Actions and emissions

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Martin Gustafsson

One-page infographics at www.myemissions.co.za/onepage.pdf and www.myemissions.co.za/onepage.gif.

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1 Introduction

This document attempts to do something which is not common enough, namely to describe the greenhouse gas emissions associated with specific actions which one, as a person in a particular place and context, can choose to do or not do. A brilliant United Kingdom book that does this is Mike Berners-Lee 2010 *How bad are bananas? The carbon footprint of everything*. That book is a great source of inspiration, but it's not entirely applicable to the different context of South Africa.

One of the reasons why individuals find it so difficult to take action (which often means *avoiding* certain actions) to reduce their personal footprint is that understanding what the emissions impact of different everyday things are is so complex and elusive. So one just gives up. One cannot stop doing everything, and one doesn't understand the size of the various impacts, so one just stops making any choices. Berners-Lee emphasises the importance of not understanding every damn detail, but at least developing a 'carbon intuition', or sufficient knowledge that allows us, in broad terms, to understand the emissions associated with our actions. Often that involves debunking a few myths. For instance, electrical cars may be a terribly bad choice, depending on where you live. International trade is less destructive than one may initially believe (though emissions associated with local goods tend to be lower).

My context is South Africa, and more specifically Gauteng Province. South Africa is of course a place of great inequality. Poverty co-exists with rather extravagant expenditure. The apartheid social inheritance, exacerbated by a lack of better government action since apartheid to rectify inequalities, in particular educational inequalities, means a large minority of people earn relatively well. These people engage in many high-emissions activities. I include myself amongst them. They partly explain why South Africa's per capita emissions are relatively high (for instance higher than those of some rich countries). In some instances doing the right thing with respect to emissions coincides with doing the right thing to reduce poverty in South Africa. For example, reducing one's consumption of imported goods can also be good for local job creation. In a few places within the current document I've explained these coincidences, especially where they seem interesting and important.

Section 2 presents action-emissions records. Records are organised under themes such as 'Using personal transport' ~~and 'Buying food'~~ (for now only personal transport). The aim was to include each of the following within each record:

- A short description of an action, such as 'Using an Uber taxi for a 10 kilometre ride'.
- A longer description of the action, explaining clearly what the action entails.

- An emissions value, such as ‘5 kg CO_2’ for carbon dioxide emissions, plus a breakdown into the categories ‘immediate’ and ‘full picture’. The full picture covers a fairly comprehensive chain of emitting activities, from for instance the production of the Uber car in a factory, to what we can call the ‘immediate burning’, meaning the burning of the fuel needed directly for the 10 kilometre ride. This breakdown is given partly to illustrate how limiting typical carbon calculators found online can be. Such calculators tend to cover just the ‘immediate’ part. What I have included within the category ‘immediate’ is the emissions associated with the production of the fuel, something that typical carbon calculators leave out. I wanted ‘immediate’ to be emissions that could be avoided by, say, not taking that additional drive to the shopping mall, and thus I wanted to include everything associated with the fuel burnt.

- A carbon dioxide-equivalent (CO_2-eq.) value, which would include the emissions of greenhouse gases other than carbon dioxide. Importantly, carbon dioxide is the most important of six key greenhouse gases driving global warming. The carbon dioxide we emit in the world accounts for 77% of the warming effect of the six greenhouse gases, with the methane we emit having the second-largest effect and accounting for a further 14%. CO_2-equivalent values are values that attempt to take into consideration all greenhouse gases, whilst converting non-CO_2 gases to, say, kilograms of CO_2 on the basis of their warming effect.

- A formula explaining how the emissions value is calculated. The formula uses variables which are explained in section 3. The formula is accompanied by a simple description.

- A discussion of the measurement difficulties. The aim here is partly to underline that though one is dealing with an important science, and one that is sufficiently reliable to guide behaviour, one is not dealing with an absolutely exact science. Actions are not uniformly structured, and the emissions dynamics behind even a clear-cut action can be impossible to specify with a high level of precision.

- Possibly, some description of how doing what’s right in terms of emissions is also right in terms of other social matters, such promoting local employment.

Of course the intention is not to provide information on every conceivable action involving emissions, but rather on a sufficient variety of actions to allow for an improvment one’s overall awareness of the magnitudes of effects.

