Carbon dioxide emissions from vehicles fuelled with ethanol mixtures

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Abstract
The growing interest in the possible use of ethanol from natural sources to blend with petrol (gasoline) derived from crude oil (or synthesis from other fossil fuels) should be supported by knowledge of the likely effect on greenhouse gas emissions. This contribution estimates the emission of CO_2 from petrol-ethanol blends as a function of the volume percentage ethanol in the blend and the consumption of petrol/100km in the average vehicle. The effect of the ethanol having a lower energy per unit mass or volume than petrol is specifically taken into account.

Introduction

There is a growing interest worldwide in the use of biofuels, generally as a blend with fossil fuel derived fuels, to power motor vehicles. Brazil first started using non-gasoline-powered cars during the global oil crisis in the 1970s, aided by government subsidies and tax breaks (Press 2004). Sugar millers refine sugar cane into ethanol distilling 15 billion litres in 2004. All gasoline in the country has a 25 percent mix of ethanol, but 100% ethanol is also sold. Today ethanol accounts for 40% of the fuel sold in Brazil (Murray 2005). A fuel mix of 85 percent ethanol and 15 percent gasoline, known as E85, is available in at least 22 states of the U.S., mainly Minnesota and Midwestern states. The US alcohol is derived almost exclusively from corn. Many car manufacturers now offer vehicles, which permit switching between various fuel mixes (Green Car Congress 2004).

It is obvious that the greenhouse gas impact of any fuel derived from biological sources will be less than that derived from fossil sources, because the biofuel will come essentially carbon-free. However, the question arises as to what the effect on the absolute emissions is likely to be. This question is addressed in this short note.

Model considerations

Petrol has a lower heating value (LHV) of 44.7MJ/kg and a density of 0.692kg/litre, or an LHV of 30.96MJ/litre. Pure ethanol has an LHV of 31.45MJ/kg and a density of 0.789kg/litre, or a volumetric LHV of 24.81MJ/litre. Other things being equal, a litre of ethanol will drive a vehicle 24.81/30.96 = 80% as far as a litre of petrol.

A model was set up using as a standard, the energy necessary to drive a vehicle 100km using petrol. Obviously this will depend on the vehicle, but the South African saloon car fleet probably averages around 10l/100km. The average vehicle will therefore use about 309.6MJ/100km.

The model assumed that a vehicle using an ethanol-petrol mix would use the same amount of energy per 100km, and calculated how many litres of mixed fuel would be needed to provide this energy.

Finally the amount of CO_2 generated was estimated from the combustion reactions:

$$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$$
$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Results

Typical results are shown in Figure 1, which plots the total mass of CO_2, the mass of fossil CO_2 emitted, and the fuel consumption in 100km, for a vehicle which would use 10 litres of 100% petrol/100km.

Discussion

The total CO_2 emitted drops quite slightly, from 21.4 to 18.5 kg, as the vol. % ethanol in the mixed fuel increases from 0 to 100%. However, the fossil CO_2 drops rapidly from 21.4kg at 100% petrol to zero at 100% bioethanol. These reductions occur in spite of an increase in the volume of fuel consumed as the % ethanol increases. The reason for the increased fuel consumption with ethanol increase is that ethanol has a lower energy content per litre than petrol.

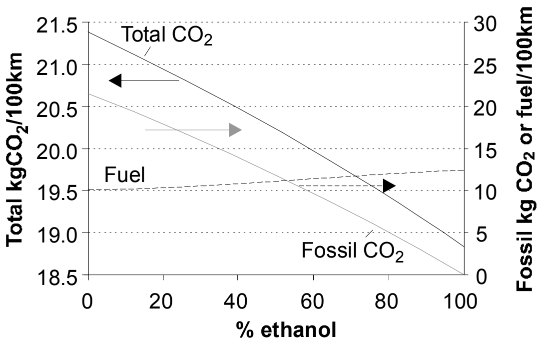

Figure 1: Mass (kg) of CO_2 emitted and fuel (*l*) consumption per 100km as a function of ethanol volume % in fuel

References

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