Reducing Emissions Associated with Electric Vehicles

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Abstract A century ago the electric car (now more frequently called the electric vehicle or EV) was seen to be the ideal city car, while at the same time addressing the serious transport polution problems of the time. With the development of lithium ion battery technology, the electric car once again offers to be the ideal city car and at the same time to address transport pollution problems. Concerns have been raised that electric cars merely relocate greenhouse gas emissions from the car exhaust to the exhaust stack of the power generation plant.This paper identifies a range of strategies to ensure that the electric car is truely a zero emissions vehicle, at a time of growing concerns about global warming and the deminishing access to conventional fuels due to peak oil.

1. Introduction

There is growing community concern about global warming, and the need to reduce our carbon footprint. The transport sector is the third biggest emitter of greenhouse gases in Australia. And we have a simultaneous challenge: when the world recovers from the current economic downturn, oil consumption will outstrip oil supply[1]. Australia will not have access to enough oil in the future. So it's timely to look again at the environmental impact of electric cars.

2. The Initial Success of the Electric Car

At the turn of the 20th century, the electric car was seen as the environmental saviour of the industrialised world. At the time, London and New York, the two major cities of the western world, were served by 100,000 horse-drawn cabs, buses and delivery carts.

The horses deposited 1,000 tonnes of manure onto the city streets each day. The cities had no way of clearing away the mess. It stank, attracted hordes of flies and was a health hazard. When it dried, it blew into the air and caused breathing discomfort and respiratory disease.

At this time, electric vehicles, emitting neither exhaust fumes nor noise pollution, were seen as the saviours of the city environments. They started instantly, accelerated away quickly and smoothly, were quiet, non polluting and easy to drive.

By comparison, petrol engine cars were difficult to start, with poor fuel mixture and required hand cranking, too difficult and dangerous for women drivers. They were hard to drive without synchromesh gearboxes, and a professional chauffeur was often employed to deal with these difficulties.

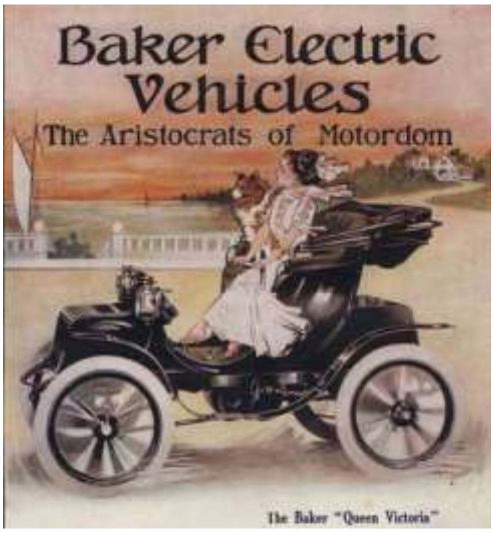


Fig 1: The Baker Electric Car 1906, Thomas Edison's first car

The petrol and oil fumes were smelly and polluting, and the exhausts were so noisy that they frightened the horses pulling the many wagons around the city.

The American inventor Thomas Edison, seen here admiring the lead acid battery pack of his Baker electric car, was a devotee of all things electric. His friend Henry Ford consulted him about whether he should build the T-model with a petrol or an electric motor. Unfortunately their discussions at this time were not documented, but Henry's decision to utilise petrol engines in his mass produced cars was to decide the future of the auto industry.

Fig 2: Thomas Edison, Battery Inventor

3. The Dominance of the Petrol Car

With the invention of the muffler, the carburettor by Maybach and Daimler, the fuel pump, and the electric starter by Kettering, these shortcomings were overcome. These new technologies transformed the petrol powered car, and when added to the dramatic cost reduction of Henry Ford's mass produced T-model, the public accepted the petrol powered car and abandoned the electric car.