Lastly, to some degree thinking through how one’s actions, and one’s very existence in fact, are inextricably linked to a global ecosystem in ways which are ultimately knowable, *should be a source of fun and pleasure.* If not, we are doomed. What is in this document should partly be thought of as material which could form the basis for games and classroom exercises for children.

2 Action-emissions records

2.1 Using personal transport

1	**Riding 10 kilometres in a minibus taxi** You ride for 10 kilometres in a Toyota Quantum fifteen-seater minibus taxi. *Immediate:* **0.3** kg CO_2-eq. $\frac{1}{11}\times\left(\frac{10}{100}\times PetrolTaxi\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$ *Full picture:* **0.4** kg CO_2-eq.

	$\frac{1}{11}\times\left(\frac{10}{100}\times PetrolTaxi\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$ $+0.000004\times TaxiEmbod$ *Here 'full picture' means that the emissions associated with producing the vehicle is taken into account. Though the taxi may accommodate 15 passengers, it is assumed that on average 11 passengers travel on the taxi. This information is used, together with the petrol consumption of the taxi, and the basic emissions factor for petrol (with the latter being augmented to take into account the emissions cost of producing and transporting the petrol). The emissions embodied in the production of the taxi are multiplied by 0.000004, the half an hour the ride takes divided by the overall five-year lifespan of the taxi (with the assumption that the taxi works 40 hours a week), all divided by the 11 passengers.* The most difficult thing to establish here was probably the lifespan of a typical taxi. There seemed little information available on this publicly.
2	**Riding Hatfield to Park on the Gautrain** You ride between Hatfield Station and Park Station, a distance of 62 kilometres, taking 42 minutes. There are 57 people in your carriage. *Immediate:* **5.7** kg CO_2-eq. $\frac{42}{60}\times\frac{1}{57}\times GautrainCon\times EFEskom$ *Full picture:* **5.7** kg CO_2-eq. $\frac{42}{60}\times\frac{1}{57}\times GautrainCon\times EFEskom$ $+\left(0.0002\times\frac{1}{57}\times TrainEmbod\times\frac{1}{TrainLife}\right)$ *Here 'full picture' means that the emissions associated with producing the train is taken into account. Clearly this makes very little difference, relative to the 'immediate' figure, which reflects the fact that the Gautrain infrastructure is very intensively used by many people. The 57 people per carriage statistic was obtained by using published total riders per day figures, details on the trains per day and carriages per train available from the Gautrain timetable, and then some assumptions around how many stations each rider travels, and the distribution of riders across the two lines of the Gautrain. The electricity consumption of one Gautrain carriage is multiplied by the emissions factor associated with Eskom electricity. The 0.0002 value used for the 'full picture' calculation is 42 minutes as a proportion of the total time use of a Gautrain carriage over a year. This is combined with the assumption of 57 passengers in the carriage, the estimated emissions associated with producing the carriage, and the lifespan of the train, in order to take into account the embodied emissions.* The above 5.7 can be compared to 8.1, the emissions for travelling the same distance by car (the 1.3 kg CO2-eq. associated with the 'immediate' approach to 'Driving your own small car for 10 kilometres' multiplied by 6.2, or 62 kilometres on the Gautrain divided by 10). Gautrain has publicised that using the train results in emissions which are half those resulting from a car. One could easily obtain this ratio of a half by adjusting, for instance, the type of car, and the number of people assumed to be in the Gautrain carriage. The 5.7 shown above is not high relative to what seems to be the value for an equivalent train ride in the United Kingdom: 6.9 kg CO2-eq[1]. This could be because the Gautrain does not operate late at night, when usage would be low. In general, one would expect an electric train in South Africa to be more emissions-intensive because our electricity is more emissions-intensive. For instance, our emissions associated with producing a unit of electricity are 23% higher than in China, 57% higher than in the United States, 68% higher than in the United Kingdom and a whole 3.5 times higher than in Brazil (which makes extensive use of hydro-electric power)[2].

[1] Uses figures from Berners-Lee (2010).
[2] Wilson (2013: 6).

