How practicable is the electric car?

For electric road-vehicles to become competitive with the noisy and air-polluting motor-car, a breakthrough is needed in the technology of electric power sources. The oil, electricity and motor industries, and the government, ought to be more interested in current research and should be prepared for the repercussions that will follow this breakthrough

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Our motorway systems, road-widening schemes and multi-storey car parks bear witness to a strenuous attempt to accommodate the unbridled growth of motorized transport. Only during the past few years has the realization dawned that there are huge social costs associated with the expansion which we and many other countries have promoted. The Road Research Laboratory estimates that the 16 million vehicles at present on the roads in the United Kingdom, 12 million of which are motor-cars, will by 1980 increase to 26.5 million, of which 22 million will be motor-cars. By the year 2000 there will be 36.2 million vehicles, 30.9 million of them motor-cars. Thus the social costs which we are accepting today will have increased markedly by the turn of the century.

Economic and social penalties

The most important of these penalties is the increasing pollution of the air by carbon-monoxide, hydrocarbons, nitrogen oxides and lead compounds. Air pollution is known to contribute to illness, disability and death from chronic respiratory diseases, and perhaps to other diseases too. Noise is less of a health hazard than air pollution, but it also affects health by preventing sleep and inducing stress; and it can interfere with education, communication and recreation.

Traffic congestion carries both economic and social penalties—the economic cost of longer and longer periods spent travelling, and social costs that include the health risk to the individual due to the tension of driving on overcrowded roads, the increased risk of accident (another cause of tension to driver and pedestrian alike) and the ugliness of even well-designed roads when strewn with street-parked cars or choked with traffic. So the entire transportation system and its individual parts require close scrutiny.

The basic objective of a transport system should be to move people and goods safely from A to B in minimum time at minimum cost. For many years now, transport scientists and entrepreneurs have been discussing possible transportation systems. New systems are often rejected on grounds of economic cost alone, without consideration being given to the external diseconomies associated with the perpetuation and expansion of the present system (estimated by Anthony Vickers at £20 000m over a 20-year period, in a recent paper to the Institution of Mechanical Engineers).

Many proposals for future systems are based on the use of electric power, which would minimize the hazards of noise and pollution. In fact, in a clearly defined market segment (such as milk and bread delivery), electric vehicles are well recognized to be economically superior to internal-combustion-engine vehicles. But in recent years much interest has been shown in passenger electric vehicles, in particular commuter cars. A passenger electric vehicle is unlikely to be significantly cheaper over its whole life than a corresponding internal combustion engine car, even given the heavy tax burden on gasoline fuel. It is limited by the currently available technology (based on the lead-acid battery) to a maximum range of 40 or 50 miles, with overnight recharging. Its defined market segment consists almost exclusively of second cars for households with facilities for overnight charging.

A study of second-car usage would tell us how much flexibility is at present needed in such a vehicle. The numbers of two and three car families will undoubtedly grow, but such a vehicle is likely to sell only in very small numbers. Its tangible advantages of easy start, less time off the road for maintenance, and lower maintenance costs, are insignificant when set against its inflexibility and utilitarian appearance. Although 70 per cent of cars in the UK at present do no more than 20 miles per day, the necessity for occasional journeys of more than 40 miles is likely to render such a vehic[le] unattractive.

Acceptable level of congestion

Certainly, the vehicle would be pollution-free an[d] largely noiseless, but even if it did secure much o[f] the market for which it is appropriate, it would d[o] little to alleviate the problems created by the co[n]ventional car—assuming that the present free-fo[r-]all in road usage continues. And the suggestio[n] that, since it is likely to be a smaller vehicle, [it] would reduce congestion requires careful examina[-]tion. Any effect there might be short-lived as mo[re] vehicles might come on to the road to restore t[he] congestion to a level which is just acceptable [to] road users.

