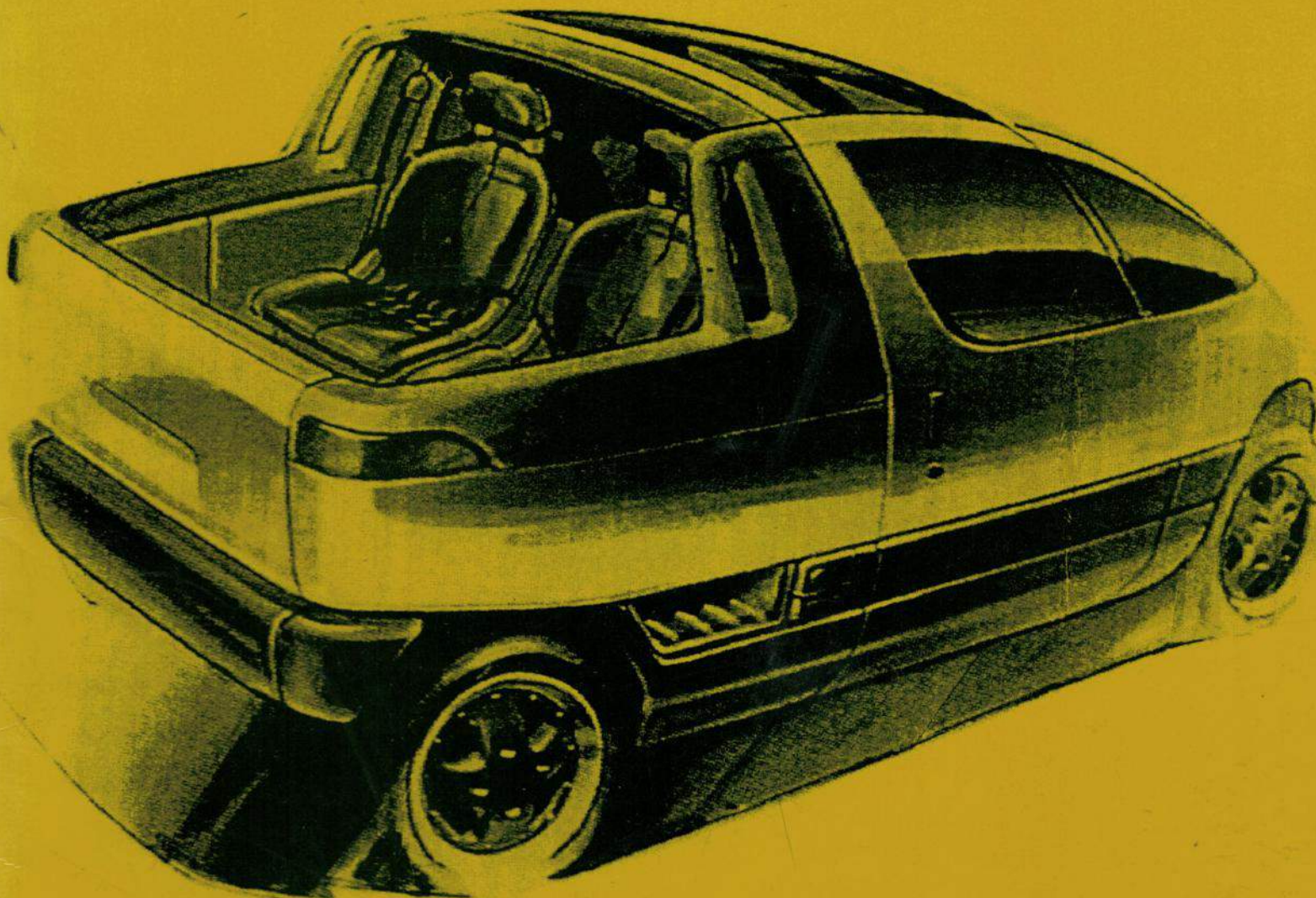


Office
Copy.

GREEN MACHINES

Dr Madsen Pirie



GREEN MACHINES

by

Dr Madsen Pirie

From the original manuscript
by the
Admiral's Institute
London
1938

1. Introduction	1
2. The Dirty Engine	2
3. Cleaner Variations	2
4. The Electric	11
5. The Gas Treatment	11
6. Conclusion	11

GREEN MACHINES

THE MOTOR VEHICLE AND THE CITY

First published in the UK in 1990
by ASI (Research) Ltd,
c/o Adam Smith Institute, 1975.

All rights reserved. Apart from fair dealing for the purposes of private study, research, criticism or review, no part of this publication may be reproduced, stored in a retrieval system, or transmitted without the prior permission of the publishers, ASI (Research) Limited, 19 Box 316, London SW1P 3HQ (071-221 6555).

The views expressed in this publication are those of the authors and do not necessarily reflect those of the publisher or copyright owner. They are presented as a contribution to public debate.

From research sponsored
by the
Adam Smith Institute
London
1990

ISBN 1-85107-99-3

Printed in Great Britain by Lasercopy Limited, London SW1.

CONTENTS

1. Introduction	4
2. The Dirty Engine	6
3. Cleaner Variations	8
4. The Electric Alternative	11
5. The Tax Treatment	17
6. Conclusion	21

First published in the UK in 1990
by ASI (Research) Ltd,
(c) Adam Smith Institute, 1990.

All rights reserved. Apart from fair dealing for the purposes of private study, research, criticism or review, no part of this publication may be reproduced, stored in a retrieval system, or transmitted without the prior permission of the publishers, ASI (Research) Limited, PO Box 316, London SW1P 3DJ (071-222 4995).

The views expressed in this publication are those of the authors and do not necessarily reflect those of the publisher or copyright owner. They are presented as a contribution to public debate.

ISBN 1-870109-89-9

Printed in Great Britain by Imediacopy Limited, London NW1.

1. INTRODUCTION

The automobile is regarded by some observers as the symbol of our age. It can denote many of the factors by which modern life can be described. To some it stands for the consumer society, with large numbers of people recklessly spending their resources in order to acquire the latest, glossiest and most desirable package that the advertising trade can put together. It can represent all of the most reprehensible features ascribed to modern corporate practice, from planned obsolescence to superfluous and functionless 'extras.'

To others the private car represents freedom. It stands for the ability of individuals and families to get up and go where the mood takes them. Instead of the collectivist conception which seeks to move large numbers in orderly fashion to preselected destinations, the private vehicle offers individual choice and spontaneity. It offers a private space, cocooned and insulated from the world beyond, and in which individual tastes and preferences can be expressed through personal choices.

