

Electric Vehicles and New Zealand: Identifying Potential Barriers and Future Considerations

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Introduction

New Zealand is facing an energy future where the continual production of greenhouse gas emissions will become progressively less acceptable. Alternatively fuelled electric vehicles have been identified as a possible pathway for the transport sector to reduce emissions.

This paper has been prepared around the concept that electric vehicles should form a significant component of our future transport energy. It investigates mitigating factors that could prevent electric vehicles from entering the fleet and identifies the potential problems they could create. It does not aim to offer immediate solutions but instead highlights the areas that will require additional work to make a comprehensive uptake possible.

The focus is on the light vehicle fleet.

Executive Summary

1. There are three different types of electric vehicles: hybrid vehicles, plug-in hybrid vehicles and battery electrics. Battery power and capacity limitations will initially limit the availability of plug-in and battery electric vehicles. Advancement in battery capability is required before these vehicles can be mass produced to provide the same mobility benefits of an internal combustion engine.
2. Electric vehicles will reduce greenhouse gas emissions and the oil consumption of the transport sector. They can provide improvement in air quality, especially in urban areas, and significant advantages relating to energy security.
3. Plug-in and battery electric vehicles will allow us to take advantage of New Zealand's natural endowment of renewable electricity. As emissions created by electric vehicles are derived from the electricity source, increasing our renewable sources of electricity will provide the most gains in emissions reduction.
4. The extra electricity required to charge electric vehicles can be expected to fall within the existing capacity of the grid if uptake is supplemented with a charging policy to manage peak demand.
5. Electric vehicles do not require a large investment in infrastructure to begin being introduced to the fleet. Public charging facilities may be required as uptake levels increase and vehicles gain capacity to travel further.
6. A fleet of electric vehicles will require new technical expertise in servicing and repair. If a corresponding service industry is not developed then uptake will initially be limited by proximity to service nodes.

7. Despite common perception to the contrary there are no physical barriers preventing electric vehicles from driving on New Zealand roads provided they pass our minimum safety standards. There have been electric vehicles here in the past.
8. It will be useful to have a new registration criterion for engine type as we currently have no way of identifying electric vehicles in the fleet. This is useful for monitoring and statistical purposes, as well as for future charging regimes.
9. An emerging new breed of battery electric vehicles that are small and light are classified as “quadricycles”. They have been designed for specific operating environments in Europe and Asia. Quadricycles are not designed to meet Frontal Impact standards and to register them in New Zealand would require creating an entirely new vehicle classification and a relaxation of our current safety standards.
10. New Zealand is a unique transport environment and the operating environments that quadricycles are designed for may mean that they have little or no application on our existing roads. The limited application of quadricycles means the emission reductions from allowing them could be negligible and a valid option exists to not create a new classification to allow quadricycle style vehicles to enter our fleet on safety grounds.
11. A new classification should only be considered if it is coupled with practical limitations on the operating environment of these vehicles. Limitations imposed will have to incorporate the unique transport situation present in New Zealand.
12. Battery disposal is seen to be a consideration rather than an obstacle.
13. Petrol hybrids and plug-in hybrids will increase petrol displacement through improved fuel efficiency and begin decreasing land transport revenue by gathering less petrol excise duty. Raising Petrol Excise Duty would disproportionately affect less efficient motorists. This could be justified as an incentive to adopt more efficient vehicles. A more comprehensive solution is to apply Road User Charges (RUC) for all vehicles.
14. Enough investment is being put into electric vehicle research and battery capability to ensure electric vehicles will enter New Zealand eventually. The largest barriers to a fast uptake will be the high cost of vehicles and time delay due to our status as a technology taker. Economic incentives could be used by government to encourage consumers by making electric vehicles comparatively more attractive.
15. In addition to cost, the availability of charging facilities, global under-supply and range limitations will significantly inhibit the uptake of plug-in electric vehicles over the next decade. The first generation of the new

