomass from its point of origin (agricultural field or clearing area) to a processing plant that turns it into a SAF intermediate (vegetable

[1] The estimate of biomass trucking jobs has been undertaken for WWF South Africa by Imperial Logistics; a slide deck with the analysis is available on request.

oil, ethanol or syncrude) and "secondary" transport that moves the intermediate product to a facility that will process it into SAF.

A more detailed description of the approach to estimating the number of jobs in biomass hauling can be found in Appendix A. The biomass supply chains considered are summarised in Figure 1.

Figure 1: Overview of biomass-to-SAF supply chains analysed for possible job transfers



In the final step of the analysis, with the help of a geographic information system (GIS), the numbers and routes (and related home bases) of truck drivers that would be required to transport the biomass and SAF intermediates were overlayed with coal producing areas, to estimate opportunities for job transfer between the two. The location of current coal trucking jobs in South Africa was approximated to those of the coal mines. This is because trucks are generally used to transport coal over short distances (Ratshomo and Nembahe, 2016), thus the drivers will most likely reside in the vicinity of these mines.[2] The intersection between the two supply chains is where the opportunity for job transfers are most likely.

[2] A list of currently operating coal mines was obtained from Quantec EasyData. 2021. Operating Mines by Type of Mine and Commodities at District Level. Pretoria. Available from: https://www.quantec.co.za/.

3. RESULTS

This section unpacks the trucking job creation potential of the different pathways presented in Figure 1. The bubbles on the maps in this section show the home bases of drivers who would be required to haul biomass and its intermediates for the supply chains analysed, i.e. where they would operate from and their distribution across South Africa. The home bases were chosen to be the intermediate processing facility locations on the basis that both primary and secondary transport operates from the intermediate processing facility. The size of the bubbles shows the difference in the number of drivers required in each area to support the production facilities located therein.

3.1 Pathway 1: Solaris seeds and vegetable oil

Based on the analysis of the potential for sustainable production of Solaris seeds in South Africa (Fischer et al, 2019), the number of trucks and the related driver jobs and supporting roles required to transport a) the seeds to a vegetable oil extraction facility (primary transport), and b) the vegetable oil to a SAF refinery (secondary transport), are as shown in Table 1 and Table 2.

Table 1: Primary transport job analysis breakdown for vegetable oil-based pathway

TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Primary	12 hr 5 days	649	837	40	20	40	937
Primary	15 hr 5 days	519	670	40	20	40	770
Primary	24 hr 5 days	324	837	80	20	40	977
Primary	24 hr 7 days	232	598	161	20	40	819

Table 2: Secondary transport job analysis breakdown for vegetable oil-based pathway

TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Secondary	12 hr 5 days	133	172	10	5	10	197
Secondary	15 hr 5 days	106	137	10	5	10	162
Secondary	24 hr 5 days	66	172	20	5	10	207
Secondary	24 hr 7 days	47	123	41	5	10	179

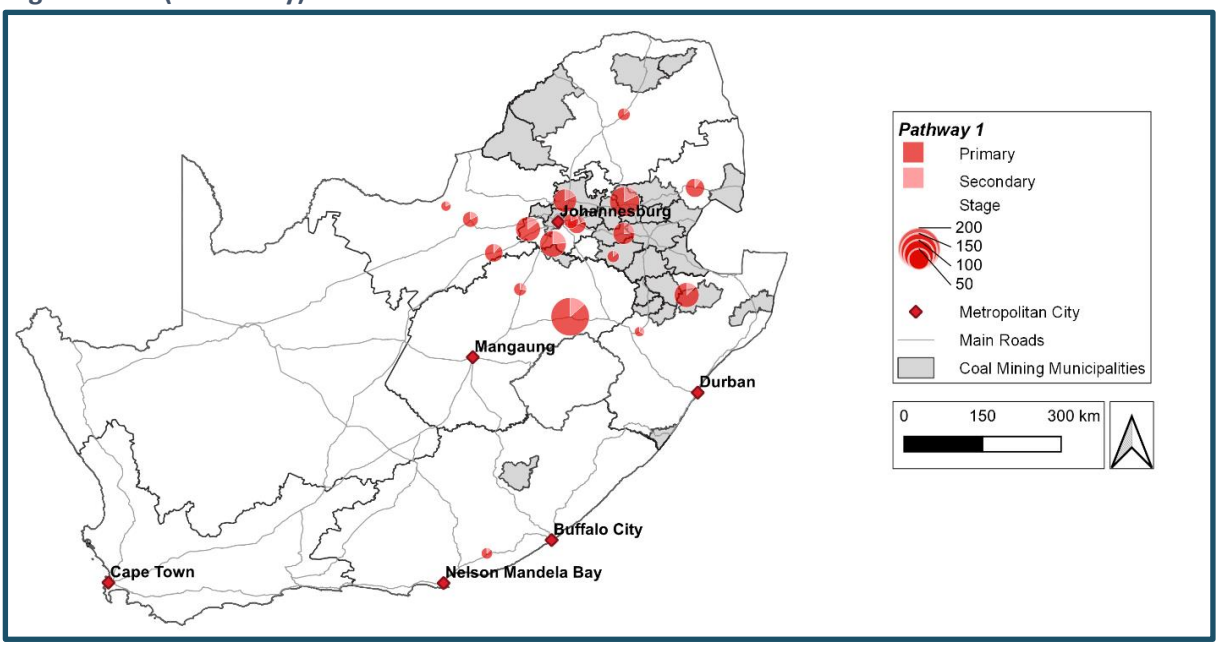
As can be seen from Table1 and Table 2, a 12 hours/day, 5 days/week shift model would require almost 650 trucks to move the Solaris seeds from the fields to the oil press, which would create close to 840 driver positions and another 100 supporting roles, in addition to preserving most existing jobs in truck maintenance and refuelling. A 24-hour shift for the same number of days (5) would half the number of trucks but require the same number of drivers. Extending the shift length to 15 hours/day or 7 days/week reduces the number of trucks required and the corresponding number of drivers.