3	**Using an Uber taxi for a 10 kilometre ride** You call an Uber taxi, which is 5 kilometres away when it is called, and you travel for 10 kilometres with it. You travel alone. The Uber taxi is a 1.0 litre Ford Focus (a fairly common Uber car in Gauteng). *Immediate:* **2.2** kg CO_2-eq. $\left(\frac{5+10}{100}\times PetrolSma2\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$ *Full picture:* **3.0** kg CO_2-eq. $\left(\frac{5+10}{100}\times PetrolSma2\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$ $+\frac{5+10}{CarLifespan}\times CarEmbodMid$ *This is 15 kilometres of driving, with 'full picture' meaning that the emissions associated with producing the petrol is taken into account, as well as the emissions associated with producing the car.* If one assumes that the distance travelled by the Uber to get to you is always 5 kilometres, then if the ride distance doubles, the emissions do not quite double. In fact, if the ride is 20 kilometres, the emissions 'full picture' becomes 4.5 kg CO_2-eq. (not 3.0 times 2). One variable not considered in the above calculation is the emissions associated with the labour of the Uber driver, whose personal consumption is associated with emissions. In fact, emissions associated with labour are never explicitly included in these kinds of 'bottom-up' calculations. Roughly, and using the fact that emissions per capita in South Africa is 8 tonnes per capita per year (after dealing with international trade factors), and assuming that the Uber driver spends 30 minutes on your ride, the labour of the driver adds around 0.5 kg to the emissions total seen above.
4	**Riding a bicycle for 10 kilometres** You ride a bicycle for 10 kilometres. *Immediate:* **0.05** kg CO_2. $10\times Cycling$ *Full picture:* **0.08** kg CO_2-eq. $10\times Cycling+\frac{10}{10\times 365\times 15}\times BicycleEmbod$ *Full picture (five-year view):* **0.11** kg CO_2-eq. $10\times Cycling+\frac{10}{5\times 365\times 15}\times BicycleEmbod$ *The 'immediate' figure is only the carbon dioxide exhaled by the cyclist, over and above what the cyclist would emit if he or she was sitting still. It does not include the emissions associated with the production of the food which is the source of the cyclist's energy. The 'full picture' calculation assumes that the bicycle lasts for ten years and is ridden 15 kilometres a day.* The emissions associated with cycling as a mode of transport are instructive, because commonly cycling is assumed not to produce any greenhouse gas emissions at all. The details in fact help us understand the many components of, and the great complexity of, human impacts on our environment.
5	**Driving your own small car for 10 kilometres** You drive alone for 10 kilometres in your Citroen C1, with a 1 litre engine, for 10 kilometres in average conditions. *Immediate:* **1.3** kg CO_2-eq. $\left(\frac{10}{100}\times PetrolSma\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$ *Full picture:* **1.4** kg CO_2-eq.

$$\left(\frac{10}{100}\times PetrolSma\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$$

$$+\frac{10}{CarLifespan}\times CarEmbodSma$$

For the following, it is assumed that you drive your car 20,000 kilometres a year.

<u>*Full picture (five-year view):* **1.9** kg CO_2-eq.</u>

$$\left(\frac{10}{100}\times PetrolSma\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$$

$$+\frac{10}{5\times 20{,}000}\times CarEmbodSma$$

The 'full picture' includes the emissions associated with producing the car. The simple 'full picture' assumes that the car lasts for as long as it takes the car to drive 320,000 kilometres (the estimated 'lifespan' of the car). Thus if the car was driven 20,000 kilometres a year, it would last 16 years. The 'five-year view' assumes that the car is scrapped after five years, regardless of how many kilometres it has driven. This scenario is probably more in line with reality than the simple 'full picture' scenario.

6 **Driving your own large car for 10 kilometres**

You drive alone for 10 kilometres in your Land Rover Discovery, with a 3 litre engine, for 10 kilometres in average conditions.

<u>*Immediate:* **3.5** kg CO_2-eq.</u>

$$\left(\frac{10}{100}\times PetrolBig\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$$

<u>*Full picture:* **4.6** kg CO_2-eq.</u>

$$\left(\frac{10}{100}\times PetrolBig\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$$

$$+\frac{10}{CarLifespan}\times CarEmbodBig$$

For the following, it is assumed that you drive your car 20,000 kilometres a year.

<u>*Full picture (five-year view):* **7.0** kg CO_2-eq.</u>

$$\left(\frac{10}{100}\times PetrolBig\right)\times EFPetrol\times\frac{100}{100-PetrolBack}$$

$$+\frac{10}{5\times 20{,}000}\times CarEmbodBig$$

The notes for the small car apply here too.

