Biofuels, air quality, and human health.

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1. Background

Ethanol and biodiesel are widely perceived as sustainable alternative fuels. However, when they are used as ethanol-petrol, biodiesel-diesel blends then the blend properties can differ sufficiently from either of the base fuels that intensive studies are needed to determine the air quality implications and the resulting human health implications. CSIRO/ABARE/BTRE undertook a desktop study in 2003.

This was followed by an intensive study of 10% ethanol in petrol by CSIRO and Orbital Engine Corporation that used the results of the airshed modelling work reported in CSIRO and Orbital Engine Corporation (2008). Adding such small quantities of ethanol to petrol increases the vapour pressure, thus increasing evaporative emissions. The oxygen in the ethanol alters the combustion characteristics of the fuel leading to a different chemical profile of tailpipe emissions. The concentration of an air pollutant provides an approximate measure of the dose of an air pollutant inhaled by an individual. The relationship between the dose of an air pollutant and the health impact is quantified using a dose-response relationship.

The exposure of an individual represents the accumulated dose arising over a period of time. The population exposure is the exposure calculated for the entire population subjected to the pollutant present within the airshed.

2. Method

The modelled concentration fields of the criteria pollutants (CO, NO_2, PM- including secondary organic aerosols, O_3), were used to generate population exposure statistics that were then used to estimate the change in health impacts. The exact way in which the health impacts are calculated differs for various pollutants. Overall, the calculations used a three-step “baseline-increment” method. Having determined the health impact, it is quantified by assigning dollar values to morbidity and mortality. The quantified cost of mortality is termed the value of a statistical life (VOSL). The Ambient Air Quality NEPM assumed $7 million, a value that has also been recommended in a recent study (Access Economics, 2008). This latter value of $7 million is used.

Table 1: Indicative Summary Table of Increases in Annual Baseline Health Cost (2007$millions, 90% Confidence Intervals) for Urban Australia*

Urban Australia	2006 Results (Based on February)			2006 Annual Run	2011 Results (Based on February)		
	50% E10	100% E10	100% E5	100% E5	50% E10	100% E10	100% E5
PM Mortality	-38.466	-75.853	-61.663	-55.594	-19.497	-41.600	-37.899
PM Morbidity	-0.0305	-0.0602	-0.0490	-0.0441	-0.0155	-0.0330	-0.0301
Ozone	0.1412	0.2985	0.5798	0.3874	0.1309	0.2400	0.5623
Nitrogen Dioxide	0.0004	0.0008	-0.0189	-0.0182	0.0145	0.0289	-0.0139
Air Toxics	-0.6239	-1.2176	-0.2838	-0.2838	-0.5067	-1.011	0.0320
Total	**-38.979**	**-76.831**	**-61.435**	**-55.553**	**-19.874**	**-42.375**	**-37.349**
90% CI	-13 to -81	-27 to -159	-21 to -127	-13 to -124	-7 to -41	-15 to -88	-13 to -78

3. Health Impact Results

Quantified health impacts, as in Table 1, are based on one month of modelling in the Sydney airshed (February), scaled up to represent a full year as well as a full year's modelling for 2006 for the 100% E5 scenario, which assumes that all cars that are capable of using E5 do so.

* Sydney, Melbourne, Brisbane and Perth

3.1 Particulate Matter (PM)

Baseline

The Impact Statement for $PM_{2.5}$ Variation (NEPC, 2002) sets the baseline for health impacts in Australia on the basis of Sydney, Melbourne, Brisbane and Perth. The health impacts in terms of the number of people affected annually are given in Table 5-4 of the NEPM document.

ABS data gives the population for Sydney in 2001 as 4,128,272 and as 4,284,379 in 2006. The population of Sydney, Melbourne, Brisbane and Perth (which we refer to as Urban Australia) in 2001 was 10,220,931 people and 11,368,662 in 2006. Using these figures yields the values in Table 2 for Sydney and for Urban Australia, to which have been added the 95% confidence intervals of Burgers and Walsh (2002).

NEPC (2002) contains health costs associated with hospital admissions for asthma ($8,875), cardiovascular disease ($11,709) and chronic obstructive pulmonary disease (COPD, $9,610) in 2001 dollars. Adjusted to 2007A$ using CPI inflation figures this results in $10,447 for asthma, $13,783 for cardiovascular disease and $11,312 for COPD.
It should be noted that the agreed Australian baseline value for particulate matter is based on $PM_{2.5}$ concentrations. This means that quantified health effects are based on the $PM_{2.5}$ data collected during the vehicle experiments documented in CSIRO and Orbital Engine Corporation (2008).

