WWF

BRIEF

ZA

2016

Low Carbon Frameworks: Transport

PHOTO: SHUTTERSTOCK

TRANSPORT EMISSIONS IN SOUTH AFRICA

How does the transport sector give rise to greenhouse gas emissions?

The direct route by which the transport sector contributes to greenhouse gas emissions is through the combustion of fossil fuels. Fossil fuels contain a substantial amount of carbon, and when these fuels are burned in the presence of oxygen they form carbon dioxide, the most extensive greenhouse gas by volume. Small amounts of methane (CH_4) and nitrous oxide (N_2O) are also generated during combustion of fuels in the transport sector.

Other important emissions from the sector, apart from those produced in direct combustion of fuels, include those produced during the manufacture of liquid fuels, and those generated during the production of electricity for electric trains and electric vehicles.

Contents

Greenhouse gas emissions from combustion of fuels in the transport sector

Various estimates of the overall emissions from the transport sector are available. The methodology used in providing many of these estimates – that is to say how they are calculated, and what is included and excluded – is in line with that described by the IPCC[1].

Transport emissions are most commonly estimated using a "top down" approach, on the basis of fuel sales data, rather than using actual measured data from the vehicle fleet. These estimates include emissions from primarily diesel and petrol consumption for **road transport**, only diesel for **rail transport** and jet kerosene and aviation gasoline for **domestic aviation**. They exclude emissions from electricity generated to run electric trains and fuel transport pipelines[2], from combustion of fuels supplied in South Africa for international aviation and marine transport (so called "bunker fuels") and those emissions from the manufacture of fuels. The latter are significant, as discussed further in the following section.

Whilst the methodological framework is similar, differences in estimates do, however, occur due to the baseline information used in the calculation[3] and the choice of emission factors (the factors used to convert fuel consumption into emissions), as well as in some places where methodological choices in allocating emissions are available.

The latest South African Greenhouse Gas inventory[4], an official submission to the UNFCCC[5], was published in 2014. The latest data, for 2010, suggest that energy used in transportation contributed a total of **47.6 Mt CO_2e**, or 8.8% of South Africa's greenhouse gas emissions (excluding emissions from agriculture, forestry and land use).[6]

It is worth comparing these results to those presented in the Climate Analysis Indicators Tool (CAIT 2.0)[7], which uses data collated primarily from the International Energy Agency in the case of South Africa's data. The 2010 data estimate of emissions from the transport sector was the same as that presented in the South African Greenhouse Gas inventory.

1 Intergovernmental Panel on Climate Change.

2 Pipelines are included here as they are managed by Transnet.

3 For example, the Greenhouse Gas Inventory discussed below uses data collected from a variety of sources locally, while CAIT uses data from the International Energy Agency.

4 Department of Environmental Affairs (DEA) (2014), *GHG Inventory for South Africa: 2000 - 2010.* Compilation under the United Nations Framework Convention on Climate Change, Pretoria: DEA

5 The UNFCCC is the United Nations Framework Convention on Climate Change. It is an international treaty which was set up to explore what needs to be done to both reduce potential climate change, and what needs to be done to adapt to climate change impacts.

6 The unit of Mt CO_2e refers to megatonnes of carbon dioxide (CO_2) equivalent. In order to compare different greenhouse gases, which have different global warming and hence climate change impacts, they are all converted to a common basis – being that of carbon dioxide equivalents. To convert emissions of a gas to its CO_2e, the emissions are multiplied by a factor known as the Global Warming Potential or GWP. For example, the 100-year GWP of methane (CH_4) is 25. This also implies that methane is 25 times "worse" than CO_2, on a per kilogram basis, in terms of the warming it generates over a 100 year period.

7 Climate Analysis Indicators Tool (CAIT 2.0). (Washington, DC: World Resources Institute, 2011), accessed online at http://cait2.wri.org/, August 2016.

32.2%

growth in fuel combustion emissions from 2000 to 2010

PHOTO: BY SHUTTERSTOCK

Emissions from the transport sector have grown by **32.2%** from 2000 to 2010, and it is feasible that this growth has continued.