In addition, transporting the vegetable oil from the presses to a SAF refinery would require about 170 drivers working 12 or 24 hours/day, 5 days/week, or almost 140 drivers operating 15 hours/day, 5 days/week or about 120 drivers operating 24 hours/day, 7 days/week.

To assess the transferability of coal trucking jobs to this supply chain, their distribution in relation to existing coal trucking routes must be considered. The bubbles in in Figure 2 show the distribution of the home bases for the drivers that would be required for the primary and secondary transportation legs in this supply chain based on a 12 hour/day, 5 days/week shift. The shaded areas on the map show the municipalities that have coal mines, and it can be seen that a large portion of the jobs from the vegetable oil supply chain would be located within the coal mining regions. Of the potential 1 009 trucking jobs in the Solaris-vegetable oil supply chain, 663 or about 2/3 overlap with coal regions and

could represent realistic opportunities for coal truck drivers. The vast majority of those are in the primary transportation leg and would require drivers of superlink tautliners.

Figure 2: Distribution of home bases for drivers required to transport Solaris seeds (primary) and vegetable oil (secondary) across South Africa



For other shift types, the facility locations all remain the same; however, the number of driver jobs (and hence bubble sizes in Figure 2) changes in accordance with Table 1 and Table 2.

3.2 Pathway 2: A-molasses ethanol

Based on the analysis of the production potential for SAF from A-molasses-based ethanol (WWF South Africa, 2022), the number of trucks, the related driver jobs and supporting roles required to transport the ethanol to a SAF refinery are as shown in Table 3. Only the secondary leg is considered as the supply chain for the primary leg (plantation to sugar mill) already exists.

Table 3: Secondary transport job analysis breakdown for first generation (1G) ethanol pathway

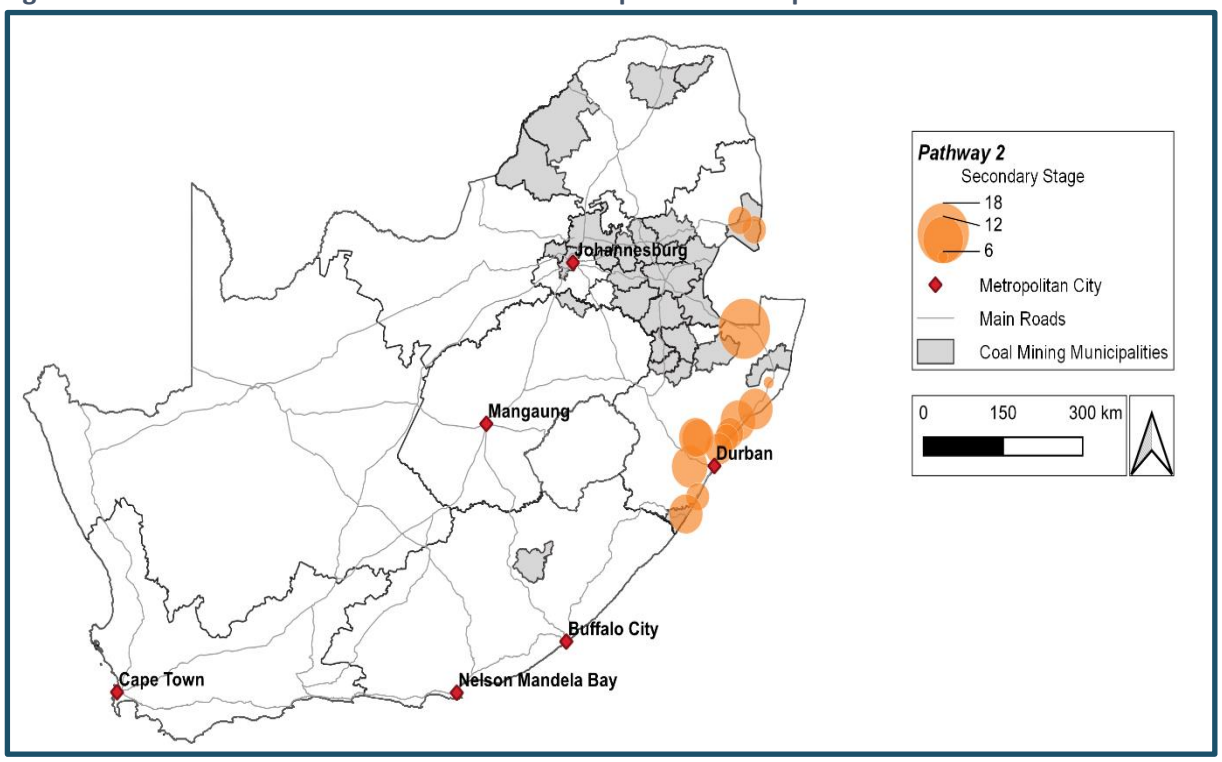
TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Secondary	12 hr 5 days	100	130	7	3	6	146
Secondary	15 hr 5 days	80	104	7	3	6	120
Secondary	24 hr 5 days	50	130	13	3	6	152
Secondary	24 hr 7 days	36	93	26	3	6	128