Either way, the automobile industry is big business. In most advanced economies it is among the industrial leaders. It employs hundreds of thousands directly in its manufacture, and legions more in the supporting components industries. Its retail distribution network is the basis of thousands of independent businesses. Its advertising forms an essential prop to the financial structure of countless newspapers and magazines, and of commercial radio and television stations. Even its second hand trade fills a substantial economic niche and supplies the livelihood of a substantial section of the economy.

Still more are employed to supply the needs of car owners, by way of filling stations and service centres. Whole subsections of the tourist industry depend upon it. Huge resources have to be allocated by governments to cope with its demands. Road construction and maintenance is a major factor in every advanced economy. A huge proportion of police time is occupied with the regulation and control of driving. A significant part of the workload of the legal system is taken up with the prosecution and punishment of motoring offenders.

Many of the vistas of modern society has been shaped by the motor car. The centres of our villages and towns have been remade to cater for its needs. The country has been criss-crossed with motorways and bridges. Some of the newer cities have developed and grown around it, shaping themselves to its requirements. The culmination of this process is, perhaps, Los Angeles, "the city fit for automobiles to live in." While few places can match those excesses, the architecture of most towns and cities in the developed world has been reshaped to accommodate the needs of car

drivers.

The automobile occupies a niche in the modern psyche. To some it represents personal power, to others it denotes the onward march of technology. Young men's imaginations dream over the raciest and sleekest models on offer, while corporate directors exude affluence and authority from the luxurious comfort of their limousines.

The car plays so large a role in today's world that life without it can scarcely be contemplated. The car is, in short, essential. But increasingly its economic importance and the conveniences it brings have superimposed on them a series of problems which have to be tackled. Its very advantages mean that everyone wants to share them, and as society generates more wealth, it becomes increasingly possible for everyone to do so.

The increasing numbers of cars cause increasing problems. With so many vehicles in circulation, it is fast becoming impossible for governments to generate sufficient road space for them to drive on, or for cities to find sufficient parking space for them to occupy. Cities in the developed world are now characterized to a greater or lesser degree by the congestion, the noise, and above all the pollution which is caused by a surfeit of motor vehicles.

There is a neo-puritan strain running through part of modern society which urges us to live more simply. Looking longingly back to easier and quieter times, it urges us to learn to do without the motor car and the conveniences it brings. This view is sometimes expressed as an aversion not only to automobiles, but to economic growth itself. It sees modern technology as the source of insuperable problems, and urges us to dismount the tiger which we have by the tail.

This report derives from the alternative view that the problems derive not from a surfeit of modern technology, but a deficiency of it. It seeks to explore how a more advanced technology can be applied to solve many of the problems arising from the technology of a lower level. It endeavours to apply the problem-solving techniques of public policy in order to accelerate the development of a technology which brings answers instead of problems.

The solution looked for is not one which seeks to banish the automobile, but one which seeks to tame it, to humanize it, to make it an acceptable companion in our cities.

2. THE DIRTY ENGINE

There are over 400 million cars on the world's roads, a figure which is increasing rapidly every year. While the United States still accounts for one third of the total, car numbers are on the increase throughout the rest of the world. There are, moreover, indications of a massive increase forthcoming in some countries. The formerly communist economies of Eastern and Central Europe have far lower vehicle penetration, despite a five-fold increase between 1970 and 1985, but their new-found acceptance of markets could well lead to increases in wealth which will result in car ownership approaching the levels of the West.

Car ownership increases as an economy modernizes and wealth expands, and there is a vast reservoir of potential demand throughout the world. Even in the countries which already have a high vehicle ownership, demand is forecast to increase as families acquire more vehicles. All of these vehicles have engines which pollute, and most of them share the city atmosphere where people have to live, work and breathe.

The average car, in 100 miles of motoring, emits something like 5 pounds of carbon monoxide, about one pound of hydrocarbons and oxides of nitrogen, plus numerous assorted gases of varying degrees of toxicity. It also puts out roughly 100 pounds of carbon dioxide. The latter, while not toxic, contributes to any greenhouse effect on the earth's atmosphere.

The jury is still out on the question of whether the earth's climate is actually warming because of our production of greenhouse gases, there is some evidence that this may be happening, and theoretical understanding of the mechanisms by which such an event could be produced. Whether or not this is happening already, there is certainly reason to suppose that it could happen if nothing were done to restrain our output of greenhouse gases.

Carbon dioxide is one such gas, and is a product of, among other sources, the internal combustion engines which power automobiles. The average car puts out nearly four times its own weight in carbon dioxide each year. Estimates vary from 12 to 36 percent as to the total proportion of carbon dioxide emission which can be attributed to motor vehicles, but a general average puts it above 20 percent of the total.

Even without the carbon dioxide and its possible greenhouse effect, motor vehicles are a major source of urban pollution. The lead salts in exhaust fumes have been related amongst other things to mental retardation in children. Unburnt hydrocarbons can produce ozone pollution in the action of strong sunlight, the so-called photochemical smog. Nitrogen oxides have been blamed

not only for smog, but as contributing to the development of acid rain. Automotive emissions are blamed not only for a high degree of discomfort experienced by city dwellers, but as a contributing factor to several respiratory diseases.

The rising seriousness of the problem of urban pollution can be seen from the reappearance of smog masks in London, the first time since the mid 1950s that they have been seen in significant numbers. The problem then was largely the product of coal burning for domestic and industrial needs, and was relieved by the passage of the Clean Air Act. Now policemen are issued with smog masks on hot days, cyclists are increasingly seen wearing them, and those contemplating exercise such as jogging in urban streets are advised against it when hot weather and traffic combine to make the air unhealthy.

Some European cities such as Turin and Athens have grown used to air that is unhealthy to breathe, but more and more cities are beginning to experience the same problems. The problem is caused by the proliferation of motor vehicles. The essence of it is the number of engines which share the same atmosphere as people.

To some extent the problem is a localized one, in that the noxious gases occupy the same space as their air which the population has to breathe. If their production and output were away from population centres, the problem would be less acute. The cars are where the people are, and the concentration of their output exceeds the capacity of the local atmosphere to cope.

The problem is also global to some extent in that the carbon dioxide put out alongside the toxic emissions may well be a contributing factor to an atmospheric greenhouse effect. This part of the problem is not localized.

