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Facilitating sustainable economic development through circular *mobility*

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The intention of this short think piece on the circular economy in mobility, is to initiate discussion on the sector opportunities for South Africa. These opportunities are framed within the context of the current challenges facing the South African mobility sector.

Circular mobility has strong themes of shared, integrated, smart, and sustainable mobility, geared towards economic development while reducing the dependance on finite resources and improving the quality of life for society. A circular mobility system is accessible, affordable, and effective; it is multi-modal in that it incorporates public transportation in combination with flexible last-mile solutions. "*Faster decarbonisation of the transport sector is key to achieve the 1.5°C Paris agreement*."[1]

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CSIR Opinion Pieces and Briefing Notes provide perspectives on current science, technology and innovation developments, and related policy topics.

Introduction

Mobility is a key component of economic development and provides access between businesses and their respective markets, households, and communities. Traditional, linear approaches for managing mobility systems, operations and infrastructure have been shown to be unsustainable as they lead to increased greenhouse gas (GHG) emissions; depletion of finite resources; congestion; wasted time; decreased productivity; urban heat-island effects; and pollution[2].

The movement of goods and people is an energy and resource intensive activity. The transport sector accounts for 19% of South Africa's total energy demand (*See CSIR Energy Briefing Note*), exacerbated by extensive travel distances. The majority (98%) of the transport sector's energy is supplied through petroleum products[3], 79% of which is used for road transportation and 13% for civil aviation[3]. As at 2019, both petrol and diesel consumption exceeded local refinery capacity production, resulting in a steady increase in imports of both petrol and diesel finished products into South Africa[3].

The transport sector accounted for 10.7% of national GHG emissions in 2017 (excl. Forestry and Other Land Uses), with road transport making up 95.7% of that. In comparison, domestic aviation and railway had smaller contributions at 2% and 0.9% respectively[4]. Emissions from transport have increased by 33.2% between 2000 and 2017, the major contributor being road transport, which increased by 37.8%, highlighting the high reliance of the South African transport sector on fossil fuels[4].

An estimated 77% of land freight is still transported via road in South Africa, which in addition to consuming significant quantities of fossil fuels, has a direct bearing on national productivity and competitiveness. The heavy reliance on road transport also negatively impacts the condition and maintenance of the national road network[5]. While South Africa has a sophisticated logistics sector, ranking 33 out of 160 countries in 2018, in terms of the World Bank's Logistics Performance Index (LPI), it is plagued by numerous challenges including the lack of adequate infrastructure investment and maintenance, lack of skills, and high costs, all of which negatively impact system efficiency[5].

South Africa's resource intensive transport systems, provides the perfect impetus for transitioning South Africa to a more circular mobility system (Fig. 1). Applying the circular economy principles of designing out waste, closing resource loops; and regenerating natural systems provide a framework for South Africa to improve the efficiency and competitiveness of mobility systems[6,7]. For mobility, this includes:

- **Design out waste**, e.g., shared, and multi-modal mobility; increased use of zero-emission mobility; encouraging remote and flexible working
- **Keep materials in use**, e.g., scaling up vehicle remanufacturing; recycling; vehicle and infrastructure design for circularity
- **Regenerate natural systems**, e.g., mobility systems based on renewable energy; climate resilient transport infrastructure

Circular mobility requires a primary focus on designing for users and goods, instead of vehicles – such as planning transport networks that provide reduced travel distance and time per journey. Transitioning towards a circular mobility system creates opportunities for improved productivity, efficiency, and reduced costs, with positive spillover effects for other sectors of the economy such as agriculture, manufacturing, and human settlements.