As can be seen from Table 3, a 12-hour/day, 5-days/week shift model would require 100 tanker trucks to move the ethanol from the sugar mills to a centralised SAF refinery, which would create 130 driver positions and another 16 supporting roles. Again, a 24-hour shift for the same number of days (5) would half the number of trucks but require the same number of drivers. Extending the shift length to 15 hours/day or 7 days/week reduces the number of trucks required and the corresponding number of drivers as well as the existing maintenance and refuelling jobs that would be preserved.

Figure 3 shows the distribution of the home-bases for drivers required to transport A-molasses derived ethanol for a 12-hour, 5-days/week shift model. The majority of the driver jobs are located in KwaZulu-Natal and are therefore far from the coal mining regions. Only 48 of the potential 130 trucking jobs in

the A-molasses supply chain are located in proximity to municipalities with registered coal mines and none are based in the country's coalfields.

Figure 3: Distribution of home-bases for drivers required to transport A-molasses derived ethanol



3.3 Pathway 3: Industrial off-gas ethanol

Based on the analysis of the production potential for SAF from industrial off-gas-based ethanol[21], the number of trucks, the related driver jobs and supporting roles required to transport the ethanol to a SAF refinery are as shown in Table 4. Once again, only the secondary leg is considered, this time because the feedstock production (industrial off-gas) and its conversion to ethanol take place at the same site.

Table 4: Secondary transport job analysis breakdown for the off-gas ethanol pathway

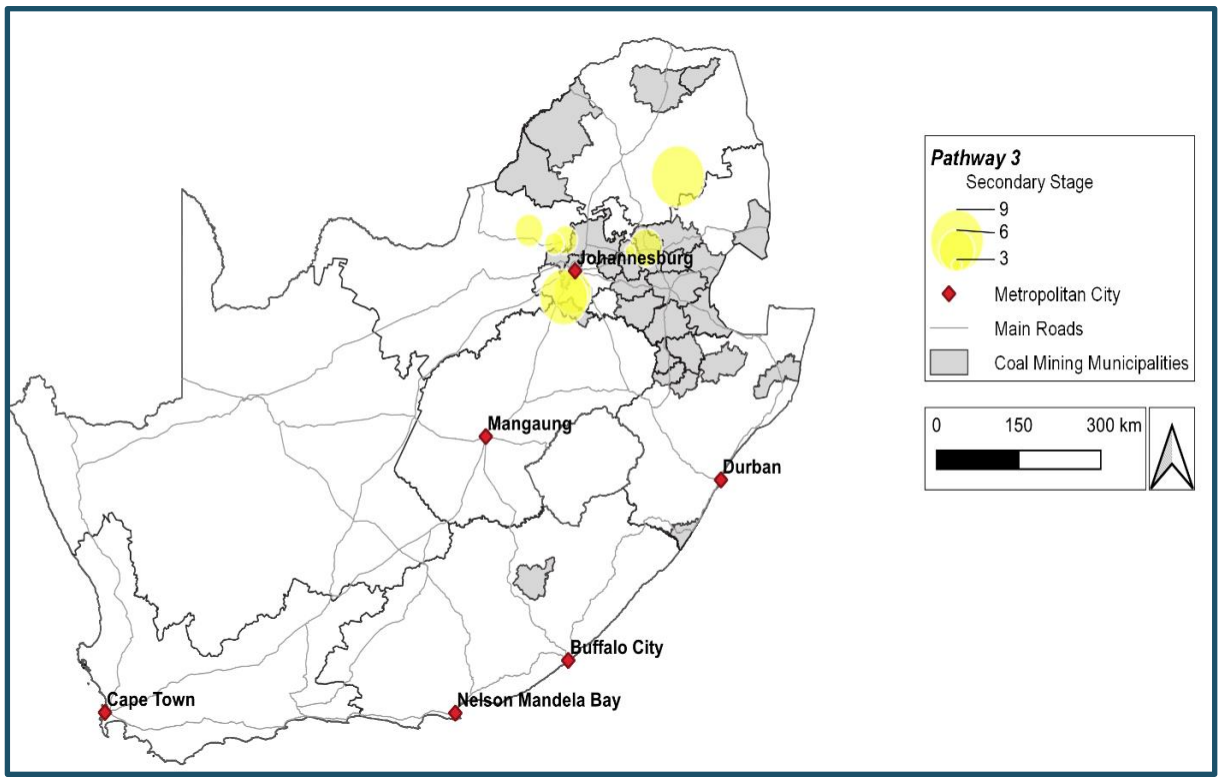
TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Secondary	12 hr 5 days	36	47	2	1	2	52
Secondary	15 hr 5 days	29	38	2	1	2	43
Secondary	24 hr 5 days	18	47	3	1	2	53
Secondary	24 hr 7 days	13	34	6	1	2	43