battery electric vehicles will probably have limited application in New Zealand

16. The most exciting development for the New Zealand transport fleet for the next 20 years will be plug-in electric hybrids. If affordable, high capacity in mass production will find widespread application for New Zealanders. Plug-in hybrids have the potential to significantly contribute to reducing CO₂ emissions from the transport sector if there is a large uptake of these vehicles and technology.
17. Areas of further work are identified under the headings of electricity supply considerations, understanding benefits of electric vehicles, assisting appropriate level of vehicle uptake, and supporting measures. There is a need to pre-emptively manage the problems that electric vehicles will inevitably create to enable a smooth transition when products become widely available.
18. Moving towards electric vehicles is a very attractive policy for reducing the total emissions (greenhouse and harmful) from the transport sector without restricting the mobility of New Zealanders. We still need to take care to ensure occupant safety is maintained as a priority and that the vehicles we adopt are suitable for our national transport network.

The Current State of Electric Vehicle Technologies

The global electric vehicle market is currently small due to a lack of affordable, mass produced products and a shortage of supply. Research is continually being conducted by a large number of players to improve capacity and performance.

There are three main types of Electric Vehicles both on the market and in development: hybrid electric vehicles, plug-In hybrid electric vehicles and battery electric vehicles.

Hybrid Electric Vehicles

Hybrid electric vehicles involve a conventional internal combustion engine supplemented by smaller electrical engines at low speed or when additional power is needed, such as accelerating when passing (<http://www.fueleconomy.gov/feg/hybridAnimation/hybrid/hybridoverview.html>) This allows a smaller, more efficient engine to be used whilst still supplying the requisite power, reducing total fuel consumption. New hybrids also take advantage of regenerative braking by reversing the engine direction to slow the vehicle and recharge the battery.

Hybrids have been in production since 1997 and nearly 400,000 have been sold worldwide, half of which have been sold in the United States. In the last 6 months Nissan and GM have joined Lexus, Toyota, Ford and Honda as mass producers of hybrid cars. The additional dual engine technology means that hybrid models cost considerably more than their conventional counterparts. In spite of this the market is still growing rapidly and new models will begin infiltrating the market as manufacturers begin offering a larger range of hybrid alternatives.

Based on current information available, concept diesel hybrids have been built that can achieve 25% more efficiency than petrol hybrids and are being developed by manufacturers in Japan and Europe. However, no diesel hybrids are currently in production and none are expected until at least 2010.

Plug-in Hybrid Electric Vehicles

Plug-in hybrids are the next evolution in electric vehicle technology. Essentially they operate like a conventional hybrid with an electric engine supplementing the internal combustion engine. The twist is that the electric motor can be literally “plugged in” to a wall socket to recharge the battery and the vehicle can operate independently on electric power at low speeds until charge is expended (<http://www.iags.org/pih.htm>). In this way fuel efficiency can be expanded well beyond a conventional hybrid as short trips and slow speeds are covered independently by the electric engine, removing the reliance on petrol for most daily driving.

At this stage information available indicates plug-in hybrids are not being produced by any of the major car companies but interest has been shown by

GM, Ford, DiamlcrChrysler and Renault. Independent companies are beginning to sell hybrid to plug-in hybrid conversion kits in California for around US\$10000 (<http://www.edrivesystems.com/technology.html>). Battery cost is the main cause of this high expense.

If petrol prices continue to rise then the plug-in hybrid market will expand rapidly. They provide all the benefits of reduced emissions and running costs without the limitations imposed by range. When these vehicles enter the market in numbers, overall oil consumption in private transport will fall dramatically.

Battery Electric Vehicles

Electric vehicles using lead acid batteries, able to do short distances at low speeds between recharging, have been around in the past. This photo is of electric vehicles in Christchurch, shortly after WWI (from the Alexander Turnbull Library). In more recent years the Canterbury Regional Council (ECan) was known for its plug-in car “Sparky”.



But, looking towards the future, battery electric vehicles with the latest technology are the next logical evolution from plug-in hybrids: electric engines sufficiently developed to not require a supplementary internal combustion engine. The success of these vehicles has only recently been made commercially viable through advancements in battery technology but further progress is required before they can realistically compete with conventional fuel sources.

Due to the high prices and relatively low capabilities of existing technologies many current models of electric vehicles are small, lightweight cars that are designed exclusively for limited urban operating environments. In Europe and Asia these smaller vehicles are classified as “quadricycles” and companies

such as Reva, Mega, Renault, Citroën and Peugeot are starting to produce these cars in increasing numbers.

