South African Road Transport
Vehicle Adoption Pathways Towards 2050

Technology choices and implications for fuel supply

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International Energy Workshop
20 June 2018, Gothenburg
South African Road Transport Sector

32% of the South African GDP that emanates from agriculture, mining, manufacturing and utilities. Globally, this figure is 30% of the total GDP.

Economy is coal-based
- 80% of primary energy supply
- 90% of electricity supply
- 30% of liquid fuels supply

Refinery capacity ~788,000 bbl/day
- Crude oil: 513,000 bbl/day
- CTL: 150,000 bbl/day
- GTL: 45,000 bbl/day

National CO2e emissions (2015) ~ 430 Mt
- Power Sector responsible for 60%
- CTL coal-synfuel facility responsible for 10%
- Transport direct emissions ~60 Mt (14%) (similar to industrial emissions)

Global Context (2015)
- GDP 0.4%
- Ton-km 1.0%
- Passenger Vehicles 0.51%
  6 million (2015)
  7 million (as of May 2018)
Transport Sector Interventions
Green Transport Strategy (2017): Low Carbon Mobility

- **Modal shift**
  - Passengers from individual vehicles to public transport (buses and rail);
  - Freight from road to rail;

- **Improved fuel efficiency** of petrol and diesel vehicles; and
  - Crude oil refinery refurbishment for Euro V fuel standard: Diesel 10 ppm

- **Biofuels**: the uptake of biodiesel blends (minimum B5 and B10).

- **Hydrogen Fuel Cell Programme**: PGM and mineral beneficiation

- **Gas/Petrol Bi-fuel Minibus taxis**
South African Road Transport Sector

Population will grow from 55 million (2015) to about 60 million people by 2050

<table>
<thead>
<tr>
<th>Public transport</th>
<th>Modal share 2003</th>
<th>Modal share 2013</th>
<th>Change 2003 - 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>7.1%</td>
<td>6.6%</td>
<td>-0.5%</td>
</tr>
<tr>
<td>Bus</td>
<td>7.5%</td>
<td>6.2%</td>
<td>-1.3%</td>
</tr>
<tr>
<td>Taxi</td>
<td>22.5%</td>
<td>25.1%</td>
<td>2.6%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>37.1%</td>
<td>37.9%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Private transport</th>
<th>Modal share 2003</th>
<th>Modal share 2013</th>
<th>Change 2003 - 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>28.5%</td>
<td>34.2%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Walk</td>
<td>32.3%</td>
<td>25.8%</td>
<td>-6.5%</td>
</tr>
<tr>
<td>Other</td>
<td>2.2%</td>
<td>2.0%</td>
<td>-0.1%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>62.9%</td>
<td>62.1%</td>
<td>-0.8%</td>
</tr>
</tbody>
</table>

Total daily trips: 100.0%

Passenger transport mainly by private car with increasing shift away from public modes.

Majority of freight transport via road.

Annual Income (1 USD = 15.4664 ZAR) 2015: Low Income (0 - 19,200); Middle Income (19,201 - 76,800); High Income (76,801 - )

Growth...
TIMES South Africa: transport sector model (SATIM)

- Vehicle Parc Model - Analytica
- Freight Demand Model - Excel
- Passenger Demand Model - Excel
- SATIM Model - TIMES
- Time Budget Model - Excel
- CGE Model (eSAGE)

Base Year
- Public & Private pkm by mode segment
- tkm by mode segment
- Private / Public split by income group
- Projected income group share of population
- Base Year Stock, Mileage & Efficiency
- Road - proj. veh-km
  Rail - proj. tkm
  by mode segment
- Projected vehicle-km by mode segment
# SATIM Vehicle Typology

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Freight*</th>
<th>Private passenger</th>
<th>Public transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCV</td>
<td>HCV1</td>
<td>HCV2–5</td>
</tr>
<tr>
<td>Petrol ICE</td>
<td>•</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel ICE</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Hybrid petrol–electric</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Hybrid diesel–electric</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Natural gas ICE</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>FlexFuel</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Battery Electric</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Hydrogen Fuel Cell</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

ICE: internal combustion engine, SUV: sports utility vehicle, BRT: Bus Rapid Transit. *LCV = light commercial vehicle, HCV1: medium commercial vehicle of 3 000–7 500 kg gross vehicle weight, HCV 2-5: heavy commercial vehicle of 7 501–12 000 kg gross vehicle weight; HCV 6-9: Heavy commercial vehicle of 24 001–32 000 kg gross vehicle weight.
Driving Demand for Transport