Governments have started to enact legislation to reduce vehicle emission. By 2007, the state of California will probably require hydrocarbon emission to be cut by 90%, carbon monoxide by 50%, and nitrogen oxides by 58%. The current European emission standards (ECE 15.04) were introduced for new type approvals in 1986, and for all new cars in 1987. They reduced allowed emission levels by 25% on the previous 15.03 standard, representing a total reduction of carbon monoxide by 70%, and of hydrocarbons and nitrogen oxides by 50% on uncontrolled emission.

The 1985 Fifth Amendment required limits on three classes (under 1.4 litres, 1.4-2.0 litres, and over 2 litres) to be phased in between 1988 and 1992. And in April 1989, the European Parliament passed a bill to adopt the equivalent of US emission controls by 1993. These are half of the levels previously determined, and only one quarter of today's levels. The stage thus seems set for ever tighter legislation to curb automobile pollution by limiting engine emissions.

3. CLEANER VARIATIONS

Both Europe and the United States have committed themselves thus far to the catalytic converter. Two-way converters use the surplus oxygen in the exhaust to render harmless the carbon monoxide and hydrocarbons, while the nitrogen oxides are limited by the way the combustion process is allowed to develop within the engine. Three way converters cannot simply be added on, but must be part of the engine design so that a balanced ratio of air to fuel operates within a closed loop.

Several European countries, including Germany, Austria, Sweden, and Switzerland, already either require catalytic converters or encourage them. By 1995, all of Europe's 17 million newly produced cars will be fitted with catalysts, but even if every new car were fitted from now, the non catalyst cars would still outnumber the catalyst cars by 1995. For Britain the proportion of catalyst cars by 1995 will be between a quarter and a third.

Catalytic converters do nothing for carbon dioxide emission. On the contrary, they make it worse by being less economical on fuel. While they average perhaps 75% cleaner in respect of toxic pollutants, they do use more fuel. While laboratory tests show catalyzed engines using perhaps 4% more fuel, actual driving conditions can worsen this up to 12%. This means a greater output of greenhouse gases.

Not only are the catalysts costly, in that they add about £400 on average to the cost of a car, they are costly to run. They add roughly £100 to the average annual fuel bill. This takes their annual extra cost in Britain alone to over £1 billion per year. Part of the problem is caused by their use of the rare and expensive metal platinum.

Catalytic converters have a life expectancy of about 50,000 miles, and the problem is that if they become defective, they can increase by many times the vehicle's emission of pollutants. What this means in practice is a system of rigorous inspections to take faulty or ineffective catalysts off the road.

University of Denver researchers performing on-the-road checks found that proper maintenance is a key factor in pollution, with badly-tuned cars emerging as the worst offenders. They found that the dirtiest 10% of vehicles accounted for 50% of emissions. One finding was that most of the pollution was generated by poorly tuned cars, whether or not they were fitted with catalysts. The 90% reduction they can offer in toxic output can turn to an increase when they are defective.

Clearly catalysts are limited in their benefits. Some estimates suggest that much of the improvement they promise in toxic

emissions will be greatly limited by the projected increase in numbers. And they increase total fuel consumption and the output of greenhouse gases. It is hardly surprising that they are regarded only as a stop-gap, with attention turning to other ways of controlling automobile pollution.

One approach, in use for some years in the USA, mandates better fuel efficiency to reduce the total quantity used. If cars do not achieve a 27.5 mpg (US) efficiency, there is a \$5 fine for every 0.1 mpg over the limit. In terms of British measures, this can mean a £25 fine on every car sold which fails to achieve 31.8 mpg or better.

These so-called CAFE laws (Corporate Average Fuel Economy) managed to achieve a 25% increase in fuel economy following the oil crisis of the 1970s. Again, though, the gain is countered by increase in total numbers, and some studies have charged that it was achieved by a move to smaller and lighter cars, which had an adverse effect on safety.

An alternative approach has looked to alternative fuels, the burning of which produces less problems than the conventional fossil fuel favoured by petrol and diesel engines. The alcohols ethanol and methanol have both been tried.

Methanol is produced from coal and natural gas. Several companies in California, including Shell, Exxon, Chevron and Arco, supply a mix of 85% methanol and 15% petrol called M85. Among its problems are that while its use does reduce carbon monoxide and hydrocarbon emission, its production process causes more pollution than it eliminates. When it is used in vehicles they emit formaldehyde, which is both toxic and has an offensive smell.

Methanol is also highly poisonous and corrosive. Because it is water soluble it can pollute drinking water if it spills. Vehicles which are to handle it require expensive anti-corrosion treatment. It is also highly volatile.

Ethanol faces some of the same problems: it cuts some emissions, increases others. The widely used mix of 10% ethanol with 90% of petrol, called Gasohol, has been estimated to cut carbon monoxide emissions by 25%, but to increase hydrocarbon output by 50% and nitrogen oxides by 15%. It is also expensive to produce, and takes a great deal of land dedicated to the purpose.

Brazil spent £5 billion on its ethanol project, and managed to cut its dependence upon foreign oil imports by 60% between 1979 and 1986. But the sugar used in its manufacture took out huge areas of land. Current estimates suggest that it would take 40% of the US corn harvest to meet only 10% of fuel demand there.

Hydrogen might yet prove to be an acceptable fuel. It emits very little by way of pollutants, but is expensive to make and tricky to handle. BMW have fitted out a standard 735i as an experimental hydrogen powered vehicle, fitted with a 20.5 gallon hydrogen tank

in its boot. The tank has 70 layers of aluminium foil sandwiched between its two layers to cope with the temperature of -253C which has to be maintained. Even so, there is a 2% loss each day. The car has a range of 150 miles, and a top speed of about 112 mph. Its exhaust, when run on its hydrogen power, is virtually pure steam, but the car also has a conventional fossil fuel drive as well.

The problem with hydrogen is that the technology to handle such an exotic fuel and to produce it cheaply is some way off. It is, of course, at risk of explosion in the event of a crash, as are most fuels, but the measures required to cope with this risk are not insuperable. In the long term, hydrogen might have an acceptable future as fuel for long distance journeys, and could well supplement some more convenient fuel source used for urban driving.

Lean burn engines are under experimental development by several companies. They function by increasing the ratio of air to petrol, and raise fuel efficiency. Volkswagen, Toyota and Volvo all have lean burn engines, with efficiency ranging between 75 and 125 mpg. PSA's Ceres lean burn 1905cc engine fell foul of changed EC requirements when they were revised in 1989. The high oxygen content of its exhaust made it incompatible with the three way catalytic converters now required.

