AIR POLLUTION

Emission Impacts of Electric Vehicles in the Los Angeles Region: A Public Policy Analysis

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Abstract

This paper summarizes the findings of a study, conducted by The Claremont Graduate School's Public Policy Clinic, which examines the air quality benefits of electric vehicle use in Los Angeles. Evidence is presented showing that EVs could provide the greatest air quality benefits of any alternative transportation technology or fuel now being considered for near-term application in the Los Angeles air basin. The implications of this finding for public policy makers is then discussed, and a list of policy options for encouraging greater use of EVs is provided.

The need for integrated public policy in the areas of environmental quality, transportation, and energy is perhaps nowhere more apparent than in the Los Angeles area. This region, more than any other in North America, exemplifies the problems and the opportunities created by a mobile society that is fueled by cheap oil and powered by the internal combustion engine.

The South Coast Air Basin (SoCAB), which includes the City of Los Angeles, is unique among the nation's polluted air basins, due to its geography, meteorological conditions, and demographics. The sea breezes blow air contaminants generated near the coast back against the mountains. Frequent temperature inversions create a low "ceiling" which slows the upward dispersion of the offending gases. Sunshine provides the energy necessary to promote the chemical reaction of the trapped pollutants, forming ozone and other substances that are thought to be harmful to human health, vegetation, and a variety of building materials and fabrics. Ozone (O_3) is by far the worst problem for the Los Angeles region, exceeding the federal standard an average of 140 days per year during 1984-1986. New York, Houston and Denver, the cities with the next worst ozone problems, exceeded the standard at most only 20 days per year during the same period.

Transportation within the basin accounts for over 50 percent of all nitrogen oxide emissions, 70 percent of carbon monoxide, 74 percent of fine particulates, and 22 percent of reactive organic gases. Emissions from the nearly 8 million highway vehicles in use account for more than 60 percent of the region's man-made ozone production. And with ozone levels that are three times the allowable federal standards (see Figure 1), many citizens and elected officials are asking what can be done to preserve a system of private transportation without endangering public health.

Most observers agree that the Los Angeles area will not be able to meet current clean air standards for at least fifteen to twenty years, if ever. The reason for this gloomy assessment arises from the expectation that the number of people and vehicles in the basin will increase dramatically--five million more people and two-and-one-half million more cars and trucks by the year 2010. Pollution control technology is expected to improve during this period, along with fuel efficiency for gasoline powered vehicles, but the rate of advance may not keep pace with the growth of pollution sources, let alone improve on today's levels of emissions.

Related to the issue of air quality is the question of how the greater Los Angeles area will deal with the problem of congestion in its transportation system. Slower vehicles mean increased pollution on a per-mile-traveled basis (see Figure 2). With an expected increase of 3 million new trips to work per day by motorists in the year 2010, the compounding effects of gridlock on air quality could be severe. Average daytime freeway driving speeds have slowed to about 31 miles per hour today and are projected to decline sharply to a mere 11 miles per hour by 2010.

Policy makers have responded to these challenges with three types of programs to combat air pollution from mobile sources: (1) strengthening standards for

Table 1

EMISSIONS FROM EV BATTERY CHARGING[1] COMPARED TO EMISSIONS FROM INTERNAL COMBUSTION ENGINE VEHICLES (ICEVs)[2]

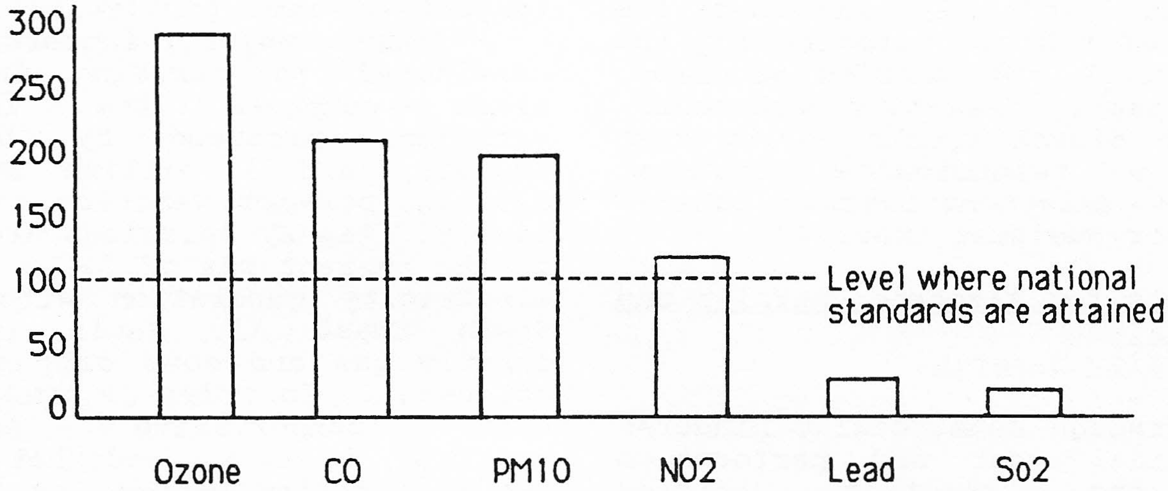
Type of Emissions	Avg gms/mi for EV[3]	Avg gms/mi for ICEV	AGGREGATE TONS PER YEAR 100,000 EVs	100,000 ICEVs	500,000 EVs	500,000 ICEVs	1,000,000 EVs	1,000,000 ICEVs
NOx	0.232	1.0	369	1,320	1,845	6,600	3,690	13,200
CO	0.043	8.3	68	10,956	340	54,781	680	109,560
HC	0.0135	0.41	22	541	107	2,708	215	5,410