Table 1 shows the cumulative breakdown of the three primary greenhouse gases emitted from transport between 2000 and 2010, demonstrating the negligible contribution of methane and nitrous oxide.

Table 1 **Cumulative greenhouse gas emissions from the transport sector from 2000 to 2010 (DEA, 2014)**

Greenhouse gas	Emissions ($Mt\ CO_2e$)	% of total
Carbon dioxide (CO2)	444.21	97.86%
Methane (CH4)	3.19	0.70%
Nitrous oxide (N2O)	6.52	1.44%
Total	**453.92**	

The relative contribution of different modes of transport to the emissions presented in the above table is shown in *Table 2*.

Table 2 **Contribution of different modes of transport to emissions in 2010 (DEA, 2014)**

Mode and energy carrier	% contribution to overall emissions
Domestic aviation (kerosene and aviation gas)	7.7%
Road (diesel and petrol)	91.2%
Rail (diesel only)	1.1%

Once again, these figures include emissions from diesel, LPG, residual fuel oil, other kerosene and petrol consumption for road transport, only diesel for rail transport, and jet kerosene and jet gasoline for domestic aviation. They do not include electricity used in rail transport.

91.2%
of fuel combustion emissions comes from road transport

The greenhouse gas inventory for 2010 also provides the emissions for international aviation (2.57 Mt CO_2e). The emissions from South Africa's international marine bunkers were given by the International Energy Agency for 2010 as 9.82 Mt CO_2e)8.

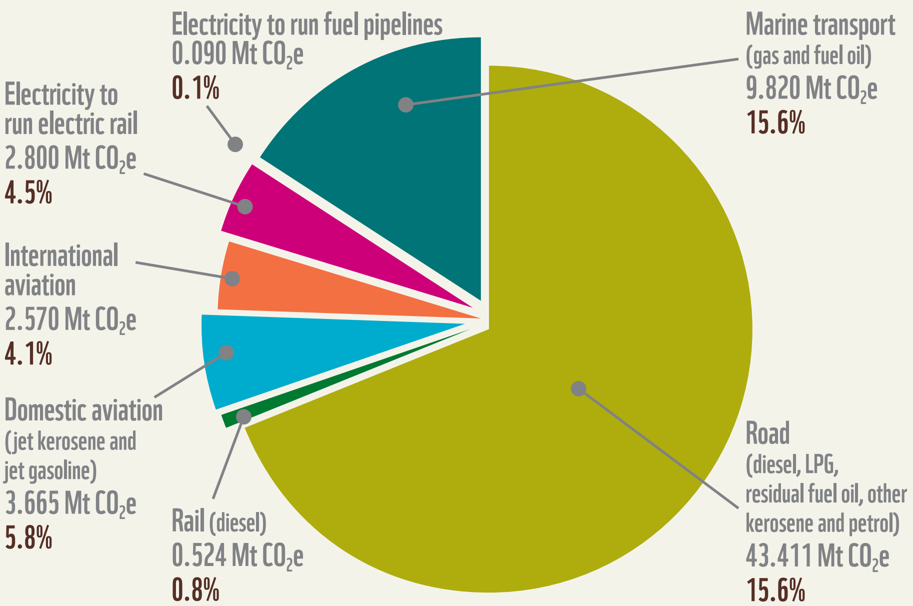
An indication of the emissions associated with electric rail and pipelines used for fuel transport can be obtained by looking at electricity consumption associated with these activities. An estimate of the contributions of these two sources to emissions in 2010 is presented in *Table 3*.

Table 3 **Estimate of emissions from electricity associated with rail and fuel pipeline transport (2010)**[9]

Mode	Electricity consumption [GWh]	Greenhouse gas emissions [Mt CO_2e]
Electric rail	2 938	2.8
Pipelines	100	0.09

All of the emissions described here exclude emissions from the production of fuels in crude oil refineries and Sasol, which can be substantial. These are discussed in the following section.

Figure 1 **Contributions to total transport emissions (excluding emissions from the production of fuels) in 2010**



8 IEA (2015), *CO2 Emissions from fuel combustion: Highlights*. Available online: https://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2015.pdf, accessed August 2016.