Lean burners are another stop-gap measure, producing less pollution by more efficient fuel use, but only delaying the day when a more user-friendly fuel altogether has to be employed. The same is true to an even lesser extent of diesel engines. They are 30% more efficient than petrol engines, and already occupy some 13% of the European market. EC proposals will further encourage their use by increasing the difference between petrol and diesel fuel from 17p to 50p per gallon.

Other developments using conventional fuels include the VW Futura, which uses direct fuel injection like a diesel, and a high compression ratio of 16:1, as against the typical 10:1 for a petrol engine. The fuel saving is, like a diesel, about 30%.

They also include the compact two-stroke under development in Japan, and the gas turbine which can use multiple fuels, but has higher consumption and noise levels, combined with a distinct lag in acceleration. None of the alternatives appears to offer any long term solution to the problems of automobile pollution, although some will undoubtedly be used as palliatives in the short term.

4. THE ELECTRIC ALTERNATIVE

Electrically powered vehicles have advanced far beyond Sir Clive Sinclair's ill-fated C5. The C5, using conventional batteries and a washing machine motor, attempted to introduce electric transportation in the shape of a three-wheeled open top vehicle with a top speed of 15 mph and a range of roughly 10-15 miles. The C5 was pedal assisted, which proved useful on hills and when the battery was low. It cost almost nothing to run and, because of a legislative loophole, could be driven on the public highway without the need for driving licence, tax, insurance, MOT or crash helmet.

It was commercially unsuccessful, being widely perceived as too small, too exposed and under-powered. Sir Clive never referred to his vehicle as a car. Had it been launched as a fun bike for teenagers in summer, rather than as a serious road vehicle in the middle of winter, its commercial story might have been different. It could well have caught on in seaside resorts and holiday parks, and provided the cash flow needed for its designer to develop more serious electric vehicles. As it was, it proved unsuited for its market and rather ahead of its time.

Electric cars now available or nearing their production stage are far ahead of the C5 both in both sophistication and capabilities. Many of the major manufacturers now offer an electric automobile, either purpose built, or as a version of one of their regular production models.

As a city car, the electric vehicle has the potential to operate without polluting the atmosphere at all. There remains the question of whether the generation of electricity simply transfers pollution from the car to the power station. That issue will be addressed below; but certainly the vehicle poses no pollution problems for city streets. It is not only clean in respect of air pollution in cities, but also with regard to noise pollution. Electric vehicles are virtually silent in operation. If they become widespread, they may even have to be equipped with some warning signal to alert unwary pedestrians of their approach.

Electric vehicles currently or soon to become available have advantages and disadvantages compared to conventional cars. Their top speed is lower at present, and their range between charges tends to be about 100 miles. They have acceleration performances below those of petrol engined cars. On the plus side they do not pollute, they are silent, and very cheap to run. They are easy to operate, and require very little maintenance.

It should also be noted that they are improving very rapidly in terms of their performance and suitability for general use. If

they become a mass market option, the rate of improvement will accelerate, bringing them rapidly on a par with conventionally-powered cars. They are already at the stage of being suitable for city driving and most commuting journeys. It is significant that the average car journey in Britain is of only 10 miles.

PSA, which produce Peugeot and Citroen, have a range of electric options including the Peugeot J5, the 205, and the Citroen C25 and C15 van. The Peugeot 205 is one of Europe's best selling compact cars. It was deliberately chosen for an electric option because of its familiarity. The aim is to make the point that we are a long way from the age of the C5. The 205 electric looks like a normal Peugeot 205, but runs on electric power.

The Peugeot 205 is an electric car in production. It is powered by 12 6-volt batteries weighing 282kg. Its top speed is low, at 55-60 mph, but suitable for city driving. Its range is roughly 75 miles. Later versions will feature higher speeds of up to 100 mph and a 100 mile range between charges. It manages to accelerate from 0-20mph in about the same time as the conventional version, but has no gearbox.

The batteries are sealed, and require no topping up. They last 2 years before they need to be replaced, or at least subject to a thorough examination and possible overhaul. They can be recharged overnight in 5-6 hours from a household socket, and there is a 3-hour high speed charge for emergencies.

The electric version costs about 30% more than a standard version 205, but this is recouped on running costs and maintenance. The car runs for an estimated 1.5p per mile. Peugeot expect the extra cost of £3,000 at present could easily become a discount of £3,000 by 1995 as production levels expand. They have applied to the European Commission to match the reductions in motor tax which West Germany allows for those with catalytic converters.

Users report that the 205 Electrique is a viable city car. They report that its heavy front loading makes steering rather sluggish. This is no doubt because the production model uses conventional lead batteries in place of the Nickel-Iron or Nickel-Cadmium batteries which cost 7 times as much.

One feature which the Electrique shares with other electric cars is its use of regenerative braking. The batteries are charged during the process of braking, which adds significantly to the duration of battery power between charges.

The 205 leads a range of electric versions of conventional models, including the Fiat Panda Elettra. None of them yet match the performance of their petrol-engined counterparts, though they are increasingly becoming an acceptable option for urban driving and commuting. The basic technology is advancing to the point where prices will start to come down and specifications will go up within a very few years.

Among the most promising is the General Motors Impact, already

going through its paces and scheduled as a mass production road-going car by 1995. Unlike its European rivals, the car was designed from scratch as an electric vehicle. It is made of composite materials and features no exhaust system. It is also devoid of a large multi-ratio gearbox; instead it has the three automatic modes of forward, reverse and neutral.

The GM Impact has a top speed of 100 mph, and a range of 120 miles. It does 0-60 in 8.0 seconds, which is faster than the VW Golf GTi. It uses a new electronic system to convert its battery DC to AC for its motors, and without significant power loss. This solves the earlier dilemma of whether to opt for less efficient DC motors, or convert with substantial power loss to AC.

The Impact's 32 batteries are sealed lead/acid, with the acid in the form of a non running jelly. The current set are good for 32,000 km before they need to be changed at a cost of £1,000, but within 2 years GM will use batteries with a life of 70,000 km. It is working on new batteries developed by its Isuzu offshoot for when mass production takes place prior to 1995.

The batteries charge overnight within 6 hours. There is an emergency charge which restores 90% of power in 1 hour, but this usage reduces total battery life and cannot therefore be done regularly.

The GM Impact has one motor for each front wheel, using power more efficiently than an internal combustion engine. Like the Peugeot 205 it uses regenerative braking; the motors become generators when the pedal is released. The car is equipped as a conventionally powered car, with electric windows, a first class stereo system, air conditioning, and with digital instruments.