Increment

The above baseline values and the results of the population exposure modelling were applied to four different scenarios for Sydney for 2006 and 2011. The four scenarios are ULP (100% of the petrol-driven vehicles running on ULP, which is taken as the baseline), 50% E10, 100% E10 and 100% E5 (note that the percentages indicate the proportion of the fleet reported to be suitable for use with ethanol blends, not the percentage of the total fleet). The time periods are (1) Vehicle emissions in 2006, based on records of registered vehicles in Sydney; and (2) Vehicle emissions for 2011, based on projections for uptake in newer vehicles with reduced emissions (due to better technology and adherence to new Australian emissions standards), and corresponding retirement of older vehicles. 2011 costs have also been increased slightly to account for the expected population change between 2006 and 2011.

Table 2: Health effects (number of people affected) for 2006 attributable to levels of PM2.5 in Australia

Area	Short Term Health Endpoint						Long Term Health Endpoint		
	Mortality			Hospital Admissions			Mortality		
	All cause	Respiratory	CV	Asthma	Cardio-vascular	COPD	All cause	Lung Cancer	COPD
Sydney	286	85	57	164	257	61	729	92	550
95% CI Low	163	52	8	64	152	13	250	28	191
95% CI High	406	119	105	262	361	113	1291	142	932
Urban Australia*	701	214	140	333	574	103	1770	214	1205
95% CI Low	402	132	20	130	345	21	614	67	424
95% CI High	1001	299	261	536	816	196	3178	337	2071

* Sydney, Melbourne, Brisbane and Perth

The values in Table 1 show the annual differences in health costs for the scenarios and time periods compared to that of 100% of the petrol-driven vehicles using neat ULP (based on the month of February) and for a run of the model for the entire year. Negative values indicate a benefit, i.e. savings in health costs (in millions of 2007A$) as a result of reduced $PM_{2.5}$ emissions. These values have then been scaled up for Urban Australia on a population ratio basis. Values in parentheses are the 90% confidence intervals (rather than the 95% confidence intervals used by Burgers and Walsh, 2002).

Over 99% of the $PM_{2.5}$ health costs are due to reductions in short and long term mortalities; morbidity costs due to asthma, cardiovascular disease and COPD make up only about 0.1% of the overall health costs.

Despite there being more petrol-driven vehicles and a higher population predicted for Sydney and Urban Australia in 2011, in most cases the quantified health impact differential between ULP and ethanol fuelled vehicles drops from 2006 to 2011. This is because modern petrol vehicles, due to increasingly stringent emissions standards, emit measurably less emissions than their older counterparts, and will make up a higher proportion of the fleet in the future – hence the beneficial effects of reductions in particulate matter with the use of ethanol become less significant as the fleet produces lower emissions as a whole.

Similar calculations were undertaken for the other criteria pollutants and for air toxics. Because the health impacts are dominated by particulate matter, they are not reported in this paper but can be perused in the report (CSIRO and Orbital Engine Corporation, 2008)

4. Conclusions

This study estimates that there is a health benefit to Sydney and the Urban Australian population (taken as Sydney, Melbourne, Brisbane and Perth) arising from a move from neat ULP to ethanol blends in spark-ignition vehicles. Based on the average fleet make-up in 2006 this value for Sydney is approximately $16 million for a 50% take-up of E10, (based on the results for February; for an average annual run of the model the value for a 100% take-up of E5 is approximately $23 million in 2006). For Urban Australia the 2006 values are approximately $39 million for a 50% take-up of E10 (based on the results for February; for an average annual run of the model the value for a 100% take-up of E5 is approximately $56 million in 2006).

The overall quantified health benefit of using ethanol blends is overwhelmingly dominated by reductions in particulate matter.

The benefits reduce with time as newer vehicles enter the fleet. For 2011 it is estimated that the quantified health benefits for Sydney are approximately $8 million for a 50% take-up of E10, $15 million for a 100% take-up of E5, and $17 million for a 100% take-up of E10. For Urban Australia the corresponding values are approximately $20 million for a 50% take-up of E10, $37 million for a 100% take-up of E5, and $42 million for a 100% take-up of E10.

References

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