[1] In-basin NOx, CO, and HC emissions from EV battery charging assume 100% in-basin power plant generation and EV travel of 12,000 mi./yr.

[2] From California New Passenger Car Exhaust Emission Standards at 100,000 miles, driving 12,000 mi./yr.

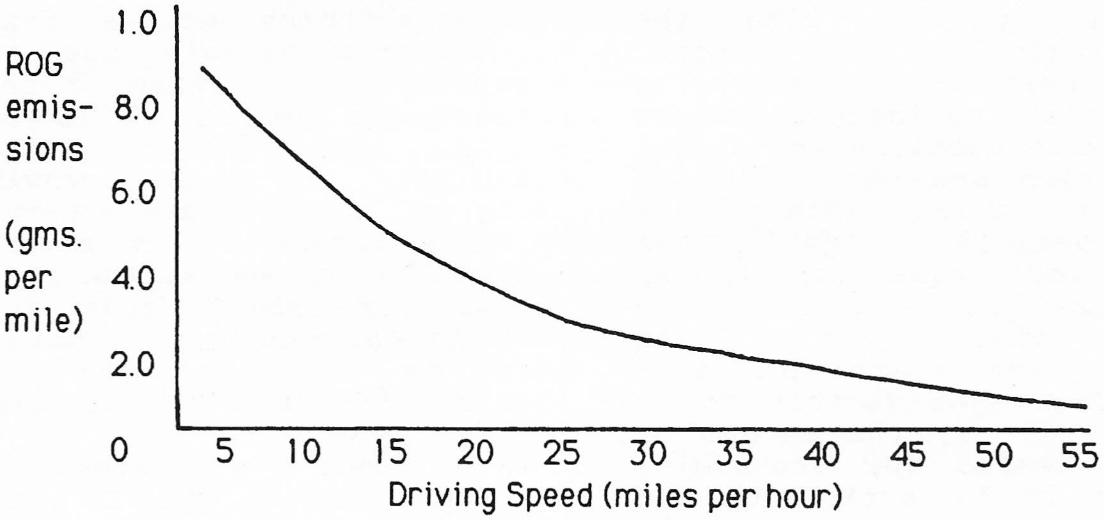
[3] EV efficiency of 2 mi /kwh from the battery, emissions are calculated with the assumption of 0.83 efficiency of battery charging

Figure 1
1986 Emissions Levels in the South Coast Air Basin as a Percentage of National Standards



Source: South Coast Air Quality Management District and Southern California Association of Governments, 1987.

FIGURE 2
RELATIONSHIP BETWEEN VEHICLE EMISSIONS AND VEHICLE SPEED
Estimated emissions of reactive organic gases (ROG) for the year 2010 at temperature of 75 degrees Fahrenheit



Source: California Air Resources Board (EMFAC 7C), 1987 pollution control technology and ensuring their continued effectiveness through semi-annual inspection programs: (2) encouraging the development of cleaner alternative transportation fuels, particularly methanol; and (3) limiting the volume of vehicle trips during the day through ride-sharing programs, mass transit, flex-time work hours, bans on diesel trucks during rush hours, and technological advances, such as telecommunication substitutes for business travel.

Prospects for Electric Vehicles and Potential Air Quality Benefits

Although commercially hindered by initial cost and performance limitations, electric vehicles could provide by far the greatest air quality benefits of any alternative transportation technology or fuel now being considered for near-term application in the South Coast Air Basin. Moreover, because less than 10% of the region's electricity is generated from oil sources, electric vehicles would be relatively unaffected by future oil price shocks or import interruptions.

The air quality benefits of electric vehicles are measured by comparing the tailpipe emissions of conventional vehicles with the smokestack emissions of electric powerplants used in the recharging of EV batteries. Refinery emissions associated with gasoline and diesel fuel production are then added to the balance sheet. Since the electric vehicle itself has essentially zero emissions, the key questions are: how clean are the powerplants which provide its electricity, and where are they located? The major factors to be considered are: (1) the amount of electricity needed for recharging (a function of EV efficiency and vehicle miles traveled); (2) the fuel mix used to generate recharge electricity (e.g., oil, gas, coal, nuclear, hydro); (3) the emissions produced by each type of fuel used in power generation; and (4) the location of the powerplants with respect to human populations.