As can be seen in Table 4, a 12-hour, 5-days/week shift model would require 36 tanker trucks to move the ethanol from the industrial site producing the off-gas to a centralised SAF refinery, which would create almost 50 tanker driver positions and another five supporting roles in addition to the preservation of existing maintenance and refuelling jobs. Again, a 24-hour shift for the same number of days (5) would half the number of trucks but require the same number of drivers. Extending the shift length to 15 hours/day or 7 days/week reduces the number of trucks required and the corresponding driver requirements.

Figure 4 shows the distribution of the home bases for drivers required to transport industrial off-gas derived ethanol for a 12-hour 5-days/week shift model. All 47 driver jobs are located near the coal

regions. With the additional training required to operate a tanker truck, this supply chain would be a feasible opportunity for drivers currently engaged in transporting coal. As in other relevant pathways, for other shift types, the facility locations all remain the same, however the number of driver jobs (and hence bubble sizes in Figure 4) changes in accordance with Table 4.

Figure 4: Distribution of home bases for drivers required to transport industrial off-gas derived ethanol



3.4 Pathway 4: Lignocellulosic biomass and syncrude

Table 5 and Table 6 are based on the Centre for Scientific and Industrial Research's (CSIR) assessment of the current availability of accessible alien invasive biomass across South Africa and show the number of trucks; the related driver jobs and supporting roles required to transport the chipped biomass to a gasification and Fischer-Tropsch (GFT) plant (primary transport) and the syncrude to a SAF refinery (secondary transport).

Table 5: Primary transport job analysis breakdown for lignocellulose-based pathway

TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Primary	12 hr 5 days	4762	6 143	257	128	256	6 784
Primary	15 hr 5 days	3809	4 914	257	128	256	5 555

Table 6: Secondary transport job analysis breakdown for lignocellulose-based pathway

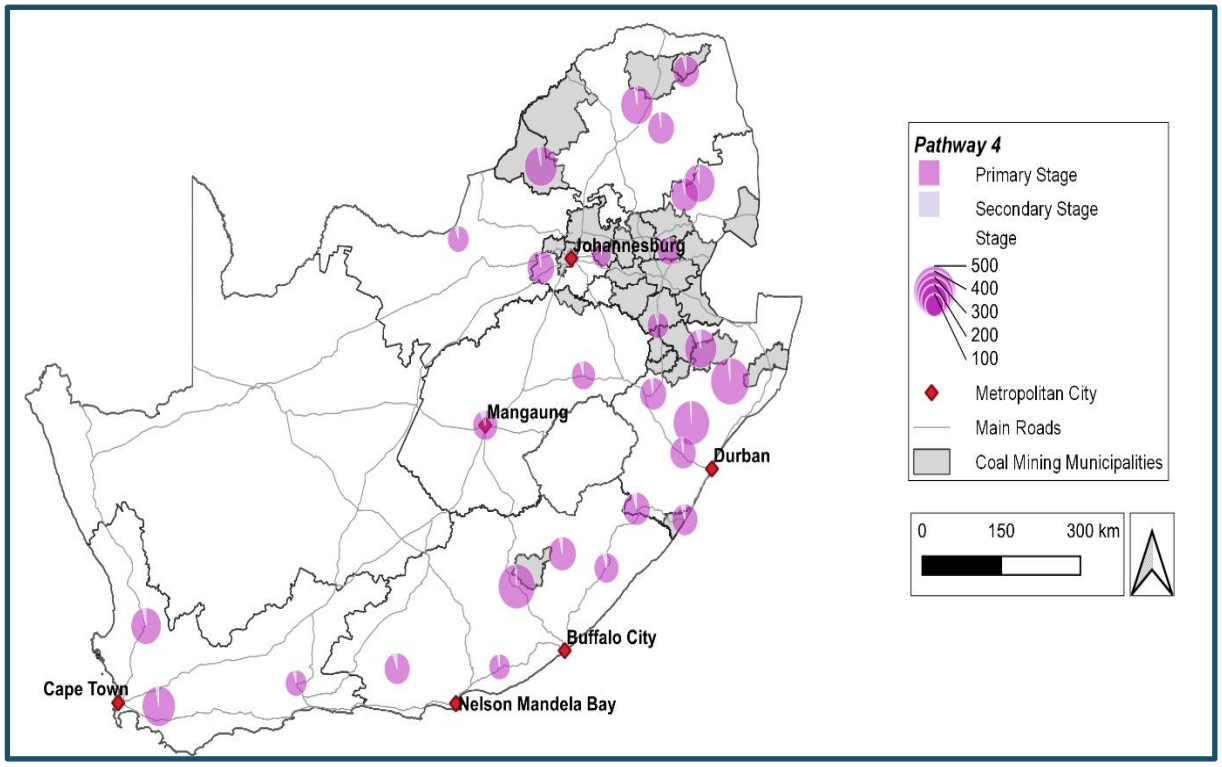
TRANSPORTATION STAGE	SHIFT TYPE	TRUCKS REQUIRED	DRIVERS REQUIRED	CONTROLLERS	PROOF OF DELIVERY CLERKS	FINANCE CLERKS	TOTAL JOBS
Secondary	12 hr 5 days	186	240	7	3	6	256
Secondary	15 hr 5 days	149	192	7	3	6	208
Secondary	24 hr 5 days	93	240	14	3	5	262
Secondary	24 hr 7 days	66	171	27	3	5	206

