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Low-Carbon Frameworks

BRIEFING NOTE ON TRANSPORT EMISSIONS IN SOUTH AFRICA

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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 possibly in the future, electric vehicles).

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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].

For transport emissions, these are estimated using a "top down" approach, on the basis of fuel sales data, rather than using actual measured data from the vehicle fleet. These figures only include emissions from diesel and petrol consumption for **road transport**, diesel for **rail transport**, and an estimate of emissions from **domestic aviation**[2]. They exclude emissions from electricity generated to run electric trains and fuel transport pipelines[3], 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[4] 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.

[1] Intergovernmental Panel on Climate Change.

[2] The reason why domestic aviation is an estimate is that assumptions need to be made about what percentage of aviation fuel sales are used for domestic purposes and what percentage are used for international flights. There is no internationally agreed methodology for making this allocation.

[3] Pipelines are included here as they are managed by Transnet.

[4] 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. It may be argued that the former is somewhat more accurate.

The Climate Analysis Indicators Tool (CAIT)[5] provides one of the more recent estimates, using data collated primarily from the International Energy Agency in the case of South Africa's data. The latest data, for 2007, suggests that energy used in transportation contributed **46.3 Mt CO_2e**, or 13.1% of South Africa's greenhouse gas emissions.[6] For comparison, the global total transport energy emissions, calculated on the same basis, were 5 610.5 Mt CO_2e.

In order to show the differences between emission estimates, it is worth comparing these emissions to those presented in South Africa's Greenhouse Gas inventory[7], an official submission to the UNFCCC[8]. The latest inventory[9], published in 2009 but reflecting data from 2000, suggests a total of **39.5 Mt CO_2e** from energy used in transport in that year. The CAIT estimate of emissions from the transport sector for the same year was **35.7 Mt CO_2e**.

[5] Climate Analysis Indicators Tool (CAIT) Version 8.0. (Washington, DC: World Resources Institute, 2011), accessed online at http://cait.wri.org/, September 2011.

[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] Department of Environmental Affairs and Tourism (DEAT) (2009), Greenhouse Gas Inventory for South Africa: 1990 to 2000. Compilation under the United Nations Framework Convention on Climate Change, Pretoria: DEAT

[8] 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. The Kyoto Protocol was established under the UNFCCC as an addition to the treaty.

[9] It is noted that the Department of Environment is currently busy with an update of the inventory, but this has not yet been released.

Although the two estimates differ, it can still be seen that emissions have grown by between **18%** and **30%**, and it is feasible that this growth rate has continued to 2011. The proportion of total South African emissions produced from combustion of fuels in transport grew from approximately 9% in 2000 to 13% in 2007.

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

Table 1 – Greenhouse gas emissions from the transport sector in 2000 (DEA, 2009)

Greenhouse gas	Emissions ($Mt\ CO_2e$)	% of total
Carbon dioxide (CO2)	38.624	97.8%
Methane (CH4)	0.258	0.7%
Nitrous oxide (N2O)	0.629	1.6%
Total	**39.5**	

The relative contribution of different modes of transport to the emissions presented in the above table is shown in *Table 2*. These proportions were derived from the greenhouse gas inventory for 2000, but are not expected to have changed significantly. The more recent source does not disaggregate to this level of detail.

Table 2 Contribution of different modes of transport to emissions in 2000 (DEA, 2009)

Mode and energy carrier	% contribution to overall emissions
Domestic aviation (kerosene and aviation gas)	5.2%
Road (diesel and petrol)	93.1%
Rail (diesel only)	1.7%

Once again, these figures only include emissions from diesel and petrol consumption for road transport, diesel for rail transport, and an estimate of emissions from domestic aviation.

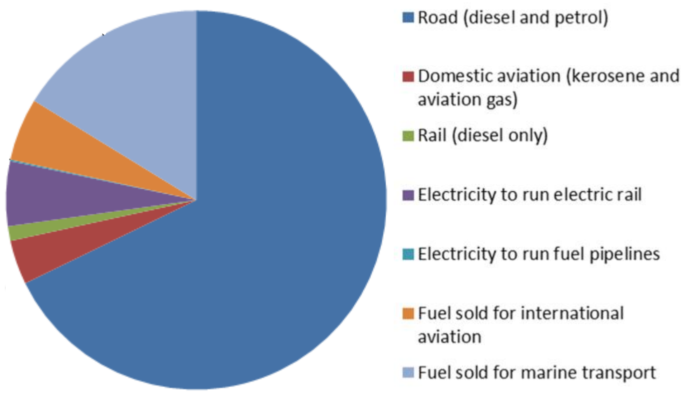
The greenhouse gas inventory for 2000 does, however, provide an indication of the emissions from fuels sold in South Africa for international aviation (2.9 Mt CO_2e) and marine transport (8.8 Mt CO_2e).