Electric vehicles that look and operate like existing internal combustion cars do exist (Tesla (see figure below), Venturi, Phoenix) but these are expensive and are not currently being mass produced. Battery capacity advances will be the key to progressing range, power and recharge time and will be the prime factor that underpins future developments.



Battery electric Tesla Roadster. 135 miles per gallon equivalent. 250 mile range. 0-60 in 3.7 seconds. First 1000 already presold at US\$93000 and being assembled by Lotus, UK. 100 million dollar production facility to be built by 2008.

Another growth market is in electric scooters and motorcycles. They have a low maximum speed and relatively small range and do not require a license to drive. They are currently soaring in popularity in Asia with over 10 million on the roads of China and a yearly production of 500,000 in India from eight different manufacturers.

The last development that deserves mention is home conversions being undertaken by enthusiasts. Effectively they simply remove the internal combustion engine and replace it with a large number of lead acid batteries, (<http://www.eaaev.org/>). These cars do exist but not in significant numbers outside California. With our propensity to use “kiwi ingenuity” these could start arriving on our roads following large increases in petrol prices.

The Benefits of Electrification

The benefits available from transferring our fleet from oil to electricity will expand with uptake. The recently released draft New Zealand Energy Strategy (2006) reaffirms our need to reduce CO₂ emissions whilst guaranteeing our future energy security. Wholesale adoption of electric vehicles will provide gains in both these areas.

One of the primary preconceptions held about electric vehicles is that they produce fewer emissions (greenhouse - CO₂, and harmful). This is almost true. A battery electric vehicle does create zero emissions from the tailpipe and almost no noise pollution but hybrids and plug-in hybrids still produce emissions when utilising the internal combustion engine. Additional emissions are also produced when utilising non-renewable electricity.

Consumers can also benefit from electric vehicles having less running costs than internal combustion engines. The conversion of electrical energy into motive power is significantly more efficient than burning fuel in an internal combustion engine and as electricity costs significantly less than oil, the operating cost per kilometre falls to a fraction of that in a petrol car.

Arguably the largest benefit for New Zealand will be gains in energy security. As our cars progressively use more electricity our total oil consumption will fall. This means we will increasingly become less reliant on imported energy. Using transport fuels other than oil will increase our energy diversity, improve our ability to cope with fluctuations in international oil prices and significantly improve our balance of payments.

Increasing our electrification in transport should have flow-on benefits across the economy. Decreasing costs and an improved national autonomy on energy decisions should provide an increased comparative advantage for New Zealand products.

One of the reasons that electrification is tipped to advance faster than other alternatives is due to the comparatively small infrastructural requirement. Hydrogen fuel cells will require an entirely new fuel production and distribution network that imposes a barrier on uptake that electric vehicles will not have to initially deal with. Technological developments that can largely fit within the confines of our existing network will be the most accessible for consumers.

Barriers and Considerations

Although electric vehicles will provide very real benefits there are several barriers and issues to be considered before they can become a regular addition to New Zealand's vehicle fleet. No barrier is insurmountable but many require early notice and will shape the direction of future policies in this area.

1. Electricity

As electricity is needed to power these vehicles, ensuring that electricity is carefully managed is of primary importance. To ensure we have a secure and low emissions energy source for our transport sector several areas of concern need to be examined.

Demand

We first need to ensure there is sufficient capacity within the system to cope with an influx of electric vehicles. The application of electricity in commercial vehicles will be limited until battery technology can power heavy tonnage over large distances. As investment and development is almost exclusively in the light transport sector, this is where the uptake of electrics will occur first.

Fuel for the private light vehicles accounted for approximately 100 Petajoules¹ of the 224 Petajoules of our domestic transport energy consumed in 2005. As electric motors currently utilise energy approximately three times as efficiently as internal combustion engines, changing the entire private transport fleet to electricity will require approximately 30 Petajoules of electricity if all cars became electric overnight.

