Road Transport Energy Transitions

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Global trends

EVs

Petrol stations numbers plummet as UK now has more electric car charging points

THE UK now has more public places to charge electric cars than it does petrol stations.

By LLOYD JOHNSON
PUBLISHED: 06:45, Thu, Aug 15, 2019

https://www.express.co.uk/life-style/cars/1165595/petrol-station-near-me-electric-car-charging-points-UK


EV share of annual vehicle sales by segment

Source: BloombergNEF. Note: Passenger car and bus figures are global. Commercial vehicle segment adoption figures in both charts cover the main markets of China, Europe and the U.S.
South African Road Transport Sector

32% of the South African GDP that emanates from agriculture, mining, manufacturing and utilities

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

**National CO2e emissions ~ 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**
- Ton-km ~1.0%
- ~ 1 billion passenger vehicles - South Africa: 0.7%

**South African Vehicle Parc**
- 12,46 million registered vehicles at the end of 2018
- 7,34 million passenger cars: 58.9% of parc.
- 176 vehicles per 1000 persons

**Energy utilisation**
- ~ 894 PJ, comparable to industrial utilisation (1294 PJ).
  Larger if emissions attributed to transport fuel supply are included (i.e. Refineries)
South African Passenger Travel

Population expected to grow from 55 million (2015) to about 65 million people by 2050

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

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Public transport</td>
<td>Train</td>
<td>7.1%</td>
<td>6.6%</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>7.5%</td>
<td>6.2%</td>
</tr>
<tr>
<td></td>
<td>Taxi</td>
<td>22.5%</td>
<td>25.1%</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>37.1%</td>
<td>37.9%</td>
</tr>
<tr>
<td>Private transport</td>
<td>Car</td>
<td>28.5%</td>
<td>34.2%</td>
</tr>
<tr>
<td></td>
<td>Walk</td>
<td>32.3%</td>
<td>25.8%</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>2.2%</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>62.9%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Total daily trips</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Motor Cars and Station Wagons

2018, 39%
South African Freight

Majority of freight transport via road
Electricity/hydrogen fuel cells are the primary fuels displacing petroleum product

- 13 million passenger vehicles:
  - 80%-90% of vkms via BEV
  - No Hydrogen FC passenger cars

- 6 million freight vehicles:
  - 75% of v-kms via BEV
  - Primarily Light Commercial Vehicles & Light Trucks
  - 90% of corridor v-kms Hydrogen FC

GHG emissions reduction in road transport ~70%; emissions reduction in national total ~18%

- 60 TWh: 30 GW of additional generation capacity: Wind, Solar PV and Batteries (... smart charging)

- Crude oil refinery capacity would commence retirement by 2030 with practically no domestic production by 2050

- CTL retired by 2040
Framing the Modelling

NATMAP 2050
Integrated Mobility Plan of Action (IMAP)

“preservation of the environment in tandem with accessible, cost reflective and affordable transportation services”

National Climate Change Response Policy (2011)

“climate-resilient and low carbon economy by 2050”

Green Transport Strategy (GTS)

“to substantially reduce GHG emissions and other environmental impacts from the transport sector by 5% by 2050”
Overview of SATIM

**Inputs to optimization model**
- Residential sector future technologies
- Future power generation technologies
- Future liquid fuel supply technologies
- Future coal/gas supply technologies
- Existing power system
- Existing liquid fuel supply system
- Existing coal/gas supply system
- Renewable energy resource potential
- Fossil fuel reserves
- Import/export (electricity, oil, gas)

**Outputs from optimization model**
- Base Year Energy Balance
- MARKAL/TIMES optimization energy model (GAMS with CPLEX solver)

**Intermediary information flow**
- MARKAL/TIMES optimization energy model
- Base Year Energy Balance

**Demand Sectors** (commercial and agriculture omitted from diagram)
- Residential sector future technologies
- Industrial sector future technologies
- Residential sector base-year calibration
- Industrial sector base-year calibration
- Residential sector Demand projections
- Industrial sector Demand projections
- Transport sector future technologies
- Transport sector base-year calibration
- Transport sector Demand projections

**Energy Resources/Import and Exports**
- Renewable energy resource potential
- Fossil fuel reserves
- Import/export (electricity, oil, gas)