The detrimental environmental effects of driving a large car are often emphasised. However, there are positive effects associated with choosing a smaller car, apart from the environmental ones. Having more money available to enjoy local services, such as restaurants and entertainment, by buying a smaller car, contributes to job creation. Moreover, if you ensure you buy a car that is manufactured to a large degree locally you are creating local jobs, and you might be reducing your carbon footprint by reducing the need for international shipments. Unfortunately, it is very difficult to find facts one would need to inform these choices. For instance, easily accessible information on the degree to which different makes and models of cars involve local manufacture does not seem to exist.

7 **Driving a Nissan Leaf electric car for 10 kilometres**

You drive alone in your Nissan Leaf, possibly the most established electric car on the market, and one which is available in South Africa, for 10 kilometres in normal conditions.

<u>*Immediate:* **2.1** kg CO_2-eq.</u>

	$\left(\frac{10}{100}\times CarElec\right)\times EFPetrol$ *Full picture (five-year view):* **3.2** kg CO_2-eq. $\left(\frac{10}{100}\times CarElec\right)\times EFEskom$ $\times\frac{10}{5\times 20{,}000}\times CarEmbodElec$

3 Emissions factors and other background values

Values which are CO_2 (or equivalent)

'[c]' indicates that 'c' would be added to the variable name if one wanted to refer only to the carbon dioxide, not carbon dioxide equivalent emissions.

Code	*Description*	*CO_2*	*CO_2-eq.*	*Source*
BicycleEmbod	The CO_2-equivalent emissions, in kilograms, associated with the production of a bicycle, using in part an inclusive calculation based on input-output modelling		166	Calculations based on figures in Walsh *et al* (2008: 395-396).
CarEmbodMid	The CO_2-equivalent emissions, in kilograms, associated with the production of a mid-range car (Ford Mondeo), using an inclusive calculation based on input-output modelling.		17,000	Berners-Lee, 2010.
CarEmbodSma	The CO_2-equivalent emissions, in kilograms, associated with the production of a small car (Citroen C1), using an inclusive calculation based on input-output modelling.		6,000	Berners-Lee, 2010.
CarEmbodBig	The CO_2-equivalent emissions, in kilograms, associated with the production of a large car (Land Rover Discovery), using an inclusive calculation based on input-output modelling.		35,000	Berners-Lee, 2010.
CarEmbodElec	The CO_2-equivalent emissions, in kilograms, associated with the production of a small electric car (Nissan Leaf).		10,500	The 6,000 value for *CarEmbodSmall* was adjusted upwards, by a ratio of 7 to 4, to acknowledge the fact that electrical cars tend to have a more emissions-intensive manufacturing process. The 7 to 4 ratio was obtained from Wilson (2013).
Cycling	The CO_2 emissions, in kilograms, of the breathing human during a one kilometre cycling trip, over and above what this human would have exhaled in an inactive sitting position.	0.005		Walsh *et al*, 2008: 395.
EFEskom	The CO_2-equivalent emissions in kilograms resulting, on average, from an amount of one kilowatt hour of electricity generated by Eskom. A value of 1.015 kilograms, taken from Letete, Guma and Marquard (2009), was the point of departure. This is the CO_2-equivalent emissions resulting from just the power plant. This amount was inflated by 7%, giving 1.086. The 7% inflation occurred to reflect background processes, above all the emissions associated with coal mining (around 90% of South Africa's		1.086	Letete, Guma and Marquard, 2009; Berners-Lee, 2010.

Code	*Description*	*CO_2*	*CO_2-eq.*	*Source*
	electricity is obtained through coal). The 7% value comes from Australia and China, other countries with a high degree of reliance on coal (Berners-Lee, 2010). A figure derived from South African data could not be found.			
EFPetrol[c]	Kilograms of CO_2 emissions from the burning of 1 litre of petrol. This figure does not include emissions associated with the production or transportation of the petrol.	2.29167	2.29968	https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2015 (May 2016). Several other sources provide the same value.
TaxiEmbod	The CO_2-equivalent emissions, in kilograms, associated with the production of a Toyota Quantum minibus, using an inclusive calculation based on input-output modelling.		34,000	The value for *CarEmbodMid* was inflated using the mass of the Ford Mondeo and the Toyota Quantum.
TrainEmbod	The CO_2-equivalent emissions, in kilograms, associated with the production of a car of the Gautrain, using an inclusive calculation based on input-output modelling.		386,364	The value for *CarEmbodMid* was inflated using the mass of the Ford Mondeo and the mass of a train car roughly equivalent to a Gautrain car (that mass was found to be 32,500 kilograms).