This is a hypothetical situation, and this many electric vehicles in New Zealand, even if desired, would not be possible by 2030. A best case scenario would be approximately one quarter of the fleet making the transition to electrics by 2030 and not all of these would be full electrics. (Hybrids are not included as they do not derive electrical power from the grid.)

In terms of electricity capacity, an extra 7-8 Petajoules of new electrical capacity would be required by the medium term (assuming vehicles are driven in materially the same manner as current internal combustion engines and not driven further to take advantage of reduced running costs). This should easily be met by natural increases in the grid capacity.

Although electricity demand is unlikely to be a major concern for the system in the next few years we should prepare for what happens when electric vehicles make up a large proportion of the fleet. The effect on transmission and distribution networks, new generation development and security of supply will all become important considerations in the longer term.

Smart metering and peak management

Although the electricity may be available, if there were large numbers of plug-in and battery electric vehicles in the fleet and every owner of an electric vehicle came home from work and charged their car, then peak capacity would come under pressure. The extra demand from these vehicles would put unnecessary strain on the system.

A system of peak management is essential for the sustainability of our electricity system. Essentially this will involve the purchase and installation of a smart meter- a device that can either read the demand on the electricity system or operate on a timer- which will constrain demand to off-peak times.

A device that can recognise when the system is peaking and shut down power accordingly will flatten out the demand curve until capacity is used up. Alternatively, a device that is limited by timer to only recharge during off-peak hours (i.e. 8pm to 8am) will also achieve a flattened demand curve, but only across the hours it is set for. Aside from peak management, these meters will charge electric vehicles during periods of off-peak pricing and ensure lower costs to consumers.

¹ Petajoule (PJ) is a unit of power which equals 10¹⁵ joule and corresponds to 31.6 million m³ of natural gas, 23 million kg of oil or 278 million kWh of electricity. It is the amount of energy used by approximately 8700 households in one year.

These systems work only until transmission capacity is saturated. It also raises issues of having our electricity network operating at full capacity 24 hours a day. Increasing our use of off-peak power will create difficulties with lines management and involves altering our power generation cycles to produce more during the night.

These issues should all be manageable. The main concern is to not increase peak demand.

Greenhouse Gas Emissions

Emissions from electric vehicles are calculated from the greenhouse gases produced from the source. If the additional demand can be absorbed by existing capacity then the calculation used to derive greenhouse gas emissions would be the average emissions across our energy sector. This is where New Zealand will have considerable comparative advantage as we get approximately 65% of our electricity production from renewables, the third highest level in the world.

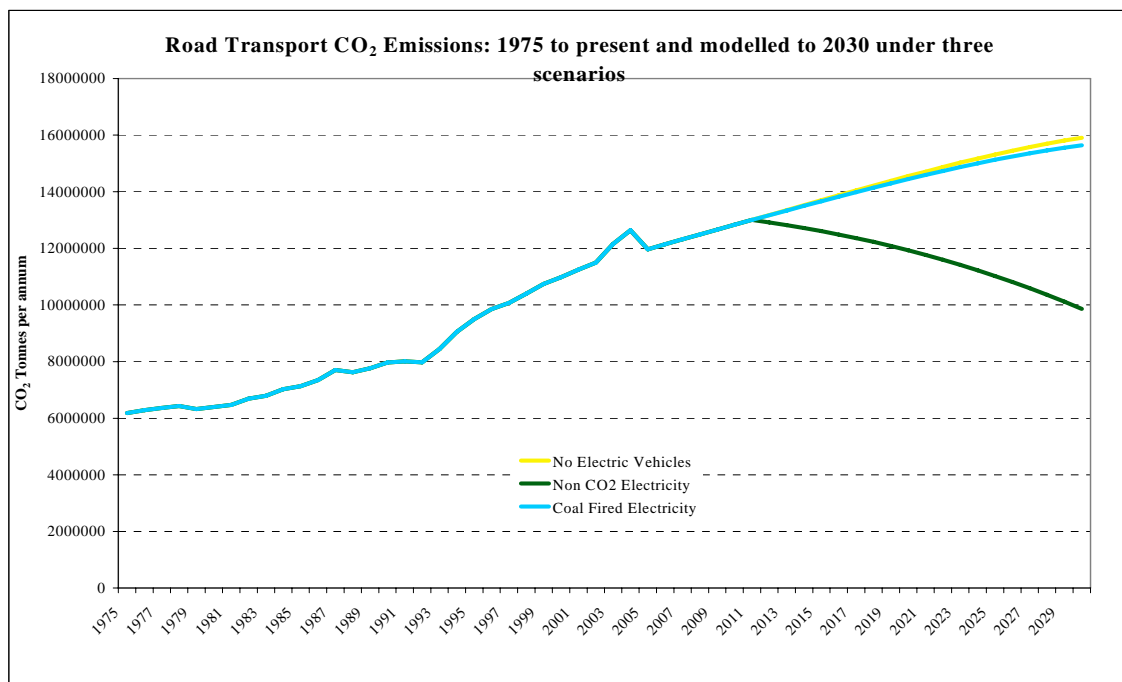
If off-peak charging is not adopted and there is good uptake of plug-in and battery electric vehicles then extra transmission capacity will be required. This marginal electricity production can dramatically alter the calculations for greenhouse gas emissions from electric vehicles.