As can be seen from the Tables 5 and 6, a 12 hours/day, 5-days/week shift model would require almost 4 800 trucks to move the chipped alien invasive biomass from clearing sites to a number of GFT plants dotted around the country, which would create over 6 000 driver positions and almost 650 supporting roles. As before, a 24-hour shift for the same number of days (5) would half the number of trucks but require the same number of drivers. Extending the shift length to 15 hours/day or 7 days/week reduces the number of trucks required and the corresponding number of drivers.

Transporting the syncrude produced at the GFT plants to a SAF refinery would require almost 190 tanker trucks operated by 240 tanker drivers operating 12 or 24 hours/day 5 days/week, or about 190 drivers operating 15 hours/day 5 days/week or about 170 drivers operating 24 hours/day, 7 days/week.

The bubbles in Figure 5 depict the distribution of all the drivers' home bases, broken down per transportation stage for a 12-hour 5-days/week shift model. A total of 3076 driver jobs could be created in coal regions through this supply chain, most of them in the primary transportation leg that uses tipper trucks, making it the pathway (out of the four explored) with the highest trucking employment potential. This is just under half of the 6400 trucking jobs which could be created nationally through this supply chain, in addition to the existing maintenance and refuelling jobs that would be preserved.

Figure 5: Distribution of home-bases for drivers required to transport lignocellulosic biomass (primary stage) and syncrude (secondary stage)



As in other relevant pathways, for other shift types, the facility locations all remain the same, however, the number of driver jobs (and hence bubble sizes in Figure 5) changes in accordance with Table 5 and Table 6.

3.5 Combined pathways

The four pathways assessed are not mutually exclusive and can exist in parallel. If South Africa were to develop a SAF sector that would take full advantage of locally available sustainable feedstock opportunities, this could result in almost 7 500 jobs for truck drivers, of which the vast majority (almost 7 000) would be in the primary transportation leg, as well as another 840 supporting roles, as can be seen in Table 7. This is in addition to the existing maintenance and refuelling jobs that would be preserved.

Table 7: Total number of transport jobs for all SAF pathways

PATHWAY	PRIMARY LEG DRIVERS	SECONDARY LEG DRIVERS	SUPPORT JOBS	TOTAL JOBS
1,2,3,4	6 990	493	837	8 320

Figure 6 shows the distribution of home bases for drivers required to facilitate all the assessed SAF chains. Of the nation-wide potential to create some 7 500 trucker jobs in hauling biomass and various liquid products derived from it, over 3 800, about half, would be based in coal regions. The breakdown of these jobs by truck type is given in Figure 7.

Figure 6: Distribution of home-bases for drivers required to facilitate biomass supply chains in South Africa