9 Department of Energy Statistics (2010). Available online: http://www.energy.gov.za/files/energyStats_frame.html, accessed August 2016.

7.7%

of emissions came from refineries and Sasol's processes

Life cycle emissions from the transport sector

In addition to the direct emissions from fuel combustion and the production of electricity, emissions from fuel manufacture need to be considered when thinking of the overall emissions from the transport sector as these can be significant. Emissions from energy used in refineries, including those from Sasol's processes, contributed around 42 Mt CO_2e to South Africa's emissions in 2010. This is 7.7% of emissions (excluding agriculture, forestry and other land use).

Sasol's coal-to-liquids plants are highly CO_2-intensive, and make up more than half of this contribution to the national emissions. It is difficult to use information published by Sasol in the public domain to determine the CO_2 emissions associated with manufacture of each litre of synthetic fuel, as their processes give rise to a host of products, not only liquid fuels. The remainder of the emissions associated with energy use in refineries come from crude oil refineries.

Biofuels

One final note on including life cycle considerations in the assessment of transport emissions relates to biofuel production, even though this industry is still in its infancy in South Africa. Although biofuels are made from renewable materials, which are considered to close the carbon cycle (i.e. the carbon which is released during combustion is that which is taken up during growing), there are other emissions associated with both growing dedicated crops and the biofuel production processes themselves.

In terms of growing crops, if land is used which was previously used for other purposes, carbon that was previously held in the soil may be released as a result of the new usage type. Furthermore, energy is required for irrigation and transport in agriculture, which will give rise to greenhouse gas emissions.

In terms of processing, energy is required to manufacture the biofuels from the crops (particularly bioethanol, which requires energy intensive distillation to refine the product).

These considerations suggest that biofuels do not always provide a carbon reduction benefit, and different crops and fuels need to be assessed on a life cycle basis to establish the energy and emissions mitigation return on the energy and emissions investment. This should be considered alongside the food security concerns that have been raised with increased biofuels production.

PHOTO: NATALY REINCH / SHUTTERSTOCK.COM

Options for reducing emissions from the transport sector

The Long Term Mitigation Scenarios (LTMS) study and Mitigation Potential Analysis (MPA) explored various options for greenhouse gas mitigation in South Africa. These included:

- Higher use of rail for freight
- Passenger model shifts from private vehicles to public transport use
- Increases in vehicle occupancy
- Ramp up of the number of hybrid vehicles on the road
- Introduction of electric vehicles
- Increases in efficiency of private passenger vehicles
- Increases in the number of private diesel cars, which are less CO_2-intensive than petrol vehicles
- Blending of biofuels with petrol and diesel (although as discussed previously, calculation of the benefits should take into account life cycle considerations in producing biofuels)

The approach taken in both the LTMS and MPA around determining the potential contribution of different interventions to mitigation was to make assumptions about what was theoretically achievable in terms of efficiency gains and penetration rates of the different interventions. The implications of achieving these for mitigation and the economy more broadly were then determined under different scenarios.

The assumptions used in both the LTMS and MPA were loosely based on literature and consultation with sectoral stakeholders, and are to be used more for guidance on what could possibly achieved, rather than to provide an accurate reflection on what is actually achievable in the sector.

A few of the assumptions made for some of the above interventions in the MPA include:

- The use of rail for freight could increase to 71% in 2030 and 68% in 2050, expressed as a share of tonne-km demand
- Public transport could account for 51% of total demand for passenger transport by 2030
- Energy efficiency for vehicles could increase by 0.5% per annum
- The uptake of biofuels in rail could increase to 10% increase 2030 and 27% by 2050
- Hybrid vehicles could account for more than 23% of passenger cars sales and 17% of SUV sales in 2030, increasing to 40% and 23% in 2050 respectively.
- Overall biofuel use for road vehicles could be 10% by 2030, with this increasing to 27% by 2050.

8.8%

of South Africa's greenhouse gas emissions in 2010 came from fuel combustion

Many of the assumptions for the remaining interventions listed previously are available in the LTMS and MPA study reports.