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 2006 is presented in *Table 3*.

Table 3 Estimate of emissions from electricity associated with rail and fuel pipeline transport (2006)[10]

Mode	Electricity Consumption [GWh]	Greenhouse gas emissions [Mt CO_2e]
Electric rail	3 280	3.0
Pipelines	79	0.07

All of the emissions describe 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.



Indicative % contributions to total transport emissions (excluding emissions from the production of fuels)

[10] Department of Energy (2009) Digest of South African Energy Statistics 2009. Available online: www.energy.gov.za/files/media/explained/2009%20Digest%20PDF%20version.pdf, accessed September 2011. p. 15.

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 CO2e to South Africa's emissions in 2000, being more than those from direct fuel combustion.[11]

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 CO2 emissions associated with manufacture of each litre of synthetic fuel[12], 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.

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[11] Department of Energy (2009) Digest of South African Energy Statistics 2009. Available online: www.energy.gov.za/files/media/explained/2009%20Digest%20PDF%20version.pdf, accessed September 2011. p. 15.

[12] Synthetic fuels are those that are made from another energy carrier such as coal or gas, via a process such as that used by Sasol. The majority of the fuel globally comes from refining crude oil to produce a more "pure" product such as petrol or diesel. Both fuels are, however, fossil fuels.

OPTIONS FOR REDUCING EMISSIONS FROM THE TRANSPORT SECTOR

The Long Term Mitigation Scenarios (LTMS) study conducted by the Energy Research Centre at the University of Cape Town, in conjunction with SouthSouthNorth, explored various options for greenhouse gas mitigation in South Africa. These included:

- Higher use of rail for freight
- Increased public transport use
- Other passenger modal shifts, particularly from air to road or rail, and to non-motorised forms of transport, such as bicycles
- Ramp up of the taxi recapitalisation plan, including introduction of diesel and larger vehicles
- Increases in vehicle occupancy
- Ramp up of the number of hybrid vehicles on the road
- Introduction of electric vehicles
- Decrease in number of SUVs
- 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 the LTMS 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 the LTMS 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.

The assumptions made for some of the above interventions include:

- The use of rail for freight could increase to 44.6% in 2015 and 45.15% in 2030, expressed as a share of tonne-km demand
- Public transport's share of demand could achieve just over 76% of total demand for passenger transport by 2030
- In terms of the taxi recapitalisation programme, 4.7% of taxis could be diesel by 2015. This could increase further to 7.4% by 2030. The taxis are larger vehicles that seat 19–35 passengers compared with the minibuses that seat 18 people or less, and are designed for longer distances
- Use of SUVs could be capped at 1% of private passenger-km
- Private passenger vehicles and light commercial vehicles could increase in efficiency by 0.9% per annum
- Diesel cars could make up 15–30% of private passenger-km by 2030
- Hybrid vehicles can make up 2% of passenger-km by 2030
- Blend fractions of biofuel could increase to 8% ethanol with petrol and 2% biodiesel with diesel in 2013. Thereafter the percentage of ethanol in petrol is taken up to an assumed maximum of 20% and biodiesel to a maximum of 5% in 2030.

The assumptions for the remaining interventions listed previously were not made explicit in the LTMS study reports.

From the information placed in the public domain as part of the LTMS 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 modeling 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, electric vehicles, charged with renewables and/or nuclear, showed the largest potential of the transport sector emissions (reducing emissions by 300 Mt CO_2e per annum by 2050), but at high cost (R102/tonne CO_2e saved).[13] Improved vehicle efficiency also showed potential for substantial savings (around 35 Mt CO_2e savings per annum by 2050), with a negative cost (i.e. a cost saving) of R269 per tonne CO_2e. Interventions with lower, but not insubstantial CO_2 savings include passenger modal shift which came at significant cost savings of R1 131 per tonne CO_2e, and biofuels and hybrids which come with a cost penalty of R524 and R1 987 per tonne CO_2e saved respectively.

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 modeling 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.

[13] It is important to note that this savings is thus highly dependant on a major transformation of the electricity supply grid.

This is one in a series of briefing papers produced by WWF South Africa's Low-Carbon Frameworks programme, which 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 transport. WWF's transport project aims to provide a platform, expertise and interactive modelling to support labour, business and government in engaging with the challenges implicit in the low-carbon transition. Consideration will be 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.

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