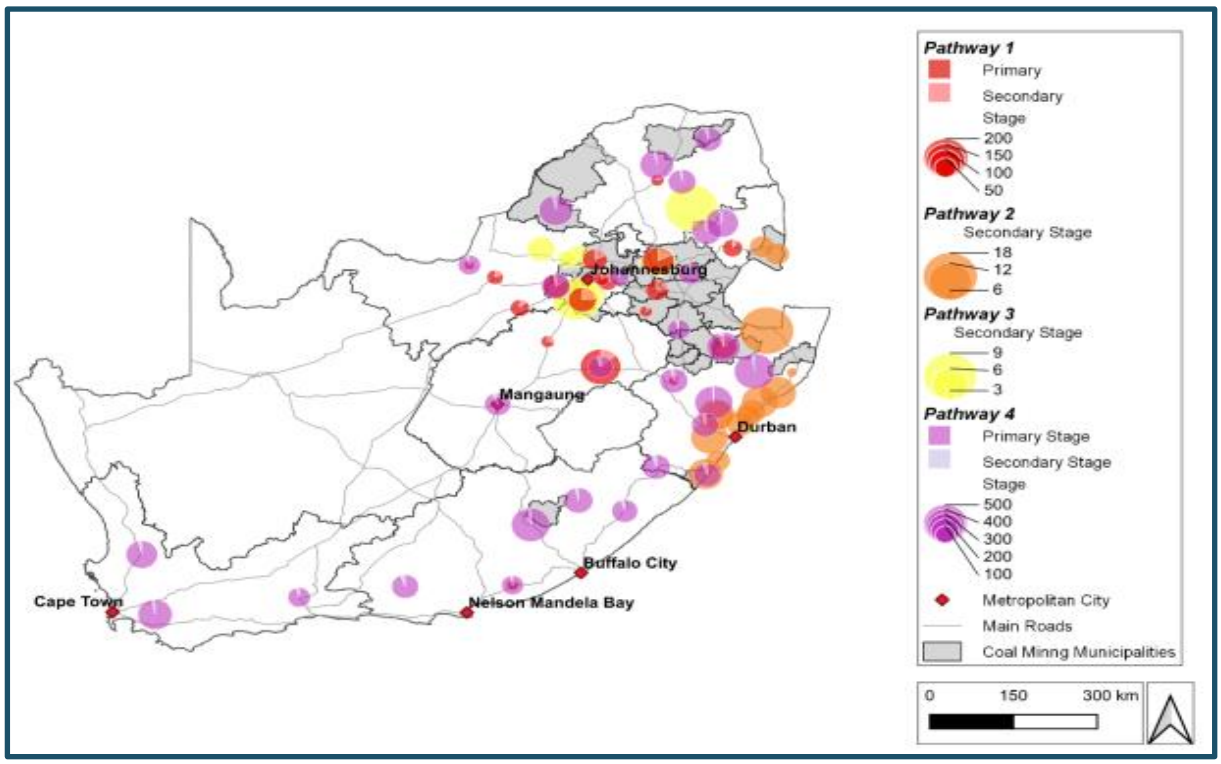
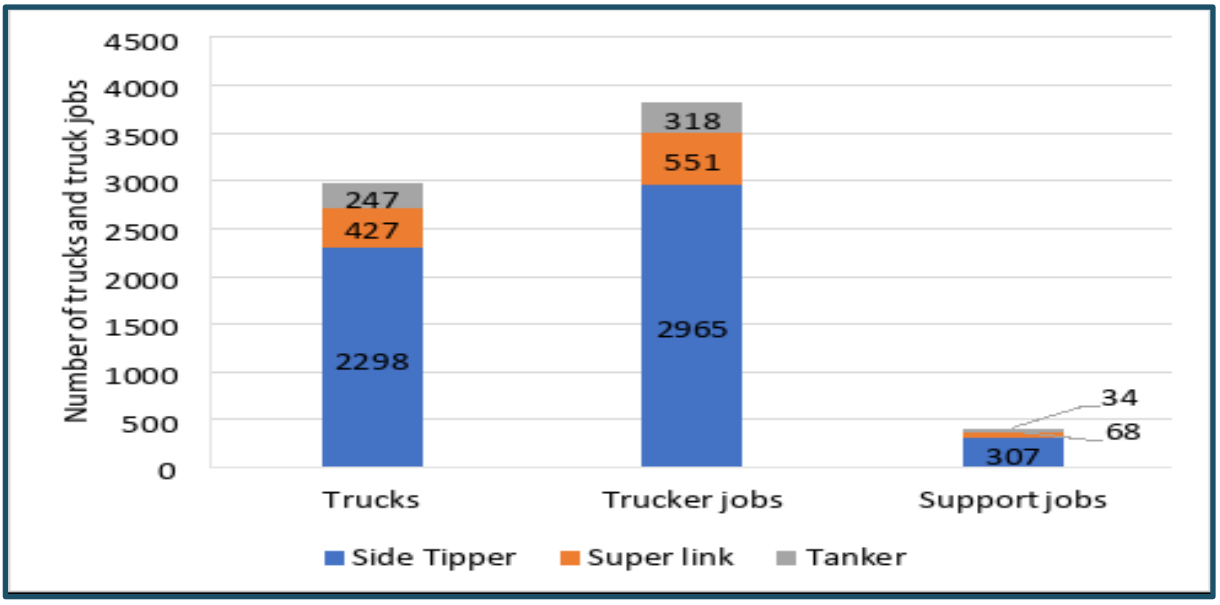


Figure 7: Potential number of trucks and jobs created by implementing biomass supply chains in coal regions



The approximately 3 800 truck driver positions required to move biomass and its intermediates across South Africa's coal regions could provide an alternative livelihood for the vast majority of the approximately 4 000 coal truckers in the country (Makgetla et al, 2019). Of these, the total number of directly transferable side tipper truck jobs is almost 3 000, with a corresponding truck requirement of almost 2 300 trucks. Thus, almost three out of four current coal drivers could transition to biomass trucking using the same types of trucks that the industry uses at present.

The potential number of biomass-related superlink trucker jobs in the coal mining regions is about 550, which represents a further 14% of current coal transport jobs. About 430 superlink trucks would be required, which means that current coal truck trailers would have to be converted to flatbed trailers. This conversion would require a capital investment of about R200 000 to R 300 000 a truck (Makgetla et al, 2019).

Finally, about 250 tankers operated by 320 drivers would be required to move intermediate products to SAF refineries located in the coal regions. There would be additional tanker driver jobs related to the transport of the final SAF product to airports or shipping ports for export, which were outside the scope of this analysis.

Tanker driving is a specialised skill and additional training may be required for coal drivers to switch to tankers. It should also be noted that tankers and drivers from the liquid petroleum sector could transition to drive biomass derived liquid fuels as an uptake of renewable fuels would mean a decline in the consumption of petroleum products.