Using fossil fuels to power the marginal electricity requirement on peak demand would begin to negate the gains afforded from an electric vehicle fleet. Initial modelling conducted by the Electricity Commission indicates that increasing off-peak electricity use will require extra thermal generation. Therefore, to support electric vehicles, effort should be made to reduce our reliance on thermal generation.

In contrast, having more renewable sources to power the grid will provide the greatest reduction in greenhouse gas emission from transport. 100% renewable electricity sources would essentially power these vehicles with zero greenhouse and harmful emissions. Another issue identified by the Electricity Commission is securing off-peak supply with intermittent renewables (e.g. wind and marine). To fully realise emissions savings, firm renewables (e.g. from hydro and geothermal) are required.

The diagram below shows the projected CO₂ emissions from road transport under these three given scenarios (graph created by the Electricity Commission and the Ministry of Economic Development).²

² The small peak at around 2004 should not be given a lot of consideration. It may be a result of bring together different modelling tools.



With an increased uptake of electric vehicles it is even more crucial to follow the draft NZES guideline to increase our proportion of renewable energy as this will provide the largest gains in emission reduction.

Summary

- *The extra electricity required to charge electric vehicles can, with some management, be expected to fall within the existing capacity of the grid*
- *Large-scale uptake of electric vehicles will need to be accompanied by an off-peak charging policy to manage peak demand*
- *Increasing our renewable sources of electricity will provide the most gains in emissions reduction but extra thermal generation may be required to power initial uptake*
- *Firm renewables, rather than intermittent sources, provide the easiest means to ensure greenhouse gas emission reductions with electric vehicles*

2. Additional Infrastructure for Charging and Maintenance

The necessary infrastructure to support a fleet of electric vehicles is educated speculation. No large fleets currently exist. The best case studies can be found in California and central London where electrification of the fleet is being actively encouraged. Although both these locations are not overly analogous with New Zealand, monitoring their infrastructural needs will be increasingly useful to pre-empt barriers, opportunities and costing.

Service Industry

The technology that powers electric vehicles is revolutionary. The skills required to service and maintain a fleet of these vehicles are different from those currently held by mechanics and auto-electricians. To encourage the rapid uptake of electric vehicle technology we need to begin considering the support network an electrified fleet will require and ensure it has sufficient coverage to not overly limit the geographic dispersal of the vehicles. Subsidies may be needed to create the necessary training programs and ensure that students will attend them. Conferring with the Motor Trade Association (MTA) will be necessary to take advantage of their industry experience.

Public Infrastructure

Various issues surround the infrastructure required to allow people to charge their vehicles in public. Initial research indicates that the physical cost of the technology is expensive, especially high voltage facilities that dramatically reduce charging time.

Having outlets for use by the public also creates questions of costing how a consumer can pay for the electricity consumed. Open access to high voltage sockets in public places also raises health and safety concerns that need to be addressed. Equitable questions of funding and location will need answering, particularly if charging stations will be placed to allow longer journeys.