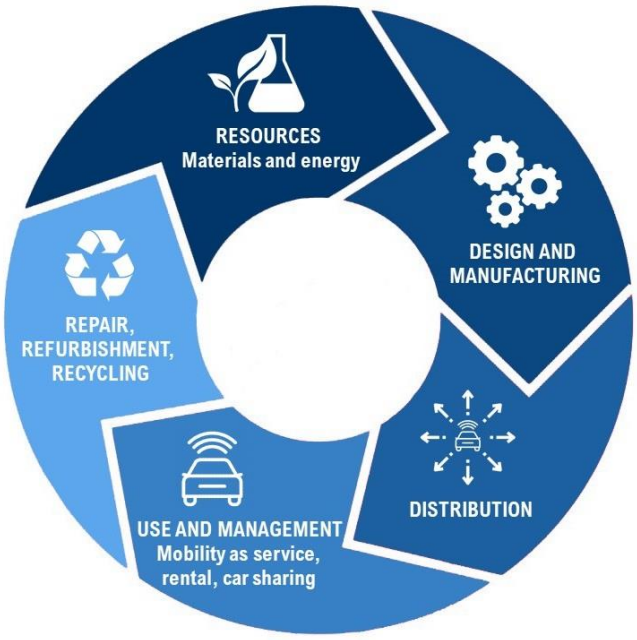

Figure 1. Mobility within a circular economy (adapted from SIFA[8])

Overview of the mobility sector in South Africa

South Africa has an extensive transport infrastructure network, with approximately 750,000 km of roads, approximately 30,000 km rail tracks, eight commercial ports, and eleven principal airports[5]. South Africa's transport and storage sector accounts for ~10% of the country's GDP (excluding unaccounted for minibus taxi services), the fifth largest economic contributor to national GDP[9]. While labour intensive, the sector saw a decrease in the number of jobs from 1,025,000 in 2019 to a low of 878,000 in the 3rd quarter of 2020 (largely due to the economic disruption caused by the COVID-19 pandemic), which recovered to 969,000 by the 2nd quarter of 2021[10]. Furthermore, the sector was the highest contributor to national economic growth for the same quarter[11].

With 77.3% of freight transported via road, the proportion of logistics costs to GDP is relatively high. The approximate cost of logistics was R480 billion in 2018[5], with two of the major operational expenses associated with road transport being fuel and tyres[12].

The National Development Plan (NDP 2030) recognises that poor transport links and infrastructure networks, raises the cost of doing business in South Africa and negatively impacts the standard of living. It calls for the sector to invest in effective, safe, and affordable public transport as a means of facilitating mobility for low-income households. There is a need to consolidate and expand transport and logistics infrastructure and reduce associated costs. At the same time, the NDP recognises the urgent need to shift to a low-carbon economy and a more sustainable economic growth path.

With South Africa's road transportation being the largest contributor to GHG emissions in the transport sector, and the highest energy consumer, the sector has employed an Emission Reduction Strategy that aims to reduce the reliance on fossil fuels for transportation. One of the key drivers of the shift being the projected decline in global oil reserves and resultant increasing prices.

Implementation of the Green Transport Strategy, which aims to reduce the transport sector's GHG emissions, provides an ideal launch pad for a circular economy transition within South Africa's mobility sector. While it is acknowledged that effective implementation and sufficient funding are critical constraints to achieving the outlined objectives, the Department of Transport has committed to achieving sustainability through the development of regulatory instruments, particularly for vehicle emissions; restructuring taxes; and providing incentives to reduce costs where possible; prioritising infrastructure development; and education and awareness to accelerate behavioural change.

There is opportunity for collaborative governance with the relevant sectors towards a more circular mobility sector. The National Transport Master Plan (NATMAP) 2050, for example, has identified twelve strategic themes, in order to achieve "*An integrated, smart and efficient transport system*" capable of supporting national sustainable economic growth and development.

Circular economy opportunities in mobility

Possible circular economy opportunities in the mobility sector are briefly highlighted, aligned with the three circular economy principles:

Design out waste and pollution

Resource efficiency in transport systems, operations and infrastructure provides an immediate opportunity area for decoupling the sector from resource consumption. Transport logistics is the backbone of many economic activities. It is therefore important that this industry be productive and efficient. It is expected that by 2040 the emissions produced from material production for vehicles will account for 60% of life cycle emissions, versus the current figure of 18%.