4. CONCLUSION

The potential for biomass supply chains to provide alternative employment opportunities for people currently employed in coal trucking is vast. Side tipper trucker jobs are a low-hanging fruit as they are used both for the transportation of coal and the largest source of sustainable biomass in South Africa, namely invasive alien plants. Almost 75% of the current coal jobs could be directly transitioned to biomass transport via side tipper trucks.

In addition, the biomass supply chains considered in this study could supply over 600 superlink driver jobs. About 480 superlink trucks would be required, which means some of the current coal side tipper trailers would have to be converted to flatbeds. This would require some capital investment.

More than 300 tanker driver jobs could furthermore be provided by the biomass supply chain. This would require about 250 tankers, and an investment in new tanker trucks. Coal truckers may also need additional training to drive tankers. However, this could also be an opportunity for tanker drivers in the petroleum sector, which could see a decline in jobs in the future as a result of the transition from fossil fuels.

It is also worth noting that shifting coal transportation to biomass transportation would preserve most of the current employment in truck maintenance and refuelling.

It should be noted that a deep decarbonisation of the South African economy would require shifting much of the freight transportation from road to rail. As rail links cannot handle the first and last mile to and from rail stations, this would not significantly reduce the number of trucking jobs required, but only the distance travelled and with that the transport emissions. Another way to minimise the climate impact of transport-intensive supply chains such as biomass is to use alternative fuels in trucks. There are already a number of initiatives aimed at introducing hydrogen trucks in South Africa. These are currently focusing on reducing emissions of mining products, but could be equally relevant for biomass supply chains. Biofuel blends could also play a (limited) role in decarbonising road freight; however, sustainable biomass is better used in higher-value products and applications that have no decarbonisation alternatives.

Finally, to realise this potential and provide a source of sustainable livelihood for coal truck drivers, South Africa must embrace the role of the bio-based and circular economy in its just transition, and in particular the role of SAF in decarbonising its aviation sector, as well as the opportunity this represents for export. Time and again, renewable energy value chains have been shown to provide at least the same or more employment opportunities than fossil-based ones. The specific case analysed in this report is in line with this general rule.

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APPENDIX A – BIOMASS HAULING JOBS MODELLING APPROACH AND ASSUMPTIONS

Feedstock selection

The estimation of biomass hauling jobs starts with a selection of biomass and waste materials that can be used to produce a final product, in this case SAF. SAF can be produced from a wide variety of feedstocks processed by a multitude of technologies. Estimates of the production potential of sustainably grown energy crops in Sub-Saharan Africa show that the technical potential for purposely grown crops in South Africa is sizeable, however, only a fraction of that would be economical to produce (Fischer et al, 2019). For economic and sustainability reasons, a variety of wastes and residues should also be considered as feedstocks for the production of sustainable transport fuels, including SAF.

To determine the most realistic pathways for the development of a SAF industry in South Africa (and the trucking jobs that go along with it) in the next five to 10 years, the following feedstocks have been selected. These can be combined into different feedstock-technology-network combinations (pathways) to cover the various ways in which SAF could be produced in South Africa:

1. Solaris: a new variety of tobacco plant specifically developed for oil seed production, as a source of vegetable oil, that can be processed into a variety of bio-based products, including SAF and biodiesel. Solaris has been successfully grown in South Africa and was the feedstock used in the first SAF-powered flights in South Africa in 2016 (SAA, 2016). Most of its production potential is located in the northeast part of the country, where most of the transport jobs related to its hauling would also be based.

   To bring the Solaris seeds from field to a pressing facility where the oil is extracted, the superlink tautliner with a typical capacity of 34 tonnes was found to be the most suitable transport vehicle. From there, a tanker truck would transport the oil to a SAF refinery.

2. A-Molasses: a co-product of sugar production that could see its output readily scaled-up at existing sugar mills (mostly located along the east coast) and converted to 1G ethanol, which can be further processed into SAF. This would reduce somewhat the sugar output of South Africa but is in line with the new Sugarcane Value Chain Masterplan (SASA, 2020) that aims to diversify market opportunities for sugarcane products in view of the prolonged global sugar glut. Redirecting part of the sugar cane production from sugar to SAF would not create additional jobs in the primary transport (hauling sugar cane from the fields to the sugar mills), but would rather preserve the existing ones, as the industry is otherwise likely to curtail sugar production.

   A-molasses can be processed into ethanol at the sugar mill site, which would then be transported with tanker trucks to a SAF refinery.

3. Carbon monoxide-rich industrial off-gases from South Africa's heavy industry can be used for carbon recycling and the production of third generation (3G) ethanol, that can be further processed into SAF. The locations of off-gas production sites are known (ferroalloy and steel plants) (Bole-Rentel et al, 2021).

   Similar to A-molasses, the conversion to ethanol takes place at the same site where the off-gases are produced, and the ethanol would then be transported to a SAF refinery with tanker trucks.

4. Lignocellulosic (woody) biomass in the form of invasive alien plants (IAPs) and garden waste. IAPs are found throughout South Africa and the majority (approximately 68%) are woody trees and have been the focus of control efforts, as per the regulations of the National Environmental Management: Biodiversity Act 10 of 2004. Due to the extent of invasions and the need for their

removal, IAPs are the largest source of sustainable carbon for the production of second-generation (2G) biofuels in South Africa, including SAF. In anticipation of the updated National Inventory of Alien Plants, the CSIR, commissioned by WWF South Africa, produced a high-level, deduced current availability of alien invasive biomass in South Africa[3] on which this analysis is based.