Following the initial 2 seater, the second version seats 4, but retains the good drag coefficient, the low weight and the low roll resistance of the first version. The Impact is virtually silent in operation. A basic price of \$15,000 is planned, with \$3,000 for the battery pack. This makes it more expensive than petrol equivalents, but GM plans to reduce the cost of its motors, and to develop a more rapid charge system for its batteries.

Within 4 years the Impact should be in mass production as a purpose built electric vehicle viable for most of the uses to which cars are put. It will not have the long range of petrol vehicles, but even this disadvantage can diminish by the use of public recharging points, rapid charge batteries, or replacement packs which can be rented on the road.

Yet another electric vehicle is under way from a British firm. International Automotive Design of Worthing is one of three contractors participating in the Los Angeles Initiative, which calls for 10,000 electric cars to be on the city's roads by 1995. IAD have a contract to build 1,000 pilot vehicles as sub-contractor or Clean Air Transport. Their LA301 is one of three vehicles sponsored by Los Angeles City Council and by the city's

department of Water and Power. (The other two are a conversion of the Chrysler Voyager and a conversion of a General Motors commercial vehicle. The LA301 is the only one of the three to be a purpose built electric).

Los Angeles plus its 5 adjacent counties is very much among the front runners pioneering cleaner cars. The area covers some 300 square miles with 12 million people, and sees 900,000 new cars sold every year. Over a 20 year period the Los Angeles basin has cut its power station emissions by 90%. Now it aims to achieve similarly impressive results with its motor vehicle emissions.

The LA301 weighs 3,240 lbs. It has a top speed of 70 mph, well above the US standard 55 mph limit, with up to 65 mph on some highways. The vehicle is technically a hybrid, but the small petrol engine (below 1 litre) does not drive the wheels. Instead it serves as an auxiliary turbine. It runs on the new reconstituted petrol, with added oxidizing agents to make it even cleaner. The California Air Resources Board rates the LA301 97% clean compared with conventional petrol engines.

The 12 battery cells are sealed lead/acid with a total charge of 156 volts, but with a sodium/sulphur pack of 180 volts on the way. The vehicle range between charges is 125 miles, but would be only 60 miles on the electric motor only. Since 90% of journeys in the US, big though it is, are below 40 miles, the LA301 seems viable.

Los Angeles is considering public charging points as electric vehicles become widespread. Marvin Braude of the LA Initiative expects 70% of vehicles in Los Angeles to be electric by 2010. As has often been the case in the past, what Los Angeles does now could be a guide as to what the world might do tomorrow.

PSA are developing a turbine assisted electric in the shape of the "Vehicule Electrique Routier à Turbine," or VERT. The VERT is designed to use batteries within the city, and a clean burning turbine to generate electric current sufficient for highway use. The specifications are for 100 mph top speed, and a range of 300 miles.

Already operating is the Volkswagen Golf Elektro-Hybrid. This is a prototype which features two engines, an electric motor and a diesel engine. Fuel consumption is about 113 mpg, between 3 and 4 times what could be expected from a petrol driven version. The diesel engine operates in first gear when the car moves off, then the car goes into electric mode. At speeds of above 37 mph the diesel cuts in again. Both engines stop when the car decelerates or when it is stationary in neutral. Basically the electronics system varies the engines according to the driving style.

The 72 volt batteries are in the boot, but by no means fill it. In typical use in cities the electric motor will run 50% of the time, the diesel for 25%, and neither for the remaining 25% of coasting. Again, there is regenerative braking to eke out the duration of the battery charge. Again, too, the batteries

recharge overnight from the mains.

The diesel has a catalyst, and the resulting performance is low on pollution. Nitrogen oxides are cut by 60%, and other toxic pollutants are down, too. Even carbon dioxide is down by 50%. From the noise point of view the car is quiet in electric mode, which is the bulk of the time within cities, but the diesel, used for longer, faster runs outside is noisier.

The electric motor is only two inches wide, and the pair of clutches are operated and engaged by micro switches in the gearlever knob acting through servos. When the driver eases back on the accelerator, the diesel engines cuts out and the electric motor is activated. The VW Elektro-Hybrid differs from other hybrids in that the diesel actually drives the car, instead of merely producing power for the electric motor.

The VW hybrid appears to offer a valid solution, albeit not as dramatically better as the GM Impact. The Elektro-Hybrid costs £12,000, the same as a Golf GTi, compared with the price of £9,700 for a standard Golf.

The outcome of work on electric and hybrid cars is that they are increasingly a valid option for city driving. They are more expensive at present than conventionally powered cars, and lack their performance. However, given sufficient stimulus to their markets to justify large scale mass production and to spur technological advances, the relative price will come down rapidly, and the performance will begin to attain that of cars using petrol engines.

Electrics and hybrids may not match high performance cars for many years, if at all. But there is no reason to employ a 150 mph supercar to travel to work, to visit the local supermarket, or to drop the children off at school. For most urban and commuter use they solve city pollution problems effectively, and eliminate much of the noise pollution which motor vehicles inflict on city ears.

The argument that electric cars simply transfer pollution from the vehicles themselves to the power stations without net gain is not a valid one. In the first place, even if there were no overall gain to global environment, it would still be advantageous to eliminate toxic emissions from the areas where people live. Urban pollution is very much a localized problem. There would be very much lower health hazards if urban vehicles switched to electric power.

But electric vehicles do offer positive environmental gains. In the first place they are charged overnight from the surplus energy which is generated off peak. This means that they do not require the generation of an equivalent amount of additional power. If most of the automobiles currently operating in London were to be replaced by electric cars, there would be no need to increase the total production of electricity.

Secondly, the efficiency of the electric motors they use is very much higher than those of the petrol engines which are replaced. This means that even where extra power has to be generated, it is by no means as much as their individual petrol engines would have had to generate.

In the third place electricity does not have to be generated by the burning of fossil fuels. Electricity is a useful medium of energy exchange, rather like money serves as a means of value exchange. There are cleaner and dirtier ways of generating electricity. There are less opportunities, to put it mildly, to use petrol engines cleanly. Electric power can be produced by wind power, tidal power, and solar power. It can be produced by nuclear power. Improvements are possible to enable the production of relatively cleaner electric power from fossil fuels. All of this gives options not available for petrol engines.

There is thus a good case for cleaning up the air of our cities by promoting the use of electric vehicles. We do not need to wait until technology develops before we follow in its wake. It is perfectly possible to use public policy to promote the development of new technologies by setting targets and by giving rewards for their attainment.