However, if the success of the battery commut[er] car is unlikely, this by no means rules out t[he] ultimate success of electric vehicles. The potent[ial] market for an electric vehicle increases as its ran[ge] and performance characteristics improve. Mo[re] sophisticated motor and control systems are no[w] being developed, but in order to make a significa[nt] impact, a battery car should have a range in exce[ss] of 200 miles at an overall cost (capital plus ru[n]ning) little different from an equivalent petrol driv[en] vehicle. The breakthrough needed to achieve t[his] advantageous position is in power source tec[h]nology.

A satisfactory power source system must co[m]bine the properties of high energy density (f[or] endurance), high power density (for acceleratio[n]) and low cost. *Battery systems* have good pow[er] density, but their energy density is very low

This article is based on a project carried out last year during a conference on "Planning for Technological Change", organized by Careers Research Advisory Centre at Manchester for over 100 PhD students. Miss Lawrence directed this project, assisted by Dr Capon conventional systems. (See also "Fuel cells and batteries get together", by Ron Brown, vol. 40, p. [illegible].) The silver/zinc battery is a considerable improvement on the lead/acid battery but its cost makes it unacceptable as a vehicle propellant.

Ford Motor Company is working on the sodium sulphur system and General Motors on the lithium/chlorine system. It appears that these systems have high energy densities, but starting temperatures in excess of 500°C are necessary, and the chemicals they use could have serious effects in the case of any accident.

Semi-fuel-cell systems, using a metallic anode and an air cathode, can also have good energy-density/power-density ratios, and the zinc/air system in particular is a promising contender. It is inexpensive, but there is one problem: during overnight recharging, dendritic growths form on the zinc plates and cause short-circuiting. Perhaps the zinc anodes could be replaced at service stations.

Fuel cell systems

In contrast to these battery and semi-fuel-cell systems, which store energy from the electricity supply and later release it, the *fuel cell* produces electricity directly from a chemical reaction at a catalytic surface. The hydrogen/oxygen fuel cell is the best developed but it suffers from several disadvantages including difficulty of handling; transport and hazard factors; and high cost. Considerable work has been carried out on fuel cells using hydro-carbon compounds, but the most successful operate at temperatures in excess of 500°C, with resultant running problems and engineering failures. Lower temperature operation is currently commercially unacceptable because of the cost of the catalyst needed to make the reaction go fast enough "cold". Work is also proceeding on hydrazine, ammonia and methanol/oxygen systems in an effort to find a low temperature system which can operate with a cheap catalyst.

Although promising high energy densities, fuel cells have low power densities, which rules out their direct use in a vehicle system. They would most likely be used in conjunction with storage batteries, peak power being drawn from the battery which would be continuously recharged by the fuel cell (see article cited above).

Should it be developed, such a fuel cell vehicle is likely to be more acceptable than a battery or semi-fuel-cell vehicle. But the necessity for overnight recharging of the storage batteries reduces flexibility, even though ranges of 200 or 300 miles on one charge might be obtained. A mechanically rechargeable semi-fuel-cell or fuel cell system, in contrast, would have similar flexibility to a petrol-driven vehicle. And such a car might be marketed successfully.

Widespread use of an electric car will, however, not in itself solve all of the social problems indicated earlier. Since much of the vehicle air pollution and noise is from goods vehicles, for a really beneficial effect vans and lorries would also have to be powered electrically.

The electric vehicle will thus do nothing to reduce congestion, although it could be an integral part of a more socially acceptable transport system.

Potential power sources for an electric vehicle

Storage batteries	Working temperature (degrees C)	Energy density (Watt h/lb) 2-5 h discharge	Life cycles (claimed)
Lead/acid	Ambient	10–15	1500
Nickel/cadmium	Ambient	10–15	2000
Nickel/iron	Ambient	10–15	2000
Silver/zinc	Ambient	40–50	100
Sodium/sulphur	300	80–150	?
Lithium/chlorine	650	100–200	?
Semi-fuel cells			
Zinc/Air:			
primary (rechargeable mechanically)	60	120	—
secondary (rechargeable electronically)	60	40–60	100
Sodium/amalgum/air	60	25	
Magnesium/air	60	45–60	
Fuel cells			
Hydrogen/oxygen	60–70	30	

It may be necessary to restrict private vehicles from entering city centres, and to allow only certain sections of the population such as police, doctors and wholesale and retail distributors to use their vehicles there. For the vast majority of the population who use city centres, electric buses, conveyor belt systems and much improved tube trains may be the only means of transport.