These major factors were considered in deriving Table 1 which compares the in-basin emissions produced by 100,000, 500,000, and 1 million EVs and gasoline-powered vehicles, respectively. The EV emissions are based on the current mix of fuels used in electricity generation within the South Coast Air Basin (predominantly gas and some oil; coal is not used). In order to present the most conservative estimate possible, it is assumed that all of the electricity needed for battery charging is generated from within the basin. This is an important assumption since nearly 70 percent of the region's electricity is normally generated outside of the basin. This means that the resulting pollution is, in large part, transferred or "exported" out of the region. The costs to public health of this exported pollution are far lower than they would be if all the powerplants were located inside the basin, but the issue of fairness in shifting urban pollution to sparsely settled areas remains a thorny one. A transition to electric vehicle use in Los Angeles is, in a sense, a tradeoff between the health of 12 million people and the unimpaired visibility of areas downwind of isolated, out-of-state powerplants. To some extent it is a tradeoff between health and aesthetics, with places like Mesa Verde National Park in Colorado experiencing more haze so that children in Los Angeles can breath cleaner air.

As Table 1 indicates, the air quality benefits of EV use are striking. An electric vehicle with an efficiency of 2 miles/kwh produces 99+ percent less carbon monoxide, 96 percent less hydrocarbons, and 28 percent less NOx than a comparable gasoline-powered vehicle.

Public Policy Considerations

It is often assumed that the marketplace alone will decide the fate of the electric vehicle. If EVs are shown to be cost-effective substitutes for conventional vehicles, so the argument goes, consumer demand for EVs will follow automatically. Up to a point, this is a persuasive argument. No matter how attractive electric vehicles may be from the perspectives of air quality improvement or greater flexibility in energy use, competitive cost and affordability remain the decisive factors in consumer acceptance.

The principal obstacles to EV mass market penetration, according to conventional wisdom, can be summarized as price, performance, and perception--the three "P's." Price is defined in terms of private internal costs; performance is measured against the standards set by large gasoline-powered engines; and perception is described, to paraphrase Ralph Waldo Emerson, as seeing what our experience has prepared us to see.

For the millions of Americans who think of a battery-powered golf cart when they hear the term "electric vehicle," current perception of EVs are not very hopeful. For those who drive high performance automobiles with jack-rabbit acceleration speeds and 500 horsepower engines, the performance characteristics of an EV will seem lackluster in comparison (the "pick-up" performance of state-of-the-art EVs has been likened to that of today's diesel powered automobile). And for those who are used to paying gasoline prices that exclude the health and environmental costs of pollution, or the military costs to taxpayers of protecting distant oil fields, electric transportation may seem prohibitively expensive.

In fact, it would appear that electric vehicles have very little to offer us if we confine our evaluations of their potential worth to the conditions of our present economy and way of life, and assume that gasoline and diesel fuels will continue to be plentiful. The status quo standards for price and performance, along with public perceptions of what counts in transportation choices, will make it difficult for EVs to compete with conventional vehicles, unless they are somehow able to take on all of the desired characteristics of the vehicles that they would replace. Since this is highly unlikely, progress in the use of electric vehicles will probably depend on changes in the benefit-cost criteria and the performance values that are used in measuring their worth. In other words, the creation of market pull for electric vehicles must await changes in public understanding about the tradeoffs involved in a transition to electric transportation. Ron Dell, a manager of one of Britain's leading battery research laboratories, describes the tradeoffs this way:

> We all wear two hats: one says Citizen, the other says Consumer. When we worry about environmental protection, balance of payments, depletion of oil resources and the greenhouse effect, we are wearing our Citizen hat. But when we go out and buy our car, we put on our Consumer hat, and we start to

worry about what car is it, how much does it cost
and does [our spouse] like it.

Somehow society has to make a marriage of these
two in such a way that there isn't a sharp con-
flict.... It's one thing to be drinking sherry
and talking in the abstract. It's another to be
sitting down writing the check, and we have to get
this right.

As citizens, we recognize that our transportation choices affect the quallity of life for those around us. But as consumers, we know that paying for cleaner air and greater energy security involves personal, monetary costs - in the form of higher purchase prices for alternative fuels and vehicles - while the benefits of our purchases are shared by everyone else, including those who continue to drive conventional gasoline and diesel powered vehicles.

In order to understand the full implications of our transportation choices, it will be necessary to identify the sources of distortion in the market prices for conventional fuels and vehicles, along with the institutional barriers and political obstacles that stand in the way of any major transition to clean fuels and vehicles. Vehicles powered by electricity, methanol, natural gas, or hydrogen are by no means panaceas. And in the case of electric vehicles, it is certainly true that the technology is not yet ready to meet the current transportation needs of most Americans, at least in an affordable manner. Thus, if EVs are to advance beyond the so called "niche" markets of today, new conceptual approaches for comparing conventional vehicles with alternatives will be needed.