Existing infrastructural nodes such as petrol stations could continue to play a large, if somewhat altered position in the future. Existing accessibility and distribution could mean that these are an ideal starting point. Oil displacement will eventually get to a level where petrol stations will be either obsolete or diversified. Charging facilities for electric motorists may work out as a mutually beneficial option for all stakeholders involved.

As electric vehicles will have sufficient range for daily operation without public charging facilities this is by no means a pressing issue. California, London, Tokyo and other fast adopting regions will confront the issue first and ensure there will be no need to reinvent the wheel. A more thorough assessment should be undertaken after uptake begins in earnest.

Summary

- *Attention should be given to the technical expertise required to support a fleet of electric vehicles*
- *Creating public charging infrastructure will need considerable consideration and New Zealand should watch international developments from electric vehicle hotspots*

3. First Generation new Battery Electric Vehicles

There are currently a number of battery electric vehicles on the market that can drive on our roads immediately. Although manufactured in small quantities at high cost they are already available for purchase (e.g. the Tesla). However there is an even larger number of cheaper, smaller, low speed, low range, and light weight electric vehicles beginning more serious production. They are creating an emerging market in Europe and Asia and are collectively known as quadricycles.



This model of vehicle includes the Reva³ G-Wiz. They are soaring in popularity in London and are a representation of the new face of quadricycle vehicles. This vehicles retails for £8299 (\$NZ24,000).

Quadricycles are not designed to meet the same safety standards of a regular light passenger car.

This is because they are specifically designed for use in restricted operating environments with narrow streets or dense, slow moving traffic.

The European Union and Asia have adopted a new quadricycle classification because they have medieval old cities with narrow roads that prohibit full-sized cars and trucks and massive cities plagued with traffic congestion. Tokyo actively encourages the use of quadricycles in the city centre as a tool to reduce air pollution.

The New Zealand vehicle classification system does not currently allow these vehicles to operate on our roads. In order to legally operate these urban-purposed vehicles require a new quadricycle classification to allow them to be registered. The main issue is whether the New Zealand environment is appropriate for quadricycles.

Should we allow Quadricycle-style vehicles on our roads?

Our current vehicle classifications make no discrimination on power source. The classifications and associated rules for safety are solely designed to reduce the likelihood of a vehicle being involved in a crash and protect the occupants in the event of a crash. As New Zealand does not have vehicle manufacturing or assembly industries, nor require purpose made vehicles, our safety standards are taken directly from the jurisdictions we buy our vehicles from.

The European Union and Asian quadricycle standards do not contain provisions for Frontal Impact or seatbelt anchorages. These are vitally

³ Reva is an emerging manufacturer based out of India that is starting an international distribution network. The Ministry of Transport has already been approached by prospective importers of Reva vehicles.

important for crashes with large vehicles at any speed. As trucks can effectively travel on almost any section of New Zealand roads we do not have areas where quadricycles could be exclusively safe from a frontal collision with a heavy truck or even an SUV. Most New Zealand centres also contain higher speed areas within the city limits, with both Auckland and Wellington having motorways in immediate proximity of the city centre. Effectively there is not an easy way to fence off a similar operating environment for quadricycles in this country.

In terms of fulfilling a niche, we already have small vehicles with low harmful emissions and excellent fuel economy (MCC Smart Car, Mercedes A-Class etc). These vehicles provide the same mobility advantages as quadricycles and also meet Frontal Impact standards. They fit within our MA passenger car classification (less than 3.5 tonnes, less than 9 seats including driver) and suit New Zealand road conditions.

It should be noted that designing a vehicle that does not have to pass Frontal Impact tests is significantly cheaper for the manufacturer. Lower production costs are a large reason these vehicles are made to a lesser standard.

The main benefits from quadricycles are reduced running costs and emissions improvements. As the first generation of these vehicles will have limited application in New Zealand the total emissions savings from the quadricycle sector are likely to be marginal at best. An assessment from a whole-of-vehicle-life perspective with equivalent MA classifiable models would be useful to quantify specific emissions gains. Also, there may be circumstances where zero emission electric vehicles are particularly useful, for example in areas with air pollution problems.