There are numerous opportunities to design out waste in transport[1]. South Africa has piloted two schemes that show great promise for supporting the circular economy – the Road Transport Management System (RTMS) and Smart Truck initiatives. The RTMS is an industry-led, self-regulation scheme that encourages consignors, consignees, and road transport operators to implement a management-systems standard in order to improve fleet management and sustainability; and reduce logistics costs. By using properly considered Performance-Based Standards (PBS) through the Smart Truck pilot project, improved heavy vehicle safety and productivity can be achieved. The pilot project has shown substantial savings, with one in four heavy vehicle trips eliminated using PBS; fuel and emission savings of 20%; and road wear reduction of 12%. These initiatives can be scaled up to form a significant proportion of circular mobility.

Greater efficiency and productivity can be achieved through integrated and multi-modal mobility, although this is proving slow to implement in South Africa. In 2007, South Africa adopted the National Public Transport Strategy, aimed at increasing passenger transport network productivity; reducing vehicles on the road and the road space required for personal vehicles; alleviating road congestion; reducing system inefficiencies and associated costs; and reducing energy consumption per capita. The program has, however, experienced several delays[13]. The reinforcement of rail for long-haul transport, which then transitions onto road freight transport for final short-haul distribution, provides a significant opportunity for improved productivity and efficiency, while reducing energy and material demands, GHG emissions, and impact on national roads. There is growing interest and support for moving suitable freight and long-haul passenger transport back to rail, given that rail transport is the most efficient and cost-effective method for long-haul land-based transport. Circular economy principles can also be applied to the rail infrastructure and vehicles to reduce resource demands and overall costs.

South Africa is located on one of the busiest international sea routes, with contrarily some of the worst performing ports in the world according to the World Bank's Container Port Performance Index 2020 report[14]. Improving the efficiency of port operations through strategies like the development of dry ports and modernisation of port infrastructure can increase productivity, efficiency and overall performance.

A key aspect of circular mobility also includes the incorporation of sharing economy principles, which focus on maximising resource productivity through the sharing of temporally under-utilised assets. In Europe, for example, cars are estimated to park 92% of the time, and when in use only 1.5 out of the 5 seats are occupied on average[8]. South Africa experiences a similar situation. Globally, the mobility sector is seeing some shift away from an owner-focused value proposition to a customer-centered one, resulting in a move away from individually owned vehicles – whether for personal or business use. Mobility-as-a-Service (MaaS) focusses on ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof. Utilising shared services in freight transport can also greatly reduce material consumption and waste in the sector. This includes initiatives such as *Empty Trips* which aims to utilize the traditional empty back-haul of heavy vehicles by offering this space to other logistics companies. Ride-sharing platforms in South Africa have shown promising outlook with growing competition in the market[15].

The heavy reliance on road transport and liquid fuels means that there is an urgent need to decarbonise the sector. This will require a shift to circular mobility solutions, including greater mobility sharing, while reduced personal mobility will shift to electric vehicles (EVs) supported through renewable energy. Many countries have moved to ban internal combustion engine vehicles (ICEV) in favour of EVs, with ambitious passenger-car and truck CO_2 reduction targets. South Africa, however, is lagging in the move to EVs, representing only 0.02% of domestic vehicle sales. Nonetheless, this creates an opportunity for South Africa, as 64% of locally manufactured vehicles are exported to global markets with South Africa already having experience with hybrid vehicle manufacturing[16]. Large-scale adoption of EVs or hydrogen vehicles (HVs) for public transport could be a game changer.

Reliable data is crucial for efficient and circular mobility systems. There are large international efforts to establish data sharing platforms and programs to unlock maximum value at every level of different value chains. There are already several integrated multimodal transport applications as well as private and public mobility providers that collaborate on making their service data accessible across platforms[1]. This is however severely lacking in South Africa.

Keep products and materials in use

The mobility sector has numerous opportunities to facilitate greater reuse, repair, remanufacturing and recycling of waste materials. These include, amongst others, end-of-life vehicles, waste batteries, and waste tyres. In addition, waste materials can be used to substitute virgin materials in transport infrastructure, for example, substituting natural aggregates with construction and demolition waste, which is currently mostly landfilled.

