EXHAUST POLLUTION FROM NEW ZEALAND TRUCKS

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INTRODUCTION

In 1990, the New Zealand road transport fleet consumed nearly 600,000 tonnes out of a national total of just over a million tonnes of diesel fuel used for various purposes in the country. There is a popular conception that the diesel-engined truck is responsible for far more than a fair share of the pollution generated by road users. The topic addressed by this paper is an examination of the true level of pollution arising from the exhausts of diesel trucks, and the significance of the pollution in terms of national and international concerns for the atmosphere.

LIMITATIONS

Before proceeding with this review, I believe it is essential that it is clearly understood that this assessment cannot be made using data readily available, or measurements made, in New Zealand. Since the mid 1980's, a consequence of the fiscal and administrative changes made by governments has been a failure to improve, or even maintain, the data bases relating to energy use and vehicle statistics. Where data has been collected, it is often only obtainable if substantial fees are paid to the collecting agency. Where exhaust pollutants are concerned, New Zealand data has never been available, since we do not have, in this country, means by which exhaust emissions from trucks (or from cars) can be measured in an internationally-acceptable way.

Fortunately, relevant truck and diesel engine data is available from Europe, America and Japan. For cars, data from these areas cannot be used because the exhaust emission equipment used in those territories is not fitted in New Zealand. For diesel-engined vehicles, exhaust emission control equipment is only now appearing on trucks, so data taken recently is still valid. By 1994, the situation will have changed, particularly in America, where the emission regulations will be so stringent that elaborate engineering changes to engine technology will be essential in order to meet the regulations.

Much of the data on which this paper is based was collected by DSIR and Auckland University as part of a study carried out earlier this year for the Ministry for the Environment. That study was part of a programme funded by the Ministry and intended to establish the contribution to total nitrous oxide emissions made by road transport. Some information was obtained from the vehicle registration centre at Palmerston North; further information was provided by the Ministry of Transport, but possibly the most valuable information relating to the commercial fleet had, of necessity, to be extrapolated from the work of the New Zealand Energy Research and Development Committee carried out in the mid-1980's. Emission data was provided by a variety of authorities, including the EPA and the Californian Energy Commission in America and by the Japanese Automotive Research Institute in Japan.

POLLUTANTS

We have all become accustomed to the idea that road vehicles emit a variety of harmful constituents in their exhaust gases, and everyone, I imagine, is familiar with the knowledge that over much of the OECD world there are strict limits on the amounts of carbon monoxide (CO), oxides of nitrogen (NOx) and unburned hydrocarbons (HC's) that are permitted. To date, New Zealand does not have legislation controlling these emissions, and it is probable that the substance that is first going to attract legislative attention in New Zealand is one that, at present, has no legislation controlling its emission anywhere. This is carbon dioxide (CO_2), now being targeted as the most prominent of the gases responsible for the greenhouse effect.

There are other emissions from diesel engines that are attracting increased attention elsewhere, and which operators would be wise to bear in mind. Environmental concerns propagate very quickly, and so far New Zealand operators of diesel engines have been very fortunate to escape the stringent legislation that governs diesel engine manufacture and use in the USA, for example. We have escaped because, so far, there is no evidence that NOx emissions are causing acid rain effects on our forests and lakes, or CO and HC emissions generate photochemical smog outside Christchurch and Auckland's Queen Street. But in America it is now accepted that particulate emissions from diesels, where the particles are less than 10 microns in diameter, are carcinogenic. In 1994, very stringent particulate emission standards will be introduced for all diesel engines. Particulate traps and other measures, all of them costly, plus much more expensive fuel with lower aromatic content, will be necessary to meet the standards.

The concern over carcinogenicity will certainly spread from America to New Zealand. Diesel engines in New Zealand emit around 5,000 tonnes of soot annually, calculated for engines in good health and tune. I do not know what the evidence is that has convinced the EPA of the carcinogenic properties of sub-ten micron particles from diesel engines, but there will be evidence on which they have acted, and that evidence will be public knowledge. Eventually, there will be public pressure here to control particulate emissions.