The real costs of continued reliance on petroleum to fuel our transportation system appear to be much higher than most previous studies have indicated. Evidence for this conclusion is provided in a recent report from the University of California's Institute of Transportation Studies [Deluchi et al., 1987]. The report includes a detailed analysis of the external costs of gasoline and diesel fuel use, nationwide, for the year 1985. Included in the external costs are the military expenses of protecting oil production and transportation facilities, the costs of the Strategic Petroleum Reserve, the health and environmental costs of vehicular and refinery pollution, and the costs associated with fuel subsidies. Together, they amount to as much as $442 billion/year (in 1985 dollars). The authors estimate national pollution costs of highway vehicles to be approximately $100 billion/year. Not included in these estimates are the indeterminate costs of climate change brought on by the release of CO_2 and other "greenhouse" gases associated with the burning of fossil fuels. If gasoline prices reflected the social costs that can be roughly quantified, the present cost of a gallon of gasoline could easily double, and by some estimates triple.

Electric vehicles, particularly if their batteries are charged by nonfossil fuel electricity, offer important advantages in reducing, and in some cases eliminating, these hidden costs. They are not, however, ready to compete with gasoline or even methanol powered vehicles on a large-scale basis today. If advances in battery technology and powertrain systems continue at the rates achieved in the past ten years, and the costs of gasoline and other substitutes remain above $1/gallon (gasoline equivalent), then it is likely that mass produced electric vehicles would compare favorably, on a lifecycle cost basis, with a wide range of internal combustion engine (ICE) vehicles of the late 1990s.

The marketing challenge will then be to convince consumers that purchase prices, which can be expected to be higher for EVs than for conventional vehicles, are not by themselves sufficient grounds for choosing between vehicles with comparable features. Fuel costs, maintenance costs, and the expected life of the vehicle must also inform judgments about what to buy. Hopefully, external costs and benefits will also be of increasing concern.

It would be nice if the marketplace operated to internalize the social costs of gasoline and diesel powered vehicles. It might appear that under those conditions a transition to alternative, clean-fueled vehicles would be inevitable. But despite the "level playing field" that undistorted price signals would help to create, serious institutional, political, and psychological obstacles would remain. These obstacles would include the reluctance of those who profit from highway petroleum use to shift to alternatives prior to capturing an expected return on investments in the oil economy. They would include the reluctance of many consumers to adopt new vehicular technologies that lacked the familiarity and proven track record of the vehicles they were replacing. And they would include barriers in law and policy that, unintentionally or not, hinder transitions to widespread use of alternative fuels and vehicles.

<u>Public Policy Options</u>

Reducing the obstacles to EV development and utilization will require the combined efforts of public and private sector entrepreneurs, working in concert with federal, state, and local incentive programs. The incentives will probably consist of both financial "carrots" and a few regulatory "sticks," though it is clearly desirable from an efficiency standpoint to focus governmental activity on the removal of distorting influences in the market rather than on the insertion of countersubsidies and countervailing regulatory policies.

Table 2 provides a list of public policy options that would be potentially useful in lowering the barriers to expanded EV market penetration. The options are designed to: (1) stimulate advances in EV technology; (2) encourage electric utilities and vehicle manufacturers to enter the EV market, while creating initial demand through fleet purchases; (3) increase consumer awareness and confidence in EV technology, and inform them about lifecycle cost comparisons; (4) reduce the initial cost of an EV through clean fuel credits and various startup subsidies; (5) provide EV loans and battery leasing arrangements that are more attractive than conventional vehicle loans and leasing programs; and (6) provide "ease-of-use" incentives (e.g., free parking downtown for EV users), and "ease-of-access" infrastructures for battery charging.

Table 2
PUBLIC POLICY OPTIONS

For Encouraging Electric Vehicle Use
(listed without regard for current political
or economic feasibility)

INFORMATION

Promote public education (e.g., EV awareness programs and information clearing houses)
Extend product labeling (e.g., lifecycle cost and efficiency stickers for EVs and ICE vehicles similar to the appliance efficiency labels created by the National Energy Policy and Conservation Act of 1975.
Develop EV components for Air Quality Management Plans

RESEARCH AND DEVELOPMENT

Increase government support of EV R&D
Expand EV demonstration programs
Create task forces to investigate EV technical and commercial/market barriers
Develop public/private partnerships to coordinate EV development
Encourage greater utility involvement in EV R,D&D.

FINANCIAL INCENTIVES

Provide tax credits for EV owners (e.g., 15% income tax credit for EV purchases, up to a ceiling of $1,500)
Offer rebates
Provide free parking downtown for EV users (conversely, raise fees for non-EV users)
Give special investment tax credits to EV manufacturers
Offer free or reduced annual vehicle registration fees for EV owners
Make available government guaranteed loans for EV purchases
Create an EV development bank (e.g., modeled on the now defunct solar development bank)
Encourage internalization of environmental and social costs in the purchase price of ICE vehicles and fuels
Cut excise taxes on EVs that are imported in the future
Raise gasoline sales taxes
Consider oil import fees/taxes
Offer super off-peak electricity rates for EV battery charging

DIRECT GOVERNMENT FUNDING

Encourage government fleet purchases/procurements (Post Office and DOD, especially)
Encourage VIP use of EVs to draw attention and set a public example (e.g., An EV could serve as the President's official car)
Allocate a portion of gasoline tax revenues for development of battery chargers in public places