Waste tyres have numerous end-of-life solutions. If tyres cannot be re-treaded for reuse, they can be recycled to produce rubber crumb that has various applications in e.g. sports tracks, building materials, and road surfaces[17,18], or they can be converted to energy or liquid fuels through high temperature thermal processes such as pyrolysis or gasification. Several research and demonstration projects on the use of waste materials such as steel slag, waste glass, coal ash, construction waste, waste plastic and tyres, as alternatives to traditional road materials, have been implemented in South Africa[19,20]. The benefits of introducing alternative materials into road construction include offsetting virgin material use; reducing natural land-use for quarrying; economic savings on virgin materials; creating jobs; while also producing better performing roads[21].

Lead-acid batteries have already achieved high levels of recycling in South Africa (around 90%)[22]. However, as vehicle manufacturers move towards EVs, an increase in waste lithium-ion batteries (LIBs) will occur[23]. With South Africa slow to adopt EVs, the impact of large volumes of LIBs entering the waste stream is only expected in the next 10-20 years. However, the very low levels of Li-ion battery collection from the consumer electronics and ICT equipment sectors in South Africa, has meant that e-waste recyclers have been reluctant to invest in local recycling infrastructure[23]. With the potential for growing Li-ion battery waste, it is important that a strategy be put in place to close the loop on this waste stream and recover valuable materials for the South African economy.

ICEVs are likely to be in use for some time in South Africa, and in many parts of the world. This creates an opportunity for South Africa to position itself as a global leader in the remanufacturing

of IC engines. Remanufacturing of engines is already a well-established industry within the local automotive sector (*See CSIR Manufacturing Briefing Note*). End-of-life directives on vehicles, and other components such as vehicle remanufacturing, will be an important driver to achieve higher levels of waste reutilization within the sector[1].

Regenerate natural systems

Restorative and regenerative design is concerned with restoring social and ecological systems to a healthy state and enabling these systems to evolve[24]. Understanding current and future user needs and expected demands on mobility systems is therefore a critical component to regenerative and restorative design. The shift to alternative fuels, and EVs supported through renewable energy (as discussed above) presents an opportunity to reduce GHG emissions thus contributing to climate change mitigation strategies and international commitments.

Climate adaptation strategies include the planning, design and construction of climate resilient transport infrastructure which also has benefits of reduced repair and maintenance costs, as well as improved service life of assets. South Africa has experienced a 57% increase in recorded weather-related disasters over the past two decades compared to the previous two, resulting in an estimated R95 billion in economic damages[25]. The increase in city vehicle emissions as well as the use of heat trapping materials for construction can result in the occurrence of urban heat islands. Combined with more frequently occurring heatwaves, linked to climate change, heat stress is rapidly posing a major health risk for urban dwellers[26]. Research continues to show the importance of climate change adaptation through design of local transport infrastructure[27,28]. Restorative design can therefore be used as a strategy for climate adaptation and can assist in avoiding unnecessary social and economic costs associated with reactive and linear planning.

Crime and the circular economy

One of the biggest threats to transitioning South Africa to a more circular economy is the issue of crime. Increasing crime directly impacts the use of public transport and shared mobility. Examples include the local attacks on ride-hailing drivers and customers; vehicle theft; and hijacking. The concept of safety is a huge deterrent for many commuters who prefer to rather use their own vehicles. Furthermore, crime and corruption directly discourage investment and uptake in these circular solutions.

Conclusions

It is clear that the principles of a circular economy are not new to the South African mobility sector. However, while many of the underlying circular economy principles are already being applied, more needs to be done to accelerate and scale-up action, to ensure meaningful impact. Possible reasons for the slow uptake include the fact that South Africa is spatially segregated with large financial disparity; lack of appropriate infrastructure, and investment; and high costs for some of the necessary technologies. Reliable data sharing networks and systemic design considerations for local conditions will need to be established for beneficial implementation.

The concept of circular mobility is a multi-disciplinary area and will require involvement from various stakeholders and participants through improved relationships, across various sectors of the economy. The benefits of transitioning to a circular mobility system include improved productivity and competitiveness for business; reduced cost of doing business, reduced congestion, and reduced GHG emissions. Government policies and strategies such as the Emission Reduction Strategy, the Green Transport Strategy and the NATMAP 2050 support most of the circular economy principles and provide a launch pad to promote greater circularity within the mobility sector.

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