The draft New Zealand Energy Strategy (NZES) states that New Zealand should become a fast adopter of alternative fuel technology once it becomes economically viable. A blanket adoption of quadricycles as a quick fix now may create unforeseen and potentially harmful consequences in the longer term. This paper recognises the complexity of the issue and the need for a deeper inquiry into the benefits adopting a quadricycle classification could provide.

Summary

- *Quadricycles are an emerging battery electric vehicle designed for specific operating environments in Europe and Asia*
- *Quadricycles are not designed to meet Frontal Impact standards and to register them here would involve creating a new vehicle classification and relaxing our current safety standards*
- *New Zealand is a unique transport environment and purpose-built quadricycles may find little or no application on our existing roads*
- *The limited application of quadricycles means the emission reductions they could provide would be negligible. This has to be balanced against the practical consequences of having these vehicles on our roads.*

4. Creating a “Quadricycle” Classification in New Zealand

If we do decide to allow quadricycles on our roads then we would need to examine the possible format a new classification could take. A literature review of other jurisdictions regulations is useful for assessing possible options.

Maintaining the Status Quo

Creating a vehicle classification without a Frontal Impact standard should not be casually adopted and the first alternative is to continue preventing vehicles entering the fleet that are not MA certifiable⁴. The issue with this approach is that it will prolong uptake until the technological setbacks of battery weight, cost and charging are overcome.

Even having small numbers of battery electric vehicles on our roads with specific operating restrictions could start to gather public support for alternative fuels. The value of this perception is worthwhile in and of itself.

Possible Operational Restrictions

The next option is to change the Land Transport Rules and allow purpose-built quadricycle-style battery electric vehicles to drive on our roads in a limited capacity. There are two main models internationally.

North America has developed a policy called Limited Speed Vehicles. A classification is given to these vehicles by size and weight that limits them to 30mph (50kph) speed limit zones. This effectively restricts the use of the vehicles to short trips on urban roads. It also nullifies the argument that battery electric vehicles would slow traffic flow as they are prohibited from driving on higher speed roads.

Europe has had a long tradition of urban-purpose vehicles on their roads. European Commission Directive 2002/24/EC creates the precedent quadricycle class. Quadricycles are vehicles that are under 400kg (not including batteries) and 15KW and have a limited maximum operating speed. This model is also adopted and modified in Asia. India has the highest threshold of 800kg, 15KW and 72.5kph.

⁴ The MA certification is for passenger vehicles with less than nine seats. The MA certification has a strict requirement for vehicles to pass a minimum Frontal Impact standard. Any electric vehicle that meets the MA criteria can be driven on all New Zealand roads immediately.

Relevant Considerations

If we chose to allow these “quadricycles” on our roads then we will have to decide whether they are limited by speed, class or a new category specific to geographical area. Creating the classification would also allow the entry of quadricycles with internal combustion engines, unless there was a specific requirement specifying the mode of power.

In reality a new classification will have two aspects. The first is fairly straightforward: adopting a set of specifications that will identify a quadricycle as being a separate entity from an MA passenger car. This should be achievable by reviewing the models available and the classifications of countries that allow quadricycles on their roads.

The second aspect is trickier and will have to reflect the unique situation of New Zealand. This will be the corresponding law that refers to the category created and then imposes enforceable limitations on the operating conditions when the vehicle is on the road. Unlike mopeds, which are very distinctive making enforcement of their restricted operating environment relatively easy, small light electric passenger vehicles like the Reva resemble vehicles that do meet Frontal Impact standards and are allowed on all roads.

These two components together will be required before quadricycles can drive on New Zealand roads.

A reduced operating environment, in theory, restricts the amount of damage that can be done in the event of an accident. However the issue that occurs in New Zealand is that the main markets for these vehicles will be Auckland and Wellington that both have motorways inside and leading into the city. Aside from speed, our urban roads also allow trucks and SUVs that would render a quadricycle helpless in a crash at any speed. The scope of uptake for these cars could inadvertently become absurdly finite. Finding a final balance of operating environment will include numerous factors and take a significant amount of consideration.



It should be noted that the MA passenger car classification is not the only way to register light vehicles. The NA category⁵ in the Land Transport Rules does not require a vehicle to meet frontal impact standards. The French motor company MEGA has recently been successful in entry certifying its commercial vehicles in

⁵ The NA category of the Land Transport rules is for light goods vehicles with a gross mass of less than 3.5 tonnes.