There were a number of reasons for the electric car to fall from favour. The lead acid battery is heavy and expensive, with an energy density of less than 1% of that of petrol (one kilogram of petrol contains 12 kWh of energy, while a battery stores about 40Wh/kg)[2]. Petrol became cheap and readily available with the discovery of Texas crude oil, providing cheap motoring and a driving range beyond city transport to enable commuting between cities.

Fig 3: Henry Ford's T-model

Petrol cars could now travel further than electric cars, just as roads were developed to connect cities and cars ceased to be used just for city transportation. The petrol powered car quickly became the exclusive technology to be used throughout the world for the next 100 years. Electric vehicles continued to find limited application; they hung on in England, where they were use as milk floats, and in Germany as postal delivery vans, but the numbers were negligible compared to the millions of petrol engine cars produced.

4. The Revival of the Electric Car

It was not until the invention of the Lithium-ion battery in 1996, and the utilisation of integrated circuits in the power control system that the electric car began once again to compete with the petrol powered car as a suitable form of city transportation. The resurrection of the electric vehicle came at the same time as the emergence of community concern about peak oil and global warming. Interestingly, the first of the new generation of electric cars were developed, not by the established

global automobile manufacturers, but by new start-ups such as Tesla Motors, founded by IT specialists from Silicon Valley in California. Tesla Evs are expensive, but have high performance and extended range.

Fig 4: Tesla Electric Car

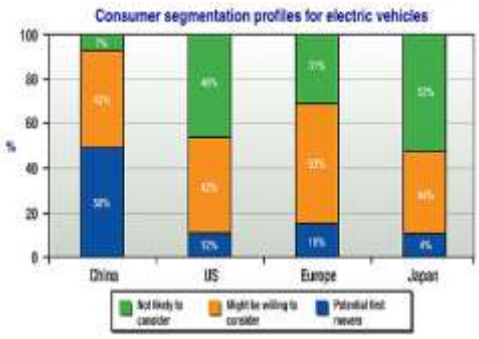
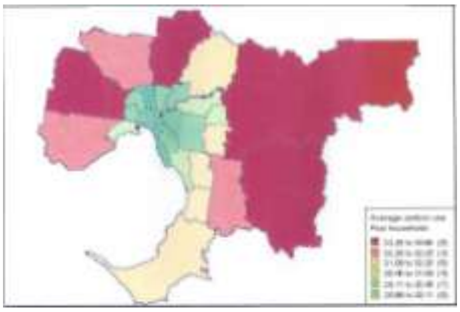


Fig 5: Global Interest in Evs

Predictions of the uptake of electric cars vary. O'Connell of Tesla Motors suggests that by the year 2020, 30% of the cars driving on the road will be battery electric or plug-in hybrid. Carlos Ghosn of Nissan predicts that 10% of cars globally will be EVs by 2020. CSIRO estimates that less than 10% of Australian cars will be EVs by 2020[3], while JD Power estimates a 7.3%[4] take-up. In a recent study[5] Deloitte found that Chinese consumers were found to be more likely 'potential first movers' in the adoption of EVs – that is, people who are very interested in an EV and likely to purchase or lease one within the next 12 months – compared to people in more developed automotive markets.



In an Australian-specific survey the study found that petrol prices need to hit $2.60 a litre before the vast majority of consumers would be more willing to consider an EV over a regular car. Analysis of carbon use in Melbourne suburbs[6] shows that low income outer suburbs will be worst affected by increased fuel prices. People living in these areas will benefit most from the lower running costs of EVs, as they frequently must rely on private transport to commute to work.

Fig 6: Average carbon use in low income households around Melbourne

After a century of domination by petrol powered vehicles, the time of the electric car has returned. 85% of Sydney and Melbourne residents drive less than 40 km per day[7], so electric cars currently have the range to satisfy this need, and this typical commute can be recharged in 3 hours from a standard power outlet.

Both China ($9 billion) and USA ($3 billion) have invested heavily in battery research, and significant development in battery performance can be expected over the next decade. The range and flexibility of electric powered vehicles will extend as battery mass and cost reduces, and energy density increases.