Garden waste is often taking up valuable landfill space instead of being used as a highly sustainable, easily exploitable source of lignocellulose, where its collection is centralised by municipal waste management services. It can be co-processed into 2G ethanol or syncrude with IAPs, and then further into SAF. Unfortunately, data on garden waste availability is patchy, therefore the study only considers that which is collected and reported by a few major metros.

Cleared IAPs and garden waste would need to be chipped prior to transportation with a tipper truck to a facility where they would be converted to either ethanol or syncrude. From there, tanker trucks would transport the ethanol or syncrude to a SAF refinery.

Some of the SAF pathways analysed thus have a primary transportation leg which involves the movement of biomass from the source areas to central processing facilities where the biomass is converted to an intermediate product such as ethanol, syncrude or vegetable oil. All the pathways have a secondary leg that involves transporting the intermediate product to a refinery where it is further refined into SAF.

While more production pathways/supply chains are possible based on the possible feedstock-technology combinations (WWF South Africa, 2022) as mentioned above, this report focuses on those perceived to be the most likely based on technology readiness, existing experience and cost-efficiency.

Centre of Gravity analysis

A centre of gravity (COG) analysis was conducted to determine the optimal locations for the intermediate biomass processing facilities, as well as the location of the SAF refineries.

The COG model grouped feedstock sites and calculated the weighted COG to optimise facility locations such that transport distances, costs and emissions were minimised. In the cases where the COG led to unviable areas (i.e. no basic infrastructure, too distant from major routes), it was moved to the nearest town.[4] Note that for pathways 2 and 3, based on A-molasses and industrial off-gasses, primary transport is not applicable as the feedstock production and its conversion to a SAF intermediate (1G and 3G ethanol, respectively) takes place at the same site.

Truck selection

For lignocellulosic biomass (IAPs and garden waste), side tipper trucks were found to be most suitable because they are mainly used for the transport of loose materials and allow for easy loading and unloading at sites. The study considered 34-ton capacity tipper trucks (with a volume capacity of 44 m^3). It was assumed that these trucks can directly replace the approximately 33-ton side tipper trucks which transport coal to Eskom's power plants (Morris, 2019).

Tankers with a volume capacity of 44 m^3 were selected to transport the flammable liquid products (vegetable oil/ethanol/syncrude/jet fuel).

[3] Available on request.

[4] The COG was not relocated if the distance between the COG result and the nearest town was less than 30 kilometres, as it was assumed that a distance of less than 30 kilometres from the nearest town is close enough for workers to have access to public transportation, infrastructure, and other amenities.

It was assumed that skills for driving the same type of truck are transferrable irrespective of the kind of load carried and that tanker driving is a specialised skill and additional training is required (MacMillan, 2019; HYTT Communications, 2020).

Loading and offloading times

The loading and offloading times per truck heavily influence the number of trucks and drivers required per pathway. Longer loading times result in fewer trips being possible per day. For tankers and the superlink truck, the loading and offloading times are assumed to be two hours, while for the side tipper truck, the loading time was pegged at two and a half hours, and the assumed offloading time at one hour.

Shift selection

Shift selection is heavily dependent on the type of operation that the facility is capable of sustaining. For example, the operations at the source of the lignocellulosic feedstock (extraction and chipping) are unlikely to be conducted on a 24-hour basis and therefore, only 12-hour and 15-hour shifts are applicable. However, for many off-gas facilities, 24-hour shifts are possible due to the industry standard of operating continuously. The intermediate product facilities (ethanol and syncrude production) also operate on a 24-hour basis, therefore 24-hour transport shifts are possible.

The type of shift selected determines the number of trucks required and the number of drivers. Choosing a 12-hour shift results in greater capital input to buy more trucks; and more trucks result in more drivers being required. A 24-hour shift has half the number of trucks but maintains roughly the same driver requirement. In addition, running 24-hour shifts would result in better use of trucks. This would result in less downtime for vehicles, which would lead to shorter pay off periods.

For 12-hour shifts, the number of drivers per truck is 1.29 to account for sick leave and annual leave. This ensures that there is always a driver on hand. For 24-hour shifts, there are always two drivers in a truck, as this is mandatory by law.

Key limitation

No routing analysis was done for the lignocellulosic biomass as the study focused on a high-level, nationwide scale. As a result, the analysis possibly overstates slightly the number of jobs that could be created by trucking lignocellulosic biomass. The pathways/supply chains analysed are modelled on the basis that a truck will drive to a point, load and then return. However, it is likely that, in reality, not all loading points in the supply chain will be sufficient to fill a truck. Therefore, when this supply chain is routed, multiple collection sites might be covered in a single trip. This will most likely reduce the number of trips required but will be at least partially offset by increased loading times per trip due to multiple collection sites. It is challenging to determine the specific impact of this at such a high level but is most likely to affect the lignocellulosic pathway, as it is the most dispersed. This effect would also be location and route dependent and would most likely require a site-specific study when the project approaches implementation.