STANDARDS/REGULATIONS

Set local, state, and national petroleum displacement goals for alternative transportation fuels
Strengthen Corporate Average Fuel Economy (CAFE) standards
Designate electricity in EV applications as Best Available Control Technology (BACT) (e.g., clean fuels credits)
Certify EV safety and performance (e.g., government approved testing)
Require a portion of existing parking spaces to be retrofitted with EV charging outlets
Require dedication of a portion of new parking spaces for EV use
Permit emissions offsets for owners of EV fleets
Permit emissions offsets for electric utilities which provide suitable subsidies for EV use
Develop franchise licensing incentives (e.g., as a condition

of licensing, require a portion of private transit/taxi fleets to be electric powered)

Use import quotas to insure that some percentage of the vehicles imported are electric powered

Incorporate EV charging capabilities (e.g., 220 outlets in garages) in building permits where appropriate

Limit EV product liability suits and educate insurance industry on EV risks and how they compare to ICE vehicles

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Environmental Benefits of Electric Road Vehicles

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ENVIRONMENTAL BENEFITS OF ELECTRIC ROAD VEHICLES

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ABSTRACT

There is increasing awareness of the environmental damage caused by traffic pollution. This paper considers the present levels of emissions from this source and compares the minimal pollution from electric vehicles. Likely effects upon the environ-ment are indicated and the latest initiatives in Europe are considered, within the context of international standards for vehicles. An attempt is made to estimate the cost to the community, and the role of Governments in providing incentives for the use of low-polluting vehicles considered

In industrialised countries, human activities are responsible for almost all air pollution, and transport accounts for about half of this, as indicated in TABLE (1). In urban areas where the majority of people live, road traffic is the main pollutant, usually accounting for all the CARBON MONOXIDE (CO), at least 60% of NITROGEN OXIDES (NOx) and HYDROCARBONS (HC), 50% of PARTICULATES and 10% of SULPHUR DIOXIDE (SO2). These percentages may be much higher in busy streets where traffic is congested (1)

We shall not in this paper consider the impact of LEAD on the environment because it is likely that this will be phased out by the time that significant numbers of electric vehicles can be introduced.

It is interesting to compare emissions from vehicles in those countries where more stringent standards apply, such as the USA, Canada and Japan, with our own in Europe, where we are only beginning to introduce the legislation which will make it essential to employ cleaner vehicles and could stimulate the use of

TABLE 1 MAN-MADE EMISSIONS OF AIR POLLUTANTS, SELECTED COUNTRIES, 1980

	TOTAL THOUSAND TONNES/ANNUM				TRANSPORT THOUSAND TONNES/ANNUM (% TOTAL)			
	SO2	NOx	CO	HC	SO2	NOx	CO	HC
Canada	4650	1942	9928	2100	140(3%)	1282(66%)	7347(74%)	840(40%)
USA	23200	20300	76000	22800	928(4%)	9135(45%)	53200(70%)	9120(40%)
Germany	3200	3090	8960	1860	128(4%)	1638(53%)	5824(65%)	707(38%)
Nether-lands	445	500	1368	452	18(4%)	265(53%)	985(72%)	100(22%)
Norway	141	125	632	158	18(13%)	100(80%)	499(79%)	70(44%)
Sweden	483	328	1250	410	24 (5%)	203(62%)	1225(98%)	230(56%)
UK	4670	1932	5127	1954	47(1%)	560(29%)	4563(89%)	313(16%)

electric vehicles. TABLE 2 compares the data which is available from the USA and Canada for 1980 with that provided by European countries, and TABLE 3 shows how the position in each country is changing over a period of time.
Although it will be noted that goods vehicles account for only a quarter to a third of distances travelled, they do of course cause more pollution than cars and they have so far been subject to less stringent regulations.
With the increase in the number of vehicles and the distance travelled, the trend in Europe has been for a gradual increase in traffic emissions, but this is being reversed in Canada, the USA and Japan, as shown in TABLE 3.
We are now begining in Europe to introduce more stringent regulations for vehicle emissions. The environmental benefits of electric vehicles were made clear by our colleagues in the European Electric Road Vehicle Association(AVERE) who prepared a comprehensive report for the Commission of the European Communities (2).