5. The Availability of Electric Energy

At a time when Australia's electrical generation capacity is falling short of peak demand, as experienced by Adelaide last summer when power failures occurred, there is concern that power demand for recharging EVs will exacerbate the situation. As shown in the chart of Daily Power Consumption, there is large off-peak generation capacity, and potentially millions of EVs could be charged overnight without any increase in generating capacity.

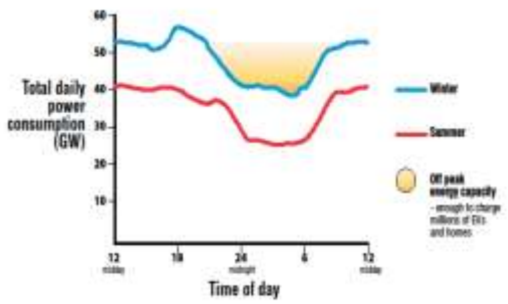
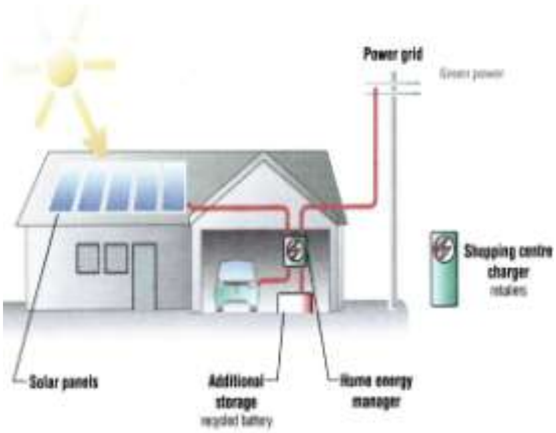


Fig 7: Daily Power Consumption

Critics of EVs point at the emissions from coal-fired power generation, and argue that efficiency losses in electricity distribution and in EV charging offset the gains in EV powertrain efficiency. Some critics of electric vehicles are concerned that there are significant environmental impacts associated with charging electric vehicle batteries from brown coal power generation, exacerbating power station emissions and grid peak loading.

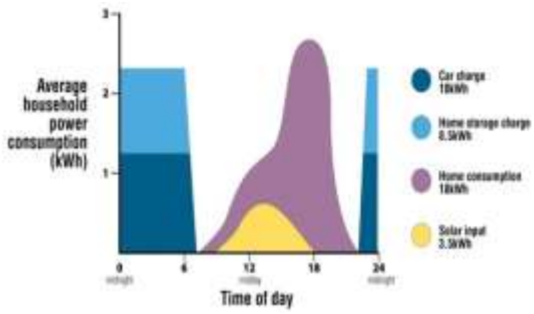
Home Energy Management, controlling the charging of the EV and home storage batteries, and utilising stored energy and solar energy to run the home during the day addresses these issues. Utilising an electronic energy manager ensures that peak energy demand from the grid is reduced, that renewable energy sources are utilised to reduce demand, and off-peak energy is utilised to



smooth power station loading. Home energy requirements during peak tariff periods will be drawn from the home storage battery, replenished partially during the day by solar panels and topped up overnight from the grid during off-peak power station loading. This power will be supplied as Green Energy. This demand load redistribution enables power stations to run more efficiently, reducing power station emissions and delaying infrastructure upgrades.

Fig 8: Home Energy Management

The Home Energy Management system utilises solar panels to provide as much of the EV recharging energy as possible, and supplements this by utilising Green Power from the grid. This encourages the power industry to grow the contribution of zero- emissions power sources.



A network of storage batteries can become a powerful resource for the electric utilities, allowing better utilisation of existing base load generation capacity, plus overnight utilisation of intermittent wind generator output. The electrical energy consumed, even with very large EV fleet turns out to be minimal, and will not require additional based load generation capacity to be constructed.