- **Access to a priv. veh.**
- **Priv. veh. per person w/ access**
- **Occupancy**
- **Public Transport**
- **Annual Mileage**
## Model Scenarios

### Model Run | Description | CO2 Cap (Gt) | EMS | Vehicle Cost Parity (2030) | Oil Price USD/bbl (2050)
---|---|---|---|---|---
**REF** | Reference | 14 | N | Y | $125
**REF_L** | Low Future Oil Price | 14 | N | Y | $80 (2020-2050)
**REF_10** | 10 Gt Carbon Budget | 10 | N | Y | $125
**REF_UCE** | Unconstrained Emissions | n/a | N | Y | $125

### HiCostLoOil

| Model Run | Description | CO2 Cap (Gt) | EMS | Vehicle Cost Parity (2030) | Oil Price USD/bbl (2050)
---|---|---|---|---|---
**REF_RHL** | Low Future Oil Price; Higher EV Costs | 14 | N | AEA (2012) | $80 (2020-2050)

### eMode

| Model Run | Description | CO2 Cap (Gt) | EMS | Vehicle Cost Parity (2030) | Oil Price USD/bbl (2050)
---|---|---|---|---|---
**EMS_R14** | Efficiency Improvements and Mode Switching | 14 | Y | Y | $125
**EMS_L** | Low Future Oil Price | 14 | Y | Y | $80 (2020-2050)
**EMS_H14** | Low Future Oil Price; Higher EV Costs | 14 | Y | AEA (2012) | $125

Caveats

➢ No account of Air Quality (PM, SOx, NOx)
➢ Fuel tax revenue not explored in CGE model
➢ Spatial nuance of transport demand
➢ No timeslice characterisation for EVs
   • peak shaping and smart charging (driver behaviour and charging habits) not gauged
➢ Solar-PV with storage and its effects on the supply sector not included in this iteration

... model improvements in the pipeline
Road Vehicles in Sum

Vehicle Parc (x1000)

Transport Emissions (CO2Mteq)
Fuel Utilisation

Transport: Fuels (PJ)

Reference

eMode

HiCostLoOil

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Hydrogen</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2030</td>
<td>2045</td>
<td>2030</td>
</tr>
<tr>
<td>Reference</td>
<td>34</td>
<td>186</td>
<td>15</td>
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<tr>
<td>eMode</td>
<td>13</td>
<td>116</td>
<td>14</td>
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<tr>
<td>HiCostLoOil</td>
<td>12</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>
Fuel by Sector

Private Vehicles: Fuels (PJ)

![Bar chart showing fuel usage for private vehicles across different sectors and years.]

Public Transport Vehicles: Fuels (PJ)

![Bar chart showing fuel usage for public transport vehicles across different sectors and years.]

Freight Vehicles: Fuels (PJ)

![Bar chart showing fuel usage for freight vehicles across different sectors and years.]

Legend:
- Hydrogen
- Electricity
- Gas
- FlexFuel (E85)
- Diesel
- Petrol
Passenger Vehicles

**Private Vehicles: Total Capacity**

- REF
- EMSR14
- REFRHL

**Private Vehicles: New Capacity**

- REF
- EMSR14
- REFRHL

**E-mobility p.km**

- Reference: 17% in 2030, 72% in 2045
- eMode: 0% in 2030, 69% in 2045
- HiCostLoOil: 0% in 2030, 0% in 2045
Supply: Refineries

Potentially Underutilised
Conclusions

➢ Uncertainty in vehicle purchase cost is the primary determinant of the rate and level of penetration of EVs into the vehicle fleet.

➢ EVs could account for approximately 80% of new light vehicle sales in 2045 for both freight and private transport.

➢ Electricity would account for ~30% of transport fuels and reduce transport energy supply requirements by about 30% in 2045.

➢ The power sector would consequently require an additional 10–20 GW of capacity during the later period 2030–2045, increasing the importance of electricity as a road transport fuel.

➢ Emissions from transport would plateau in 2030 at their current estimated 60 MtCO$_2$eq in 2015 and decline to 30 MtCO$_2$eq by 2045, equating to less than 10% national GHG emissions (excluding land use).

➢ Hydrogen fuel may also emerge as an important alternative fuel for public transport and freight in the future.

➢ Diesel and gas ICEs may remain important transport technologies. Diesel vehicles in particular hinge on continued investment in the crude oil refineries to improve fuel quality.