The Commission's report concentrates upon the use of electric vehicles in urban areas, and assumes that in most European countries the emissions from cars in such driving cycles would be 26 grams/ km CO (.002): .05 g/km SO2 (.072): 1.7 g/km NOx (.026) and 2.5 g/km HC (.44). The figures shown in brackets are for emissions from the fuel supply infrastructure and should be added to those for the vehicles themselves to give the total emissions.
In rural driving, CARBON MONOXIDE and HYDROCARBONS would be less than half these levels while NITROGEN OXIDES would be doubled. Larger vans are estimated to cause approximately double the CARBON MONOXIDE and HYDROCARBON emissions and 25% more NITROGEN OXIDES.
It was considered that if sufficient market penetration were achieved electric vehicles could make a remarkable contribution to reducing emissions particularly in urban areas, where the problem is greatest.
If only 6 million European cars (7%) and 1 million vans (12%) could be electric powered, it was estimated that they would

TABLE 2

COUNTRY	BILLIONS KMS TRAVELLED 1980 CARS	GOODS VEHICLES	TOTAL	GRAMS EMISSIONS PER KM SO2	PART.	NOx	CO	HC
Canada	152	52.6	204.6	0.7	0.6	6.3	36	4.1
USA	1789.4	618.9	2408.3	0.4	0.6	3.8	22	3.8
Germany	297.4	32.4	329.8	0.4	0.2	5.0	18	2.1
Nether -lands	61.4	8.4	69.8	0.3	0.2	3.8	14	1.4
Norway	14.4	2.0	16.4	1.1	0.2	6.1	30	4.3
Sweden	41.5	2 2	43.7	0.5	0.2	4.7	28	5.3
UK	197.3	41.3	238.6	0.2	0.3	2.3	19	1.3

TABLE 3 TRENDS IN TRAFFIC EMISSIONS IN INDUSTRIALISED COUNTRIES 1983
PERCENT CHANGE, BASED ON 1975 = 100

	NOx	CO	HC
Canada	92*	74*	71*
USA	99	77	70
Japan	71*	–	–
France	123	–	–
Germany	142	86	108
Netherlands	108	63	76
Norway	111	94	84*
Portugal	267*	116*	100*
Spain	140*	125*	133*
Sweden	104	90*	92*
Switzerland	138	100	111
UK	115	124	120

* data only available to 1980.

reduce the principal pollutants, CARBON MONOXIDE, NITROGEN OXIDES and HYDRO-CARBONS by as much as 20- 30% in urban areas. Even SULPHUR DIOXIDE would be slightly reduced in towns, but in some European countries there would be a small increase over the country as a whole, as shown in TABLE 4.

TABLE 4
PERCENTAGE CHANGE IN AIR POLLUTION IF 7 MILLION EVs INTRODUCED IN EUROPE

Pollutant	Urban Traffic (%)		All Sources (%)	
	FRG	UK	FRG	UK
CO	-21	-16	not relevant	
SO2	-2	-	+1	+2
NOx	-12	-24	-1	-1
HC	-19	-28	-4	-1
Dust	-2.5		+0.5	

These figures are based upon the present different mixes of generating stations in Germany and the UK. The various pollutants (grams/KwH) in these countries allowing for 10% transmission losses, are given in TABLE 5. The pollution caused by an electric car with urban fuel consumption of 0.3 Kwh/km can therefore be estimated and compared with the figures given previously for petrol cars.

TABLE 5 COMPARATIVE POLLUTION EV/ICEV

Pollutants generated grams/kWh

	CO	SO2	NOx	HC
UK	-	10.22	3.36	-
FRG	.079	5.53	2.62	.022

Pollutants in grams/ km

	CO	SO2	NOx	HC
Electric car				
UK	-	3.07	1.01	-
FRG	.024	1.66	.79	.006
Petrol car	26.0	0.12	1.73	2.9

Overall pollution for an electric car would be slightly less in urban driving, where it is estimated to utilise only 0.276 KwH/km. It is assumed that the electric vans would be operated only in urban areas and that the consumption would be 0.32 KwH/km and 0.62 KwH/km for the small and large vans respectively. Although the electric is overall much cleaner than a comparable I.C.E. vehicle, we cannot afford to be complacent. In Europe we are speeding up the installation of flue gas desulphurisation plants, with the aim of reducing SO2 emissions by at least 30% by 1993.

The Federal Republic of Germany is one of the most active countries in this respect, and here the aim is to reduce emissions from coal fired stations to approximately 0.8 grams/KwH for both SO2 and NOx, giving an average for all generating stations of only 0.47 grams/ KwH (3)

New standards are being introduced in Europe this year for emissions from I.C.E. cars, the most stringent applying to those with engines over 2 litres. The maximum emissions allowed for the European test cycle will be 25 grams CO, 6.5 grams HC and NOx, of which NOx cannot be more than 3.5 grams.

In order to make a rough comparison with present emissions from cars, we can divide these figures by the length of the test cycle (4.052 kms) to give 6.17 grams/km CO and 1.6 grams/km HC and NOx combined. In order to meet these standards, cars in this category will have to be fitted with catalytic con-vertors. It should be borne in mind when making any comparisons about emission standards in different countries, that the European test cycle is different from the American one, and we are considering adding a cycle at higher speed, which will of course make it more difficult for petrol engined cars to meet the NOx standard.

Electric cars can of course meet these new standards even with our present power stations but we could set the pace for really clean vehicles if we continue with our programmes to reduce SO2 and NOx emissions from power stations. Electric vehicles also produce negligible CARBON DIOXIDE and for this reason scientists at a recent meeting in the Federal Republic of Germany advocated the use of electricity and hydrogen as future fuels for road transport. (4)

EFFECTS OF TRAFFIC EMISSIONS

Why should we be concerned about air pollution, after all we do not suffer from the heavy smogs experienced in the past when coal was burnt freely in towns? However, present pollutants do cause damage, much of which is only beginning to be understood in recent years, and I give below a summary of the main effects on people and the environment.