Fig 9: Average Household Power Consumption

In discussions about transport greenhouse emissions, the emissions associated with the manufacture of the vehicle are frequently overlooked. These emissions are of the same magnitude as those caused by vehicle operation.

This aspect is of critical importance when evaluating the emissions of hybrid vehicles, as the extra manufacturing emissions associated with the additional electric, battery and power control system can equate to 15 years of operation of an equivalent conventional car before the hybrid vehicle achieves an equivalent life-cycle emissions. In order to reduce the impact of the emissions associated with vehicle manufacture, EDay will recycle their electric cars. The cars will be replaced every 2 years. A new car will be provided with the next generation of battery and control system technology. The 2 year-old battery will be recycled as home energy storage, part of the Home Energy Management system.

Fig 10: The EDay Electric Car

The used cars will be refurbished and fitted with next technology battery and control systems, and leased to new customers. By recycling the cars up to 4 times, the imbedded energy and associated emissions in new car manufacture will be reduced to a fraction of the conventional car ownership model.

The car batteries will also be recycled. At the end of their 2 years of operation in the car, the battery will be utilised for a further 20 years as home energy storage. EDay will then recycle the battery materials in the most environmentally sensitive way, utilising the best technology available by this time.

The EPad is an iPad-like device located in a docking station on the instrument panel. The EPad has all of the existing features of an iPad including navigation and music, plus additional information including where the driver is standing and where he or she parked the car, communication between the driver and EDay such as scheduling for service or updates, the ability to turn on the heating or cooling remotely to ensure the car is comfortable

before beginning a journey, plus advice on range remaining and location of nearest charging station.

Fig 11: EDay EPad interface for Eco Driving

E-Day will provide technologies that connect customers to their vehicles in ways never seen before. Taking advantage of the trends in the mobile device technology, the EPad interface will maximise safety whilst also providing apps to customers that enhance the vehicle eco-system, with updates and upgrades frequently available.

Eco Driving has the potential to reduce emissions by 15%[8]. Energy use can be minimised and recharging emissions can be reduced by smart driving techniques, informed by electric car feedback technology. An iPad-like portable device located in a docking station on the instrument panel, provides the driver with vehicle system analysis and allows remote management of the car. The EPad also provides information to facilitate more efficient driving. This information allows the driver to select less congested or less hilly routes, and provides real time feedback to the driver of the efficiency of driving, and consequently encourages lower energy use. EPad analysis of the driver's daily energy usage and carbon footprint encourages more economical use of the vehicle, and the selection of public transport, cycling or walking options where appropriate.

6 Conclusions

A century after the electric car was first recognised as a desirable technology for convenient city transport and for reducing city transport pollution, it is once again promising the same advantages. Concerns have been expressed that the electric car will not deliver the promised environmental benefits, because of the emissions associated with coal power station electricity generation. Strategies have been described, including Home Energy Management, car and battery recycling and Eco Driving, to address these concerns and provide further environmental benefits, to ensure the electric car is truely zero emissions transportation.

References

1. Sparke, L. “Gas for a Sustainable Transport System, Reduced Greenhouse Emissions & Energy Security“ SSEE International Conference, June 2009.
2. Samarin, A. “Does an electric vehicle fleet hold the key to urban transport?” *Science Alert*, Jan 21, 2008.
3. Higgins, A. and Paevere, P. (2011). Diffusion Modelling of Electric Vehicle Uptake: Methodology and Case Study for Victoria.
4. Drive green 2020: More Hope than Reality, *JD Power* 2011.
5. “Gaining traction: Will consumers ride the electric vehicle wave?“ *Deloitte*, 2011.
6. Unkles, B. and Stanley, J. “Carbon use in poor Victorian households by local government area” April 2008.
7. Simpson, A. Proceedings *EV Conference 2009*, 11 November 2009.
8. King, J. “Driving the Transition to Electric Vehicles” July 2011.