**Supplies Technology**
- Future power generation technologies
- Future liquid fuel supply technologies
- Future coal/gas supply technologies
- Existing power system
- Existing liquid fuel supply system
- Existing coal/gas supply system

**Policy objectives/constraints**
- Energy security objectives
- Environmental objectives, taxes
- Socio-economic growth objectives

**Socio-Economic variables**
- GDP
- Population

**Results Analysis**
- Investment Schedule/Plan
- Imports, exports, consumption, production, Emissions
- System costs, energy costs

**Economic Analysis**
- Socio-Economic Variables (GDP, Population)
Transport Demand Model

- SATIM
  - Vehicle Parc Model - Analytica
  - Freight Demand Model - Excel
  - Time Budget Model - Excel
  - Passenger Demand Model - Excel
  - SATIM Model - TIMES

- CGE Model (eSAGE)
  - Base Year Public & Private plkn by mode segment
  - Private/Public split by income group
  - Projected income group share of population
  - Projected vehicle-km by mode segment

- Expenditure on expansion plan
- Production and consumption functions

- GDP
- Household income
Fuel Consumption Calibration

Fuel consumption by land transport type (PJ)

- Freight Road: 54.7%
- Passenger: 36.9%
- Public: 6.1%
- Freight Rail: 1.9%
## Modelling Transport Scenarios

<table>
<thead>
<tr>
<th>GTS 2018</th>
<th>Scenario Name</th>
<th>Key Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>Baseline scenario with EV premium at 25% relative to conventional present-day technology. Rail share of land corridor freight constant (2016 share)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>FreiRail</td>
<td>30% road corridor migration to rail by 2030 reaching 50% by 2045</td>
</tr>
<tr>
<td>2</td>
<td>PassMode</td>
<td>20% relative shift to public transport by 2030 reaching 50% by 2050</td>
</tr>
<tr>
<td>3</td>
<td>AltVeh</td>
<td>Cost parity for all alternate vehicle technologies by 2030 (e.g. electric or fuel-cell)</td>
</tr>
<tr>
<td>4a</td>
<td>MinBusDual</td>
<td>Minibus taxi fleet converted to bi-fueled gas-petrol by 2030</td>
</tr>
<tr>
<td>4b</td>
<td>MetBusGas</td>
<td>Urban bus fleet converted to gas only fleet by 2030</td>
</tr>
</tbody>
</table>

Clean Fuels Phase 2 with the option to refurbish the crude-oil refineries, invest in new capacity or retire domestic production
Transport Futures: Private and Freight Vehicles

Private

Freight

Public

- Oil Product
- Gas
- Hybrid (REEV)
- Electric (BEV)
- Hydrogen (FCV)
Transport Futures: Fuel Supply

[Graphs showing fuel supply projections for 2020, 2030, and 2050 across different technologies and modes of transportation.]
Transport Futures: Emissions
Automotive Industry: Domestic/Export

<table>
<thead>
<tr>
<th>Year</th>
<th>Trade surplus/(deficit) (R billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012*</td>
<td>(42.3)</td>
</tr>
<tr>
<td>2013</td>
<td>(63.8)</td>
</tr>
<tr>
<td>2014</td>
<td>(62.2)</td>
</tr>
<tr>
<td>2015</td>
<td>(45.2)</td>
</tr>
<tr>
<td>2016</td>
<td>(32.9)</td>
</tr>
<tr>
<td>2017</td>
<td>(43.5)</td>
</tr>
<tr>
<td>2018</td>
<td>(40.3)</td>
</tr>
<tr>
<td>Vehicles</td>
<td>67.6</td>
</tr>
<tr>
<td>Automotive components (including aftermarket parts)</td>
<td>(107.9)</td>
</tr>
</tbody>
</table>

### PASSENGER CARS

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Exports</th>
<th>Total</th>
<th>Exports as a % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>120 417</td>
<td>151 659</td>
<td>272 076</td>
<td>55.7</td>
</tr>
<tr>
<td>2013</td>
<td>113 356</td>
<td>151 893</td>
<td>265 249</td>
<td>57.3</td>
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<tr>
<td>2014</td>
<td>122 610</td>
<td>154 920</td>
<td>277 530</td>
<td>55.8</td>
</tr>
<tr>
<td>2015</td>
<td>112 576</td>
<td>228 459</td>
<td>341 035</td>
<td>67.0</td>
</tr>
<tr>
<td>2016</td>
<td>97 824</td>
<td>237 715</td>
<td>335 539</td>
<td>70.8</td>
</tr>
</tbody>
</table>