Human health:

CARBON MONOXIDE can impair physical co-ordination and cause general debility. It may exacerbate heart disease and also affect the development of the foetus. NITROGEN OXIDES can cause respiratory problems, while HYDROCARBONS irritate the eyes, nose and throat. The synergistic effects of these pollutants is frequently greater, as HYDROCARBONS and NITROGEN OXIDES react in the atmosphere to form OZONE, which is instrumental in causing lung diseases and ear, nose and eye irritation. There is also growing evidence that acids formed from SULPHUR and NITROGEN OXIDES may be detrimental to human health. PARTICULATES can penetrate into the respiratory system causing long term problems, there is evidence that they aggravate heart and lung diseases and it is thought that they increase the chances of developing cancers.

Urban environment:
Diesel fumes are a major cause of soiling buildings and also cause unpleasant odours. In conjunction with NITROGEN OXIDES, they are also responsible for degrading visibility, particularly in urban areas. NITROGEN OXIDES are second only to SULPHUR OXIDES in causing damage to stonework, much of which in our old cities, is irreplaceable.

Plant and animal life:

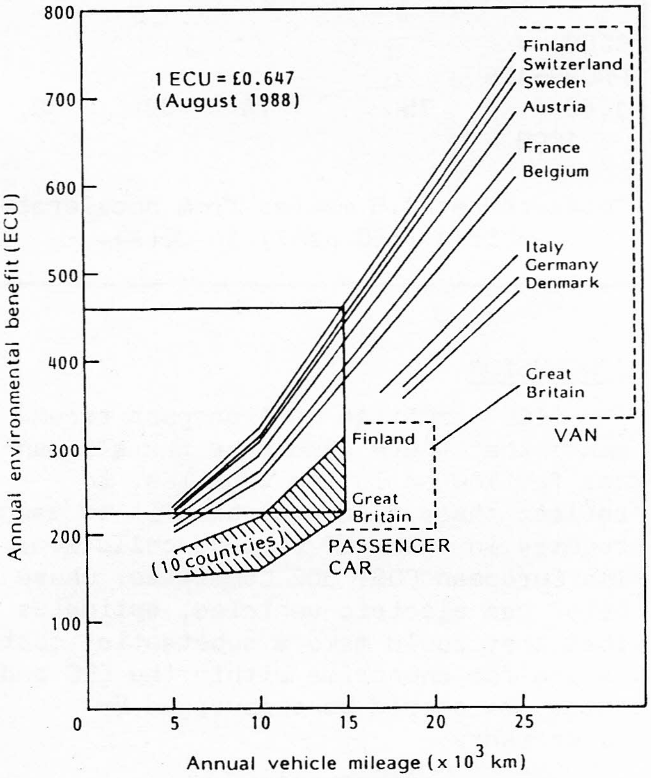
NITROGEN OXIDES are converted to form approximately a third of the acidity in rainfall and can exacerbate the formation of SULPHUR into acids. They are also instrumental, in conjunction with HYDROCARBONS, in producing OZONE, which has been found to reduce crop yields, as well as causing acidification of the soil and lakes, with the consequent decline in fish populations throughout much of Europe and North America. OZONE is estimated to cause annual crop losses around $2-$4 billion in the USA alone. While it is of course possible that intensive farming and forestry practices contribute to these problems, this does not alter the importance of dealing with the main cause, which is air pollution. The increase of CARBON DIOXIDE through burning fossil fuels may alter the balance between different species of plants. There is also considerable concern about the possibility of a 'greenhouse effect' A UK Government report earlier this year (5) deprecated the fact that so little is known about this potential problem. The lag time between the emission of gases which could cause this effect and the climatic changes themselves means that it is vital to understand the likely future impact of gases currently being released. The Committee therefore strongly recommends that additional funding should be made available for international research into possible global warming, as a matter of urgency.

COST OF TRAFFIC POLLUTION

The UK report on the environment (5) also stresses that more research is needed into the effects of environmental pollution on buildings, human health, plant and animal life. At present it is difficult to ascertain percisely what damage is caused by different pollutants and whether they are more harmful in different combinations.
The actual cost of pollution from traffic was considered in the European Commission sponsored COST 302 report (2) which attempted to evaluate the environmental benefits of electric vehicles. Again, it was found to be

impossible to obtain the data needed to assess the impact of pollution on the environment or to estimate the costs of such damage. The COST 302 Committee therefore assumed that the benefit of an electric vehicle could be equated with the cost of catalytic convertors, which fitted to I.C.E. vehicles, would give a similar environmental improvement.
On this basis, the annual environmental cost saving of an electric vehicle travelling 15,000 kms per annum ranged from approximately 230 European Units of Account (ECU) (£149 sterling) up to 460 ECU (£298 sterling) as shown.

FIG 1: Annual environmental benefit of one electric passenger car and one van.