From the information placed in the public domain as part of the LTMS and MPA study, it is not possible to determine the contribution of the individual interventions to mitigation in each year under each scenario, as the complexity of the modelling requires combinations of interventions being implemented together. Having said this, some indication is obtained of which interventions have the biggest overall potential to reduce emissions, and at what cost.

For example in the MPA, hybrid vehicles have the potential to reduce emissions by 25 Mt CO_2e per annum by 2050. The cost of hybrids varies from a cost saving of R385 per tonne CO_2e for petrol plug-in hybrid electric vehicles to a cost of R625 per tonne of CO_2e for diesel hybrid electric vehicles. Improved vehicle efficiency showed the largest potential for savings (around 255 and 28 Mt CO_2e savings per annum by 2050 for petrol and diesel respectively). Interventions such as passenger modal shift also showed significant savings of 9 Mt CO_2e and a cost saving of R1 128 per tonne CO_2e. Biofuels in both the rail and road sector showed a cost of R936 and R232 per tonne CO_2e by 2050.

Once again, it is important to treat these savings and costs as highly indicative and not absolute, and to use them purely to provide some understanding of *relative* performance of the options.

It is noted that the modelling of the transport sector in the LTMS required the introduction of a number of policies or measures to support the introduction of mitigation in the sector, particularly given the assumptions that customers are unlikely to choose more efficient vehicles without the introduction of policy, and that the purchase or use of transport modes amongst the higher income groups is done with consideration to the cost.

WWF NEDBANK GREEN TRUST

This publication is funded by The Green Trust, a partnership between WWF and Nedbank.

WWF® TRANSPORT EMISSIONS IN SOUTH AFRICA

WWF South Africa's Low-Carbon Frameworks programme explores the shift to a low-carbon economy. We seek solutions for emitting fewer greenhouse gas emissions and enabling a flourishing South Africa, which delivers developmental outcomes and social equity. The programme includes a focus on the transport sector, located within the context of South Africa's economic geography.

The transport project aims to provide a platform, expertise and perspectives to support labour, business and government in engaging with the challenges implicit in the shift to a low-carbon economy. Consideration is given to the three tiers of interventions which will be required to effect the transition of this sector, being to REDUCE movement of goods and people, SHIFT to low-carbon modes of transport, from private to public, from road to rail, and IMPROVE mobility services, and energy and fuel efficiency.

This publication is one in a series on low-carbon transport, in both the passenger and freight sectors. The series includes publications that look at employment in transport, address greenhouse gas mitigation opportunities in the freight sector, document passenger transport greenhouse gas emissions in Gauteng by income band, and present a series of low carbon transport case studies from around the world. To download these publications go to http://www.wwf.org.za/what_we_do/transport/.

WWF South Africa's Policy and Futures Unit undertakes enquiry into the possibility of a new economy that advances a sustainable future. The unit convenes, investigates, demonstrates and articulates for policymakers, industry and other players the importance of lateral and long term systemic thinking. The work of the unit is oriented towards solutions for the future of food, water, power and transport, against the backdrop of climate change, urbanisation and regional dynamics. The overarching aim is to promote and support a managed transition to a resilient future for South Africa's people and environment. The organisation also focuses on natural resources in the areas of marine, freshwater, land, species and agriculture.

The Green House is a technical sustainability consulting firm with experience working on a wide range of energy, carbon and sustainability-related projects, including strategic energy planning, carbon footprinting, and life cycle assessment. The Green House has significant experience in energy, transport, urban systems, bioenergy, biofuels, industry, commerce, agriculture, municipal waste management, mining and minerals.

Commissioned by WWF South Africa from The Green House

The Green House authors:
Dr Brett Cohen, reviewed by Kyle Mason-Jones

Available at www.wwf.org.za/transport_emissions

For WWF South Africa:
Saliem Fakir,
Head: Policy and Futures Unit
telephone +27-(0)21-6576600
e-mail sfakir@wwf.org.za
www.wwf.org.za

For The Green House:
Dr Brett Cohen,
Director
telephone +27-(0)21-6711410
e-mail info@tgh.co.za
www.tgh.co.za

Design:
Farm Design www.farmdesign.co.za

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.wwf.org.za

ZA WWF.ORG.ZA