### LIGHT COMMERCIAL VEHICLES

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Exports</th>
<th>Total</th>
<th>Exports as a % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>121 638</td>
<td>123 443</td>
<td>245 081</td>
<td>50.4</td>
</tr>
<tr>
<td>2013</td>
<td>127 051</td>
<td>121 345</td>
<td>248 396</td>
<td>48.9</td>
</tr>
<tr>
<td>2014</td>
<td>137 044</td>
<td>118 585</td>
<td>255 629</td>
<td>46.4</td>
</tr>
<tr>
<td>2015</td>
<td>140 790</td>
<td>102 664</td>
<td>243 454</td>
<td>42.2</td>
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<tr>
<td>2016</td>
<td>130 364</td>
<td>104 987</td>
<td>235 351</td>
<td>44.6</td>
</tr>
</tbody>
</table>

### MEDIUM AND HEAVY COMMERCIAL VEHICLES AND BUSES

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Exports</th>
<th>Total</th>
<th>Exports as a % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>27 841</td>
<td>1 076</td>
<td>28 917</td>
<td>3.7</td>
</tr>
<tr>
<td>2013</td>
<td>30 924</td>
<td>1 206</td>
<td>32 130</td>
<td>3.8</td>
</tr>
<tr>
<td>2014</td>
<td>31 558</td>
<td>1 414</td>
<td>32 972</td>
<td>4.3</td>
</tr>
<tr>
<td>2015</td>
<td>30 469</td>
<td>1 124</td>
<td>31 593</td>
<td>3.6</td>
</tr>
<tr>
<td>2016</td>
<td>27 010</td>
<td>1 104</td>
<td>28 114</td>
<td>3.9</td>
</tr>
<tr>
<td>MCV</td>
<td>8 432</td>
<td></td>
<td>198</td>
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</tr>
<tr>
<td>HCV</td>
<td>5 452</td>
<td></td>
<td>127</td>
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</tr>
<tr>
<td>XHCV</td>
<td>11 850</td>
<td></td>
<td>725</td>
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</tr>
<tr>
<td>BUSES</td>
<td>1 276</td>
<td></td>
<td>54</td>
<td></td>
</tr>
</tbody>
</table>
Transport Model Caveats

- Infrastructure costs (e.g. roads, railways)?
- Chemicals sector linkage to refineries?
- Air Quality (PM, SOx, NOx)?
- Fuel tax revenue (linkage 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
- Residential solar-pv with storage and its effects on the supply sector ?
- Vehicle-to-grid services?
Electricity/hydrogen fuel cells are the primary fuels displacing petroleum product

13 million passenger vehicles:
- 80%-90% of v-kms via BEV
- No Hydrogen FC passenger cars

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- Primarily Light Commercial Vehicles & Light Trucks
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60 TWh: 30 GW of additional generation capacity: Wind, Solar PV and Batteries (... smart charging)

Crude oil refinery capacity would commence retirement by 2030 with practically no domestic production by 2050

CTL retired by 2040
<table>
<thead>
<tr>
<th>Fuel/Technology</th>
<th>Freight Road</th>
<th>Freight Rail</th>
<th>Passenger Private Road</th>
<th>Passenger Public Road</th>
<th>Passenger Rail</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>LCV</td>
<td>HCV1</td>
<td>HCV2–3</td>
<td>HCV4–5</td>
<td>HCV6–9</td>
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<tr>
<td>Gasoline/ICE*</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Diesel/ICE</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Gasoline/Hybrid-ICE</td>
<td>•</td>
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<tr>
<td>Diesel/Hybrid-ICE</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Natural Gas/ICE</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Blended Bioethanol-Gasoline (E85)/ICE</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>Electricity#</td>
<td>•</td>
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<td>Hydrogen/Fuel-Cell</td>
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<td>HFO (3)</td>
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<tr>
<td>Jet Fuel</td>
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<td>•</td>
<td>•</td>
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<tr>
<td>Aviation Gasoline</td>
<td>•</td>
<td>•</td>
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