As far as the other, legislated, pollutants are concerned, diesel engines are being restricted more and more. In Tables 1,2,3,4,5 and 6 I show the limits on pollutants, and how they have changed in recent years in Europe, Japan and America. Some further restrictions will be coming, particularly for NOx, and especially in Japan. NOx limits are particularly serious for diesel engines, since there are, at present, few technical methods by which the exhaust gas stream can be treated. Reducing catalysts are not available that will function in the oxygen-rich exhaust stream that emerges from a diesel engine. At best, NOx can be reduced by exhaust gas recirculation (EGR), by the lowest practicable compression ratio, and by careful attention to injection characteristics. Fortunately, diesel engines are low emitters of NOx compared to untreated petrol engines, but the proposed limits in Japan, if they are enacted in legislation, make the survival of the domestic Japanese diesel engine questionable. Already, in the Tokyo area, there are a number of peaking diesel powered generating stations that are forbidden to operate because of their NOx emissions.

As far as CO and HC's are concerned, the problems are not so severe, and the inherently low levels from diesel engines can, if necessary, be controlled over part of the engine operating range by exhaust catalysts. The range where catalysts are ineffective, due to low exhaust gas temperatures, is where the diesel engine produces least CO and HC's.

GREENHOUSE GASES

The recognition of anthropogenic emissions of CO_2 as a major cause of enhanced greenhouse effect (EGE) presents the diesel engine with both problems and opportunities. Diesel engines are inherently more efficient than petrol engines, and therefore consume less fuel per kW of output. The increased efficiency more than offsets the higher carbon content of the fuel. There is thus an opportunity, if CO_2 emission restrictions are imposed on vehicles, for the diesel engine to replace the petrol engine on the grounds of lower CO_2 emissions. The problem is that there will be a drive to replace road vehicles with more energy-efficient forms of transport, and quite probably, in the not-so--long term, a drive to replace road with rail transport.

The New Zealand Government has a target of a 20% reduction in net CO_2 emissions by the year 2000. The present rate of growth of gross emissions, if continued, will lead to an increase of 17% instead of a reduction. The reduction, in net terms, can only be obtained by reducing emissions by 32% from what can be expected in 8 years' time, compensating by planting around 40,000 hectares per year of trees in perpetuity, or by some combination of these activities. It is very doubtful if a realistic attempt can be made to reach the target.

Internationally, it is a distinct possibility that at the UNCED meeting in Rio de Janeiro this year (1992), OECD governments will be expected to commit to an enforceable level of greenhouse gas reductions. If this should happen, it is probable that the requirement will be to stabilise Year 2000 emissions at 1990 levels. No-one yet knows if the requirement will be for gross emissions, net emissions, or gross or net CO_2 emissions only. For New Zealand it is desirable economically that the target be for net CO_2 emissions; meeting a gross CO_2 target or a target for all greenhouse emissions would place us in a very difficult position since we are very large emitters of methane and nitrous oxide from agriculture.

Whatever the target, very large reductions will be expected from the transport sector. Transport accounts for around 42% of our CO_2 emissions, and the rate of increase for transport is higher than for industry generally (though not for Electricorp if the projections for increased electricity use are accepted). Much of the increase is due to the greater proportion of more powerful and larger cars in the car fleet since about 1983 which are being driven greater distances. Average car mileages have risen by 23% over the last 10 years and fuel economy has deteriorated, even though car fleet numbers have only increased slightly. Distances covered by trucks have not changed appreciably, but, of course, average truck size has increased. Also, light commercial diesel powered vehicles have increased substantially in numbers over the last 10 years. Light commercial vehicles below 3.5 tonnes covered 17% of the total road miles of the New Zealand vehicle fleet in 1990, compared to only 6% of the total for vehicles covered by road user charges. It may be surprising to realise that the average distance covered by trucks subject to road user charges is only 23,000 km per year, and that only 10,000 trucks covered more than 45,000 km in 1990.