Values which are not CO_2 (or equivalent)

Code	*Description*	*Value*	*Source*
CarElec	The energy required, in term of kilowatt hours at an electrical charging station, to drive a Nissan Leaf all-electrical car 100 kilometres.	19.8	Two sources were consulted. The first source was a web page of the United States Environmental Protection Agency (EPA): http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=37066&id=37067&id=34918&id=34699 (Feb 2017). This source points to a value of 30 kilowatt hours per 100 miles, which converts to 18.6 per 100 kilometres. The second source was a Consumer Reports article by Eric Evarts at http://www.consumerreports.org/cro/news/2011/12/leaf-volt-tests-show-electric-cars-cost-less-per-mile-to-operate/index.htm (Feb 2017). That report produces a figure of 19.8 kWH per 100 km. It might be higher because that report is explicitly referring to the energy consumption at the charging station, not the energy consumption of just the car. It was reassuring that the two sources produced such consistent values. The second value was used.
CarLifespan	The assumed lifespan of a car, in kilometres.	320,000	http://www.consumerreports.org/car-reliability/10-best-cars-to-get-to-200000-miles-and-beyond (Dec 2016). The 200,000 miles threshold

Code	*Description*	*Value*	*Source*
			was considered an average ceiling.
GautrainCon	Electricity consumption of one carriage on the Gautrain, in kilowatts. The 600 figure is the 200 kilowatts per motor multiplied by 3 (12 motors in a four-car train gives 3 motors per carriage).	600	http://www.mytrain.co.za/index.php?cid=1326&ct=6&qid=23&menu_id=7 (Dec 2016).
PetrolBack	The percentage of the overall carbon footprint of a litre of petrol accounted for by the processes of extracting, refining and transporting the oil.	25	Berners-Lee, 2010.
PetrolBig	Petrol consumption, in litres per 100 kilometres, for a large car (Land Rover Discovery).	11.5	http://carfueldata.direct.gov.uk (Apr 2017). 'Metric combined (weighted)' figure used.
PetrolSma	Petrol consumption, in litres per 100 kilometres, for a small car (Citroen C1 1 litre engine).	4.1	http://carfueldata.direct.gov.uk (Dec 2016). 'Metric combined (weighted)' figure used.
PetrolSma2	Alternative petrol consumption, in litres per 100 kilometres, for a small car (Ford Focus 1 litre engine).	4.8	http://carfueldata.direct.gov.uk (Feb 2017). 'Metric combined (weighted)' figure used.
PetrolTaxi	Petrol consumption, in litres per 100 kilometres, for a minibus taxi (Toyota Quantum 2.5D GL Bus 14S 2.5 litre engine).	9.9	http://www.cars.co.za/newcars/Toyota/Quantum/2.5D-4D-GL-14-seater-bus (Mar 2017).
TrainLife	The expected lifespan, in years, of a train car such as those used in the Gautrain.	35	https://sparkyscrum.wordpress.com/tag/bombardier (Mar 2017).

References

Berners-Lee, M. (2010). *How bad are bananas? The carbon footprint of everything*. London: Profile Books.

Letete, T., Guma, M. & Marquard, A. (2009). *Carbon accounting for South Africa*. Cape Town: Energy Research Centre. Available from: <http://www.erc.uct.ac.za/Information/Climate%20change/Climate_change_info3-Carbon_accounting.pdf> [Accessed July 2010].

Walsh, C., Jakeman, P., Moles, R. & O'Regan, B. (2008). A comparison of carbon dioxide emissions associated with motorised transport modes and cycling in Ireland. *Transportation Research Part D,* 13(6): 392-399.

Wilson, L. (2013). *Shades of green: Electric cars' carbon emissions around the globe.* Available from: <http://shrinkthatfootprint.com> [Accessed February 2017].