Electric vehicles at present are more expensive than their fossil fuel counterparts. They are, however, cheaper to run and to maintain. They are not as flexible as their rivals, and they fall short of the performances achieved by petrol or diesel engines. But they are considerably more friendly to the city atmospheres which residents must breathe, and can have their power pulled from off peak, surplus sources, or generated in cleaner ways.

Those performance deficiencies could easily be made up if we made a commitment which promised an expanding market for electric vehicles in the future. Competition and technological advance would soon close the gap, and require only the spur of public policy to give them incentive.

5. THE TAX TREATMENT

The Treasury in Britain currently subsidizes the possession of company cars. Tax rules make it advantageous to both employer and employee to have a company car included among the perks which can be offered in addition to salary. The advantage to the employee is that the company car is not taxed on the full worth to the employee. By taking a company car, employees can in most cases drive a better and newer vehicle than they would be able to afford if they had to bear the full costs themselves. The costs of repairs and maintenance can normally be shifted to the firm, and there are annual fuel benefits to be added to the tax concessions.

From the point of view of employers, company cars are an effective way to reward employees without having to pay the full value of those rewards. Tax rules allow the employer to write down a proportion of the car's value each year to offset against taxation, and a final allowance on the difference between the car's actual worth when it is disposed of, and the written down tax value. Many employers find that the cost and quality of the company cars allowed to employees are significant factors in the retention of their loyalties and their satisfaction with the levels of remuneration.

Company cars are the single most dominant element in the car market in Britain. The car fleets purchased or leased by companies are eagerly courted by both manufacturers and dealers, by means of concessionary rates and special deals. Some estimates put the proportion of company cars on rush hour roads as high as two thirds of the total. Certainly the tax rules relating to company cars are a major element in the make-up of the total number of vehicles.

From the company's point of view the Treasury basically allows 25% of the car's value to be written down each year as a tax loss, up to a maximum of £2,000 per year. The following year sees 25% allowed against the remaining value, and so on. When the car is finally disposed of, the difference between its written down tax value and the price actually yielded is allowed as a final offset against tax.

The employee pays tax on the basis of a standard scale. For cars which cost less than £19,250, the employee pays tax on an assumed value of £1,700 per year for a vehicle of 1400cc or less, £2,200 on cars between 1401 and 2000cc, and £3,550 on cars above 2001cc. For cars which cost between £19,251 and £29,000, the annual value taxed is £4,600, and for cars costing over £29,000, the value taxed is £7,400 per year. The value for tax purposes goes up one and a half times for second cars, or if the car does less than 2,500 business miles per year.

The benefit to the employee is calculated on a lower scale of rates for cars over four years old. The fuel benefits for the three engine sizes above are £480, £600, and £900 per year. Both car and fuel charges are reduced by half where business use in the tax year reaches 18,000 miles or more.

In a typical case, an employee's 1400cc car might cost £300 per month to lease, or £3,600 in a year. The employee is only taxed on £1,700 of that if he or she exceeds 2,500 business miles in the year. This means that £1,900 of the value is not taxed. Even if less than 2,500 business miles are achieved, the employee is still only taxed on £2,550, leaving £1,050 of the value untaxed. And there is fuel benefit on top of the car benefit.

Clearly the implicit subsidy in the tax treatment is substantial. While the government may grumble about the number of vehicles which people choose to bring into the city each day, the government itself is a major cause of their numbers. With one hand it beckons people to use public transport and to leave their cars at home, while with the other hand it effectively hands out cash to encourage them to possess and to use their motor cars.

Urban pollution caused by motor vehicles is thus promoted in part by government itself. It uses taxpayers' money to promote what it regards in some degree as anti-social activity. Those who argue for public transport make the case that it ought to receive no less a tax subsidy than that which goes to company cars. They have a point. If the government is prepared to subsidize the anti-social activity which causes pollution and congestion, why not the socially beneficial activity which does not.

Furthermore, the huge numbers of company cars on rush-hour roads make extra spending necessary. Not only do the pollution and congestion have costs, but cash has to be found for the extra roads, the additional maintenance and the extra policing which the traffic generates. It could be argued that public transport, on the other hand, enables net savings to be made to public funds, and therefore merits, at the very least, a treatment no less favourable than that accorded to company cars.

If tax-free motoring in company cars is allowed to the tune of one or two thousand pounds a year, argue some, why not a season ticket on the trains or the buses? The case can be emphasized by pointing out that the latter necessitates less additional government spending than the former, quite apart from the relief it brings to pollution and congestion. At the very least there is the basis of a case for equal treatment, either equal tax relief or no tax relief.

Among the ways of promoting changes in behaviour, three stand out. One seeks to encourage people by appealing to their sense of what is desirable; one introduces prohibitions and punishments; and one adds incentives and rewards. In short, there are exhortation, sticks, and carrots. Of the three, the use of

incentives is the most popular, and the easiest for governments to enact. Exhortation is often ineffective, and restrictions are generally unpopular. Incentives, however, allow people a free choice, but alter the circumstances so that they stand to gain most by choosing the norm which is being promoted.

Members of the environmentalist lobby have been saying for years that people would happily pay more for a cleaner environment. Despite this, the sales of lead-free petrol remained negligible until Chancellor Nigel Lawson introduced a tax differential in his 1989 budget. The fact that unleaded petrol was then perceived to be cheaper led to a huge increase in sales, to the extent that some major oil companies now offer nothing else. In fact unleaded fuel can lead to increased consumption, and may not in fact be cheaper. The perceived incentive is sufficient, however.

A similar incentive can be used as an instrument of public policy to encourage the switch to electric or hybrid vehicles in our cities, and to accelerate their technological development. If government policy is such as to make electric vehicles an attractive and cheaper option, and is clearly seen to be committed to this on a long term basis, the industry itself will respond to the anticipated market conditions. Innovation will be speeded up; manufacturers will boost their investment in the development and production of electric cars; and companies will compete strenuously to have models ready with suitable specifications and attractive prices.

In the case of unleaded petrol, the government combined its perceived price advantage at the pumps with a campaign to persuade the oil companies to supply more of it and to make it widely available. The same could be done to promote the switch to electrically powered cars in our cities. In addition to using incentives to make them commercially more attractive, government could give clear and unambiguous indication that the days of exhaust fume pollution are numbered. It could indicate, as the Californian authorities do, that standards on emission control will grow progressively tighter as years go by.