Fortunately, in terms of CO_2 emissions, diesel road transport is responsible for only 23% of the road related CO_2 emissions in New Zealand, and the brunt of any reductions must (and should be) borne by the private car user. Before the transport industry congratulates itself on its virtue, however, it should be realised that the New Zealand per capita emissions due to road diesel consumption is almost exactly equal to the total per capita CO_2 emissions for India. Our per capita total CO_2 emissions are eight times those of India. Almost certainly, future restrictions world-wide are going to be based on per capita emissions, and countries with above average per capita emissions will be required to reduce their levels, whilst countries such as India or China will be allowed to increase theirs.

The other significant greenhouse gas emitted by diesel engines is nitrous oxide, N_2O. Nitrous oxide is a far more serious greenhouse gas than CO_2 (Fig 1). Fortunately, N_2O is not produced in very significant amounts by cars and trucks, and the amount emitted by all road vehicles in 1990 is estimated as just over 300 tonnes out of the total vehicle NOx emissions of around 70,000 tonnes. Of the total N_2O produced, diesel vehicles emitted less than 50 tonnes. Agricultural emissions of N_2O are orders of magnitude greater.

Even though the road user "villain" is the private car, there is still going to be pressure on the trucking industry to reduce fuel consumption and thus CO_2 emissions. The fuel consumption effect of deregulating the trucking industry in New Zealand, in terms of litres of fuel used per tonne-km of transportation has not been quantified, but in California, for example, deregulation led to a 40% increase in truck distance covered for the same amount of goods being transported the same distance as before. The New Zealand experience will be different, because there has been a shift from rail to road as well as road transport deregulation, but undoubtedly deregulation is unlikely to have improved fuel economy and transport fuel efficiency. I am not necessarily advocating a return to regulation, but somehow the industry will need to demonstrate before the turn of the century that the most efficient use is being made of fuel in terms of distance and weight of goods transported.

CONCLUSIONS

I hope that I have been able to show that the diesel engined road transport vehicle is far from being the villain of the piece where exhaust emissions are concerned on New Zealand roads. Diesel vehicles use only about one quarter of the total hydrocarbon road fuels, and generally produce far less toxic pollutants per litre of fuel than private cars. They also have greater thermal efficiency, and thus make more efficient use of the fuel that they burn. A major transition to increased diesel use in private cars would be of significant benefit in reducing New Zealand's output of greenhouse gases.

Nonetheless, it can be anticipated that the concern with the health effects of particulate emissions will spread from America to New Zealand by mid-decade, and diesel engine particulate emissions will undoubtedly be targeted by domestic environmentalists. Road goods transport will not be able to escape being targeted for reduction in CO_2 emissions, along with other road users, and it will be essential to be able to demonstrate efficient use of fuel by the industry rather than demonstrating that the vehicles have low unit fuel consumption. Already carbon taxes of up to $300 per tonne are being mooted, and the effect of such a tax on diesel fuel price is an increase of around 40%. The ultimate threat to the road transport industry will be pressure to transfer bulk long distance goods transport to rail in order to make the maximum possible reduction in CO_2 emissions.

I cannot tell you if the enhanced greenhouse effect will really threaten mankind as predicted, but I am absolutely certain that over the next 8 years governments world-wide will begin to act as if the threat is real. Road transport operators would be foolish not to plan their operations without taking this prospect into account, and using the very little time that remains before action is taken to maximise their efficiency of fuel use, and to make certain that the fuel efficiency of diesel operation is well comprehended by Government. I am not advocating a move to alternative fuels such as CNG, in spite of the lower CO_2 emissions, because the gas will run out shortly after the turn of the century, when, in all probability, emission restrictions will really start to bite.