Cars on rails

Systems of small guided cars, perhaps driven at high speeds with power drawn from a third rail (for example the US Starrcar) have been proposed for city travel. Those discussed at present, however, are unlikely to be acceptable, as they will not increase the traffic flow sufficiently to cure the congestion problem. However, systems of this kind may well be developed for use in suburbs and between towns, although they would be very expensive.

Who is interested in developing electric cars? The small market available to a utilitarian electric car of strictly limited mileage and performance characteristics makes it unlikely that a major car company will produce one. A small engineering company may enter the market, though it seems a doubtful venture in commercial terms. Such a company would also, unlike the large car company, face serious distribution problems, as car dealers in the UK are tied to specific companies, and are unlikely to switch exclusively to a car of such limited potential.

If a car which had a much greater market appeal were developed, it is unlikely that a small company would be able to finance the necessary production. The development of a vehicle with distinct advantages over a petrol-driven car would, however, force one of the major car companies into manufacture—despite the high cost and problems of dual production lines, new technology, etc. Meanwhile, car companies are likely to increase research effort on reducing air pollution and noise from the petrol driven vehicles, so that this changeover may at least be delayed. All engineering companies concerned with the motor industry, directly or indirectly, should clearly be looking ahead and preparing technological forecasts. Those in the fields of electric motors and controls, batteries, and/or fuel cells, will find increased business, while manufacturers of specifically petrol-driven vehicle parts might lose by the change.

Who else would be affected by the introduction of an electric vehicle on a wide scale? The oil companies would certainly be faced with major changes—a battery or semi-fuel cell vehicle would not consume an oil product direct. (Increased demand for electricity would increase fuel oil consumption in the short term, although in the long term use of nuclear fuels will reduce even this market.) A fuel cell system might be based on an oil product (or the service station network might handle the sale of any other fuel). But whatever the power source used, the oil companies will probably have to reconsider the variety of products they sell. Where this means that extra processes are involved in some of the products now produced almost incidentally, prices of raw materials for chemicals, fertilizers and synthetic fibres could rise.

The electricity boards, of course, may gain by a move to electric traction. Should a battery-recharge system be viable, off-peak demand would be increased. This would enable the boards to make better use of their capital equipment and thus make an overall price reduction. However, the boards would have to meet the additional capital cost of chargers. Should a mechanical-recharge semi-fuel-cell system be viable, then electricity wo[illegible] needed to replate the anodes. The effect of the [illegible] of fuel-cells depends largely on the fuel. If it were hydrocarbon, it would be obtained directly from crude oil, but were it hydrogen or ammoni[illegible] electric power would be necessary to produce [illegible] hydrogen from water electrolytically (althou[illegible] all this power would be consumed off-peak). [illegible]

We could expect the government to take action in several areas if an electric vehicle were to [illegible] successful. The taxation structure would need revision so that the loss of revenue from petrol sales could be made up. The retraining of those workers whose skills were made obsolete by the new technology might also require governmental action.

There would be little import saving, just the net of crude oil for petrol-less battery or fuel cell [illegible] Indeed, there could be large export increases [illegible] companies achieved a technological lead. [illegible] regrettable that the car companies doing [illegible] work are controlled from Detroit, though [illegible] work going on in many firms here.

The government thus has two good reasons to watch progress in this field closely. The electric vehicle could form an important part of a transport system for the United Kingdom, which [illegible] reduce the social costs we now pay when [illegible] ourselves and others from A to B. And a potential export market may be missed unless supp[illegible] given to certain developments. We are sure [illegible] magnitude of the changes outlined above does [illegible] discourage those involved in developing techn[illegible] advances which would benefit the nation.