On average, the cost savings with an electric van travelling 15,000 kms annually were found to be about 50% greater than for an electric car travelling the same distance. The electric vans also showed an additional advantage in that with present batteries they could be utilised more effectively, with higher annual mileage which could raise their annual cost benefit to 750 ECU (£485 sterling)

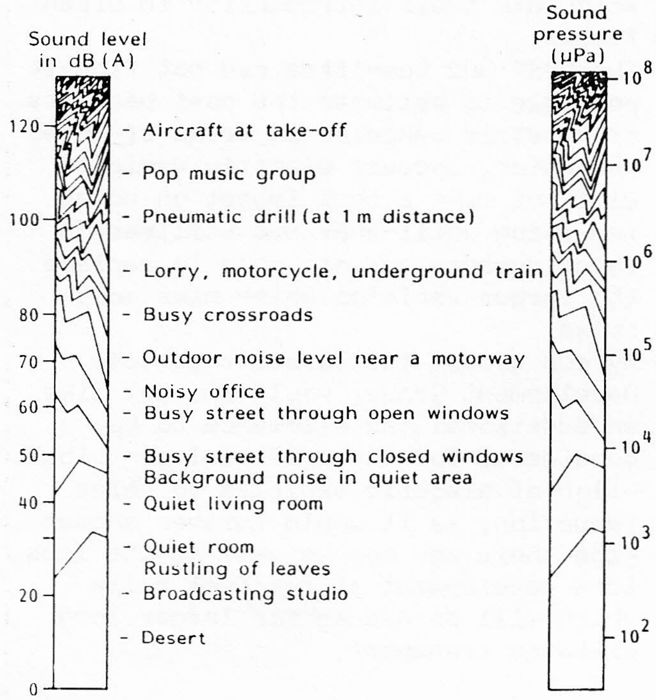
The annual environmental benefit of each electric vehicle is of course mainly dependent upon the fuel mix and emissions of the power stations in each country.
The COST 302 Committee recommended that European Governments should recognise this environmental benefit of electric vehicles, and proposed that tax allowances should be made equivalent to their potential cost savings. It was felt that such measures by European Governments could help to make electric vehicles more competitive, and would stimulate their introduction in urban fleets.
The COST 302 Committee did not find it possible to estimate the cost benefits of electric vehicles in terms of noise pollution, because electric vehicles will not make a real impact on noise reduction until they are utilised in large numbers and are able to replace the larger vehicles which make most noise.
My own group, the Electric Vehicle Development Group, would in fact like an additional tax allowance to be considered for the potential contribution of electric vehicles to noise reduction, as it would further encourage their use now as well as the long term development of the fuel cells which will be needed for larger long distance transport.

TRAFFIC NOISE

The OECD Committee on Transport finds that traffic noise is generally perceived to be a greater problem than emissions by the majority of people living in built up areas. (1)
In OECD countries approximately 16% of the population is exposed to noise levels over 65 dB(A) and more than 50% to levels in excess of 55dB(A).
Transport is by far the major source of noise, with road traffic the chief offender. It is well known that exposure to loud noise, exceeding 75 dB(A) over a period of time, can impair hearing, but it is beginning to be realised that people do not get used to

lower levels of noise, but these are a major factor in causing stress and related illnesses, such as heart diseases. Noise also interferes with communication, so that speech, music and other sounds may be difficult to distinguish. This happens when traffic noise is as low as 60 dB(A). FIG 2 illustrates the noise caused by traffic in relation to other typical sound levels.

FIG. 2. Examples of noise levels



In towns, noise is generally caused by the vehicle's propulsion, that is the engine and the power train, rather than the sound of tyres on the road, so that electric and hybrid vehicles could make the greatest contribution to noise reduction here. Hybrid systems are generally designed so that they can be operated by battery power alone in environmentally sensitive areas. They also have the advantage that the small engine is usually operated at a con -stant speed, and there is less gear changing.
The OECD Committee estimates that the cost of reducing traffic noise to the levels they recommend (see TABLE 6) would be in the region of 5% of the total cost of each vehicle.

TABLE 6 NOISE LIMITS FOR ROAD VEHICLES*

Country	Passenger car	Small van <3.5t	Large bus <150kW	Heavy lorry >150kW
EEC				
Present	80	81	82	88
1995	77	79	80	84
JAPAN				
Present	78	78	83	83
USA				
Present	-	-	86	89
Future	-	-	83	86
OECD PROPOSALS				
1985 - 1990	75	75	80	80

*measured at 7.5 metres from accelerating vehicle (ISO R362) in dB(A).

CONCLUSION

The OECD Committee on Transport recommends that there should be tax allowances for low polluting vehicles, to reflect their financial benefit to each country in terms of reduced pollution. The European COST 302 Committee, whose brief was electric vehicles, estimates that they could make a substantial cost saving for countries within the EEC and their use should be encouraged by Governments

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4. AVERE Report, Electric Vehicle Developments, London, July 1988
5. House of Commons Environment Committee, HMSO, London 1988.