TABLE 1 EXHAUST GAS LIMITS IN USA FOR HEAVY-DUTY TRUCKS WITH DIESEL ENGINES

Model Year		HC	CO	NO_x	Part.	Smoke
		g/Hph	g/Hph	g/Hph	g/Hph	% Opacity
1987	Fed	1.3	15.5	10.7	–	A Acceleration 20% B Full-load deceleration 15% C Max puff of smoke 50%
1987	Cal	1.3	15.5	5.1 6.0	–* 0.6*	
1988 1989 1990	Fed/ Cal	1.3	15.5	6.0	0.6	
1991 1992 1993	Fed/ Cal	1.3	15.5	6.0	0.25	
1994	Fed/ Cal	1.3	15.5	5.0	0.10	

*) Either 5.1 g NO_x/Hph without particulate emissions or 6.0 g NO_x/Hph and 0.6 g particulates

TABLE 2. EXHAUST GAS LIMITS IN USA FOR LIGHT-DUTY TRUCKS WITH DIESEL ENGINES

Model Year		Wt Class	Limits at sea level				Altitude limits[1]		
			HC	CO	NO_x	Part	HC	CO	NO_x
		lbs	g/mile						
1986	Fed	≤8500	.80	10.0	2.3	0.6	1.0	14.0	2.3
	Cal	≤3999	.46	10.6	1.0	0.2	-	10.6	-
		4000/5999	.50	9.0	1.5	0.2	-	9.0	-
		6000/8500	.60	9.0	2.0	0.2	-	9.0	-
1987	Fed	≤8500	.80	10.0	2.3	0.26	1.0	14.0	2.3
	Cal	≤3999	.46	10.6	1.0	0.2	-	10.6	-
		4000/5999	.50	9.0	1.5	0.2	-	9.0	-
		6000/8500	.60	9.0	2.0	0.2	-	9.0	-
1988	Fed	≤3999	.80	10.0	1.2	0.26	1.0	14.0	1.2
		4000/5999	.80	10.0	1.7	0.26	1.0	14.0	1.7
		6000/8500	.80	10.0	1.7	0.26	1.0	14.0	1.7
	Cal	≤3999	.46	10.6	1.0	0.2	-	10.6	-
		4000/5999	.50	9.0	1.5	0.2	-	9.0	-
		6000/8500	.50	9.0	2.0	0.2	-	9.0	-
1989	Fed	≤3999	.80	10.0	1.2	0.26	1.0	14.6	1.2
		4000/8500	.80	10.0	1.7	0.26	1.0	14.6	1.7
	Cal	≤3999	.46	10.6	1.0	0.08	-	10.6	-
		4000/5999	.50	9.0	1.5	0.08	-	9.0	-
		6000/8500	.50	9.0	2.0	0.08	-	9.0	-

[1]) Federal: at 1,620 m above sea level; Cal: at 1829 m above sea level

TABLE 3 EXHAUST GAS LIMITS IN USA FOR PASSENGER CARS WITH DIESEL ENGINES

Model Year		Limits at sea level				Altitude limits[1]		
		HC	CO	NO_x	Part	HC	CO	NO_x
		g/mile						
1986	Fed	0.41	3.4	1.0	0.6	0.41	3.4	1.0
	Cal	0.41	7.0	1.0	0.2	-	7.0	-
1987	Fed	0.41	3.4	1.0	0.2	0.41	3.4	1.0
	Cal	0.41	7.0	1.0	0.2	-	7.0	-
1988	Fed	0.41	3.4	1.0	0.2	0.41	3.4	1.0
	Cal	0.41	7.0	1.0	0.2	-	7.0	-
1989	Fed	0.41	3.4	1.0	0.2	0.41	3.4	1.0
	Cal	0.41	7.0	1.0	0.08	-	7.0	-
1990	Fed	0.41	3.4	1.0	0.2	0.41	3.4	1.0
	Cal	0.41	7.0	1.0	0.08	-	7.0	-

[1])Federal: 1620 m above sea level; California: 1829 m above sea level

TABLE 4 EXHAUST GAS LIMITS IN JAPAN FOR COMMERCIAL VEHICLES WITH DIESEL ENGINES

Model Year/ Vehicle Type	Limits in ppm					
	HC		CO		NO_x	
	Avg.	Max.	Avg.	Max.	Avg.	Max.
New Vehicle models as of Aug.1 1983 All new vehicles as of Jul.1 '84	510	670	790	980	4701 290[2]	610[1] 390[2]
Imported Vehicles as of Jul.1 '84	510	670	790	980	470[1] 290[2]	700[1] 390[2]