The actual incentive given to promote electric vehicles could be done simply. Tax concessions could be given either to manufacturers who develop and market electric vehicles, or to motorists who purchase and use them. There are several options, including subjecting them to lower tax rates on manufacture and sale, and lower vehicle excise duties in use.

The simplest method, however, is probably the best. Government should announce that at the end of perhaps a five year transition period, the tax concessions on company cars will only apply to electric vehicles. This indicates in unambiguous signals to the trade that the substantial annual value which a company car represents to the motorist will only be available for electric vehicles, or for hybrid vehicles which employ a stated minimum proportion of electric propulsion.

This allows the automobile trade a number of years in which to

bring forward the development of electric and hybrid vehicles to the stage of full production. The anticipated market will be enormous, given the huge proportion of company cars on the roads. Motorists will then be faced with a choice between petrol engined cars on which they must pay the full tax value, or electric vehicles which offer a substantial annual saving. In that electric vehicles already offer substantial savings on operation, maintenance and repairs, the addition of a saving on the actual purchase costs should easily tip the balance in their favour for most motorists.

An advantage of this method, and one which is by no means negligible, is that it would involve no additional costs to the Treasury. No new discounts or tax concessions need be offered, only a limitation of existing ones to a specified type of vehicle. While some motorists might choose to stay with high performance petrol cars, and pay the full cost of them, most would switch to the very much cheaper option. This would be accelerated if, as expected, the specifications of the electrics rapidly improved in anticipation of the vast market awaiting them.

It would certainly improve if the government, in addition to limiting company car concessions to electric vehicles, also committed itself to systematic and progressive reductions in the permissible level of toxic gases in exhaust emissions. The knowledge that emission standards were set to become ever harder for petrol vehicles to achieve would lead manufacturers to concentrate more on the electric alternatives. The tighter controls would mean that petrol engined cars would cost more to make, giving the electrics an even greater differential advantage over them.

Such a policy, announced a few years in advance, would give the industry some time to gear up to the changed circumstances of its operation. It would not only anticipate technological developments; it would actually help to bring them about. The incentive of the vast market awaiting manufacturers of electric vehicles would lead them to bring forward new models and to test new ideas.

Government should promote the development of this technology by making a commitment to the use of electric cars within cities. The easiest and least costly way of doing this is by a declaration that within (perhaps) five years, tax concessions on company cars will only apply to electric or part electric vehicles with a minimum proportion of electrically powered drive.

The effect of such a commitment will be to accelerate the

6. CONCLUSION

The automobile satisfies a deep need within many of us for personal mobility and independence. A Georgia farmer's wife wrote to Henry Ford in 1918: "You know, Henry, your car lifted us out of the mud. It brought joy into our lives. We loved every rattle in its bones."

Lev Navrozov wrote (in The Education of Lev Navrozov) of the Russian showing of the film version of Steinbeck's The Grapes of Wrath: "The author and the film maker wanted to show the life of the poor in the thirties. The poor rode about in trucks. The Russian audience stared." They were struck less by the pitiable condition of the Joad family than by their mobility.

It is that mobility which enables us to enjoy living in the country as we work in the city. It gives us access to services beyond where we live. It enables us to use supermarkets and schools and cinemas far beyond the distance our feet will carry us. But with that freedom and that mobility comes a price. The automobile is the most democratic form of transport; it is so democratic that everyone wants one. The proliferation of numbers of vehicles has caused our city atmospheres to fill with the toxic emissions of motor vehicle engines.

Some people urge us to give up the automobile, together with the freedom and mobility it brings, and to opt instead for the regimented world of mass public transport. It need not come to that. A more attractive alternative is to use the improved technology to which we now have access to create vehicles which give us the benefit without the unacceptable cost.

The fossil fuel engines which emit so many pollutants are being rivalled by cleaner and often quieter engines which use advanced technology to reduce poisonous and unpleasant emissions, and in some cases to eliminate them altogether. Of all options, the electric vehicles, and to a lesser extent the hybrid vehicles which are part electric, present the cleanest alternative. The technology is on the verge of providing us with vehicles which provide viable alternatives for city driving. Some would argue that it already has done; others acknowledge that it is only a few years away.

Government should promote the development of this technology by making a commitment to the use of electric cars within cities. The easiest and least costly way of doing this is by a declaration that within (perhaps) five years, the tax concessions on company cars will only apply to electric or part electric vehicles with a minimum proportion of electrically powered drive.

The effect of such a commitment will be to accelerate the

technological development of such vehicles, and to expand the investment going into their improvement and their mass production. Coupled with the announcement of ever tougher controls on toxic emissions, this will lead to a major changeover to the purchase and use of electric cars within cities.

There will be substantial environmental gains. The atmosphere in the places where people live and breathe will be vastly cleaner, and free of many of the pollutants which cause health problems and discomfort.

There will not be a switch of pollution from individual vehicles to power stations. This is because the electric cars will usually be charged overnight, using surplus off-peak power already available. Furthermore, the electric motors which drive vehicles are far more power efficient than petrol engines, leading to a net reduction in total energy needed. And the power stations themselves have a range of sources of production, many of them far cleaner than fossil fuels.

In short, government has the option of a very low cost method of improving the environmental quality in our cities. It can demonstrate its commitment to environmental improvement, and at the same time instigate the technological advances which can retain for us the advantages which motor vehicles bring, whilst shedding a significant part of the drawbacks which have hitherto been involved.

RECENT PUBLICATIONS

PRIVATIZATION NOW!

£25

Privatization is a policy being adopted by the governments of developing countries throughout the world. Many British experts have been involved in advising these governments, and in designing strategies suitable to developing economies. Privatization Now!, is based on the Third London Conference on Privatization held in 1989, and brings together the experience of these experts. How to privatize without stock markets, how aid can facilitate privatization, and how to find private finance for infrastructure, are some of the issues covered. Case studies are taken from Costa Rica, Ghana, Guinea, Hungary, Ivory Coast, Malaysia, Morocco, Mozambique, Togo, and Zambia.
ISBN: 1-870109-75-9. 113pp.

THE WAYWARD ELITE

£12

By Dennis J O'Keefe

The author, Senior Lecturer in Education at the Polytechnic of North London, warns that Britain is passing through an education crisis which may threaten our 'economic renaissance.' He locates much of the blame with the system of teacher-education. In a forthright critique, O'Keefe attacks the system for spreading "anti-elitism, and the cults of equal opportunities."
ISBN: 1-870109-76-7. 150pp.

