Ethanol Reduces Fuel Consumption

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Introduction

Transport may be the largest source of 2030 EU carbon emissions. Consequently, there is increasing recognition that climate mitigation policies in the transport sector are sorely needed, moreover, the sooner they are implemented, the better.

Ethanol can play a double role, both as a renewable fuel and as an additive to improve petrol's efficiency. This briefing does not focus on ethanol as a fuel with independent greenhouse gas (GHG) saving potential, but only on ethanol's impact on petrol when part of a blend.

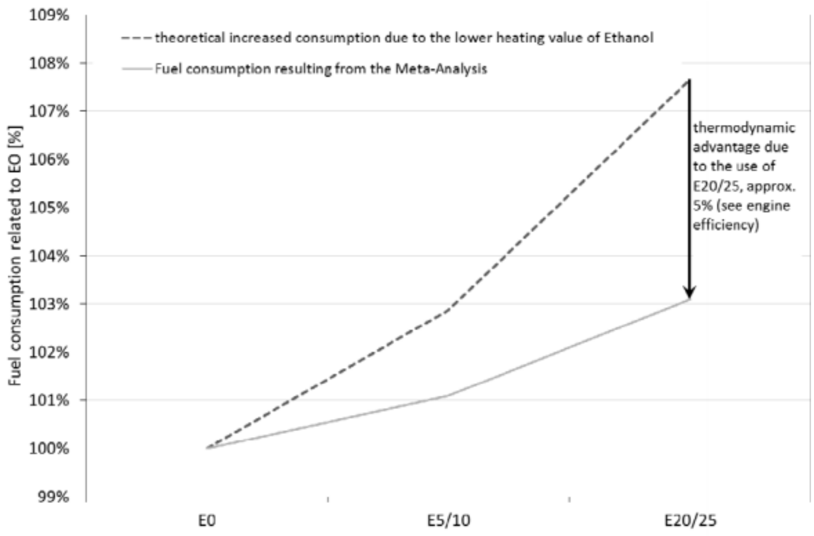
Because it is an oxygenate, ethanol increases the engine efficiency of cars, a benefit of ethanol not yet reflected in policy debates but already well grounded in science. Uncertainties remain as to the magnitude of ethanol's contribution to improved engine performance, but the existence of the effect is certain and, therefore, the effect of ethanol on engine performance should be reflected in transport policies.

Ethanol blends contribute to reduction in total fuel consumption

As CO2 results from fuel combustion, increased engine efficiency reduces CO2 emissions. When ethanol is blended with petrol, the resulting mixture has a higher octane (meaning more oxygen) rating than petrol alone, and this higher octane results in more efficient combustion than from petrol alone. The smaller and more efficient the engine (in general, the newer the car), the greater the efficiency gain.

However, ethanol has a lower energy density than petrol, meaning that while ethanol promotes greater efficiency of the petrol with which it is blended, as a stand-alone fuel it should, especially in older cars, require more volume to power a car a certain distance.

Geringer et al.'s[1] 2014 meta-analysis shows that fuel consumption, however, does not increase as much as expected given ethanol's lower energy density. Some of the loss due to lower energy density is, in fact, regained through the higher efficiency of the blended fuel. The authors' figure opposite shows this effect and suggests that E20/25[2] results in an average engine efficiency gain of about 5%, since the "loss" from ethanol due to lower energy density should be 8%, but the actual loss is only 3% thanks to the increased thermodynamic efficiency gained from ethanol. The effect is non-linear, E5/E10 is estimated to increase engine efficiency by about 2%.



1 Geringer et al. (2014): Meta-analysis for an E20/25 technical development study - Task 2: Meta-analysis of E20/25 trial reports and associated data. Vienna University of Technology (TU Wien) and Institute for Powertrains & Automotive Technology (IFA).

2 20 to 25% ethanol blended in petrol

More evidence

Similar results are shown by Kampman et al.'s[3] 2013 literature review on total fuel consumption savings due to ethanol blending. All of their reviewed studies show improvements, although to varying degrees. In practice few vehicles are optimized for higher ethanol blends (e.g. E20) yet, so the advantages of increased ethanol blending remain largely untapped. If engines are recalibrated or modified to make better use of ethanol's properties (or if engines are new and more efficient) the effect appears to be greater. Kampman et al. conclude that considerable energy consumption reduction is possible. Moreover, increased octane allows for downsizing of engines, a promising way forward for more efficient vehicles.

Case	Bio blend %	Energy consumption %	Biofuel type	Ref
Without engine modifications	5	-1.9	Ethanol	Eydogan, 2010
	10	-2.5		
Engine recalibration	20	-3.44		Costigliola, 2012
	30	-5		
	85	-4		
New engine design	22	-2.4		Costa, 2011
	100	-7.5	Hydrous ethanol	
	85	-15	Ethanol	Delphi, 2011
	20	-10		Stein, 2012
	50	-20		
	20	-6		FEV, 2012
	100	-13.5		

Source: Kampman et al., 2013

Significance

Why is this issue significant if the effects appear to be small, only a couple of percentage points? The answer is simple: the effect is disproportional. It a relatively small amount of ethanol blended contributing to have an effect on *total* petrol consumption. To put it simply, a little ethanol goes a long way.

As a result the carbon abatement cost of ethanol drops when this efficiency effect is included. Although actual abatement costs are highly dependent on the prices of both petrol and ethanol, if this engine efficiency effect is incorporated in analyses the carbon abatement cost would be negative most of the time with more modern vehicles, and low at all times for most vehicles. For instance, with the low actual ethanol prices and relatively high actual petrol prices in Europe in mid-2014, if engine efficiency is taken into account, EU produced ethanol had, by far, the lowest carbon abatement cost (less than 20 Euros/tCO2e for the average vehicle) across all climate change mitigation technology measures available in transport.

Engine efficiency improvement provides GHG savings which are not yet included in the GHG accountings of ethanol (on top of the average 60% GHG savings[4]). The magnitude of savings appears at least to be roughly in the same ballpark as the effects of any possible indirect land use change (iLUC) – only this one is a positive effect. To put it in another perspective, the engine efficiency improvement effect of ethanol seems to offset iLUC.

Conclusion

There are two faces of ethanol; renewable fuel and oxygenate. While the former is well known, the effect of the latter has just begun to be recognised. The potential climate change mitigation as a result of the latter property appears to be surprisingly large.

[3] Kampman et al. (2013): Bringing biofuels on the market. Options to increase EU biofuels volumes beyond the current blending limits. CE Delft

[4] based on 2013 industry figures and without indirect land use change