[1] Direct Injection
[2] Indirect Injection

TABLE 5. EXHAUST GAS LIMITS IN JAPAN FOR PASSENGER CARS WITH DIESEL ENGINES

Vehicle Weight (kg)	Limits in g/km					
	Homologation			Production Check		
	HC	CO	NO_x	HC	CO	NO_x
≤ 1265	0.70	0.40	2.10	0.98	0.62	2.70
> 1265	0.90	0.40	2.10	1.26	0.62	2.70

TABLE 6. EXHAUST GAS LIMITS IN EUROPE FOR VEHICLES UNDER 3.5 TONNES WITH DIESEL ENGINES

Vehicle Weight (kg)	Limits in g/test						
	Valid as of Oct. 1, 1982 EEC R 1/04		Valid as of Oct. 1 1990 for new vehicle models with engine capacity < 1.4 l [1]			Valid Oct. 1 1991 for new vehicle models with engine capacity > 1.4 l [2]	
	CO	HC+ NO_x	CO	NO_x	HC+ NO_x	CO	HC+ NO_x
≤ 1020	58	19	45	6	15	30	8
1020-1250	67	20.5					
1250-1470	76	22					
1470-1700	84	23.5					
1700-1930	93	25					
1930-2150	101	26.5					
> 2150	110	28					

[1] Valid for DI engines from 1993
[2] Valid for DI engines from 1994

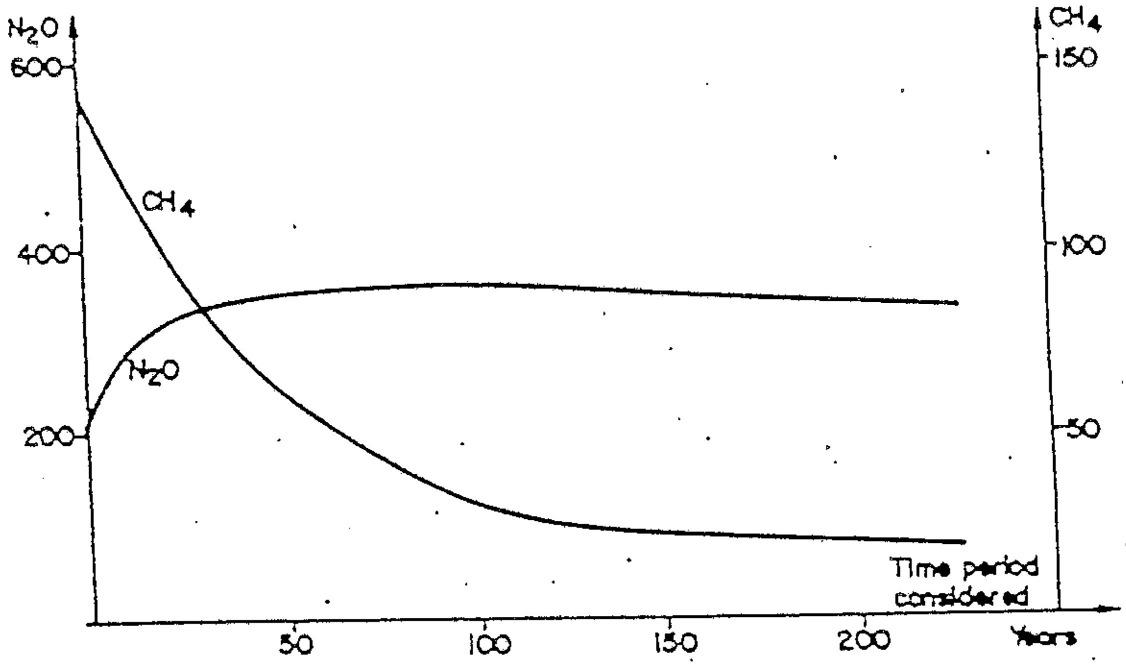

Fig. 1 Factors for multiplying the emissions of N_2O and CH_4 in order to obtain the same cumulative greenhouse effect as CO_2 (kg).