WIDER STILL AND WIDER

£10

The monumental changes in eastern Europe have made a revision of British policy towards Europe a necessity. What should be our attitude towards widening the European Community? How optimistic can we be about the outcome of reform? How can Britain help with economic revival?

Leading academics address these questions and others in an important assessment of the changes following the collapse of the Eastern bloc. They call for a wider Europe, with institutions formed spontaneously rather than imposed from the centre.
ISBN: 1-870109-77-5. 21pp.

EUROPEAN PHARMACEUTICAL POLICIES

£15

By Peter Young

A comprehensive survey of the pharmaceutical policies of European countries. The survey reveals that Britain leads the world in R&D, but that our system of licensing is causing delays for new drugs. Many other valuable facts are contained within the survey, along with an extensive bibliography.
ISBN: 1-870109-1. 53pp.

THE TENDER TRAPS

£15

The experience of compulsory tendering has brought radical change to local government. The practice of putting contracts for local services up for competitive bid has introduced a spur of efficiency, and has been a demanding challenge to local authorities. In this report, adapted from a recent conference held by the Institute, the tendering experience is reviewed. The costs and benefits are analyzed, with contributions from local government officers, private contractors, and policymakers. ISBN: 1-870109-82-1. 72pp

THE CASE FOR A NATIONAL ARTS LOTTERY

£1

By Denis Vaughan

Denis Vaughan, the international conductor, calls for a national lottery to help fund the arts. He points out that 'Great Britain and Albania are alone in having no national lottery' and calls for the law to be changed to allow for one to be set up. The proceeds of the lottery, estimated at £480 million, would go to refurbish most of the theatres in the country, to establish three new dance theatres, to renovate the Royal Opera House, and to fund many other renovations and expansions.

The author foresees that a weekly or fortnightly visit to the opera or theatre could become 'a standard part of the living pattern .. as firmly implanted as football' is at the moment. ISBN: 1-870109-78-3. 4pp.

DOES SOCIALISM MEAN NEVER HAVING TO SAY YOU'RE SORRY?

£10

By Kenneth Minogue

With socialist regimes collapsing all over the world, European socialists have hurried to deny any connection between their ideology and these crumbling dictatorships. Professor Kenneth Minogue of the London School of Economics forcefully makes the point that these intellectuals should face up to their mistakes.

Minogue singles out Bruce Kent, Eric Hobsbawm, and John Kenneth Galbraith for particular criticism. He compares modern socialists to the Antinomians of the 16th century, who believed that they were part of an "elect" and therefore immune from having to acknowledge error. Professor Minogue covers a breadth of issues, from the appeal of socialism to the illusion of rationalism. ISBN: 1-870109-81-3. 21pp.

ADAM SMITH'S LEGACY

£12

In this publication a variety of leading academics mark the bicentenary of the death of Adam Smith by examining his life and work. The authors include amongst other; Professor Edwin G West, Professor William Letwin and Rt Hon Nicholas Ridley. ISBN: 1-870109-84-8. 150pp.

VISION, IDENTITY AND ENVIRONMENT

£10

By Sir James Goldsmith

Sir James Goldsmith, entrepreneur and publisher, tackles the most challenging policy problem of our time, that of how to protect the environment upon which we all depend. In this monograph, based on a lecture to commemorate the death of Adam Smith, Goldsmith outlines an innovative scheme for preserving the South American rain forest based on a market contract.

Rejecting negative and fatalistic views, he argues that advances of technology will allow us to derive more value from fewer inputs of resources. He believes that the best way to foster innovation and ingenuity is to allow and to help many different ideas and cultures to flourish, with the west paying respect to the traditions of developing countries.
ISBN: 1-870109-80-5. 15pp.

BUCKING THE MARKET

£10

By Nicolas Gibb

With the current clamour for entry into the European Exchange Rate Mechanism reaching a crescendo, Nicolas Gibb offers some much-needed objective analysis of the ERM. Proponents claim that the ERM will stabilize the pound and reduce inflation. The report points out that currencies within ERM have often declined more than those outside, and that control of inflation will continue to depend on domestic monetary policy.

Gibb offers a timely warning that political pressures may induce ERM membership for the wrong reasons and at the wrong Sterling level. ERM is viewed by many supporters as a stepping stone to full European Monetary Union, but this report calls for the debate about the desirability of EMU to take place now, before we make the first step by joining ERM.
ISBN: 1-870109-83-X. 29pp.

SCHOOLS OUT!

£10

By Andrew Wallace

The Education Reform Act of 1988 provided the framework for a more consumer-led education system in the United Kingdom. In **Schools Out!**, Wallace argues that further legislation is required to ensure that the last remnants of producer capture are exorcised from an industry which has proved one of the most resistant to change.

He proposes regular opt-out ballots for schools still under local political control; putting an immediate and constant competitive pressure on the LEA. Other ideas mooted include allowing parents to set up their own schools while receiving state funding, along the lines of the Danish Free School system, and the abolition of the HMI in favour of a more market-led assessment mechanism.
ISBN: 1-870109-85-6 25pp.

£12

TRACK TO THE FUTURE

By Kenneth Irvine

A detailed blueprint for rail privatization. Irvine dissects the debate, and refines his own scheme of establishing a track authority with competing trains running on its rails. He provides a detailed policy formula for putting rail into the private sector. 40pp. ISBN 1-870109-38-4.

'... the Adam Smith Institute, who helped spark the recent debate on rail privatization, has published a detailed blueprint for the privatization'
The Guardian

£12

THE RIGHT LINES

By Kenneth Irvine

Irvine, a former British Rail employee, proposes a plan for privatizing rail services. The sectors of BR -- InterCity, Network SouthEast, Provincial Services, Freight, and Parcels -- should be sold off separately, he says, leaving the track in the hands of an infrastructure company.
ISBN: 1-870109-031. 38pp

£10

NEW ROADS TO FINANCE

By Rt Hon Paul Channon, Ian Clark, Prof John Hibbs, Nick Ayland, Dr Madsen Pirie

With traffic congestion an ever more costly nuisance, this report is a timely look at the private alternatives. The authors examine the practicalities of building privately-owned roads, financed by tolls. The report also contains an innovative proposal for 'infrastructure bonds.'
ISBN 1-870109-55-4. 30pp

Book orders should be accompanied by a cheque, money order, or credit card number (MasterCard or Visa). Prices are inclusive of postage and packing for United Kingdom orders and for surface mail to Europe. Add 20% for airmail and non-European orders. Cheques should be made payable to ASI Research Ltd. Send to PO Box 316, London, SW1P 3DJ.