New Zealand in the NA category with an exemption (for seat anchorages) from the Director of Land Transport. The two models of MEGA vehicle exempted from seat anchorage certification are now legally allowed to drive on New Zealand roads. Because these vehicles now meet the requirements of an existing class no operating restrictions are imposed.

It is essential to take into account that there are several readily available, low emissions, MA classified alternatives in the market sector that quadricycles would enter. It may also be the case that the current evolution of vehicles would have a severely marginalised operating environment to what they are designed for. The benefits of allowing these vehicles on our roads are only provided from oil displacement. Quadricycles will certainly help to achieve reducing greenhouse gas emissions from the transport sector but they are by no means the only way to create a cleaner fleet. Extra investigation is needed before a policy decision to adopt quadricycles is made.

Summary

- *A valid option exists to not create a new classification to allow quadricycle style vehicles to enter our fleet on safety grounds*
- *Some existing battery electric vehicles are certifiable on New Zealand roads as either MA passenger cars or NA classified light commercial vehicles*
- *A new classification should only be considered if it is coupled with practical limitations on the operating environment of these vehicles*
- *Limitations imposed will have to incorporate the unique transport situation present in New Zealand*
- *Extra investigation to more fully identify alternatives, assess risks and quantify possible benefits is required*

5. Battery Disposal

The assumption that electric vehicles will help meet environmental objectives is sound but the issue of battery disposal still needs to be considered.

Lead-Acid batteries are supposedly 97-98% recyclable and we already have the facilities in New Zealand to do so (Exide Petone and USA recyclers). If Lead Acid batteries are adopted for mass production we have adequate infrastructure to deal with their recycling. Recyclers will view the increased supply of batteries as good business.

Most advancement is being made with Lithium Ion batteries. They are lighter, have over double the life span and 4 times the charge of Lead Acid batteries. Lithium Ion batteries will most likely be used to power a future electric fleet.

There are currently several international companies investigating Li-Ion recycling (Toxico, AEA, Umicore <http://www.batteryrecycling.umicore.com/batteryRecycling>). Batteries required to charge an electric vehicle are large and heavy to provide power and range. When battery electric vehicles become a significant component of the fleet

these batteries could release large quantities of toxic heavy metals when disposed, with potentially devastating environmental impact.

Due to the value of the components (Cobalt, Nickel, Manganese) it may be commercially lucrative to recycle these batteries and costs will only fall as larger batteries provide larger gains from the same recycling process.

As electric vehicles are an emerging industry it may be possible to tackle the issue head on and transfer responsibility of battery disposal to manufacturers or importers upon purchase. The Ministry for the Environment rates the issue of battery disposal as a consideration rather than an obstacle and this is a fairly succinct summary. Battery disposal is definitely controllable with designed management.

Summary

- *Large amounts of potentially toxic batteries will need safe disposal at the end of a vehicles life*
- *There is an opportunity for a battery recycling industry to emerge*
- *Battery disposal will be a consideration rather than an obstacle*

6. Revenue Collection for Land Transport

One of the more technical issues surrounding electric vehicles is how they can be appropriately and equitably charged for the transport network they utilise. Electric vehicles use energy in an unprecedented manner that is not compatible with our current revenue collection system. If electric vehicles (hybrid, plug-in hybrid and battery electric) are going to make up a significant component of our transport fleet we may need to change the way we collect revenue for land transport infrastructure in the future.

Our existing system of revenue collection for land transport is different for petrol and diesel vehicles. For petrol, an excise duty is levied for every litre sold. Petrol Excise Duty is extremely efficient, easy to administrate and guarantees a steady flow of incoming funds. Excise duty is not applied to diesel because 35% of diesel is not used in the transport sector. Instead a paper-based distance charging system called Road User Charge (RUC) collects revenue based on how far a vehicle has travelled.

Industrial and off-road use of diesel has meant a single method of revenue collection for land transport has not been applied. Effectively we have two separate revenue gathering systems based on either mileage or fuel consumption. The introduction of significant numbers of electric vehicles means our current system will be put under pressure.

Two possible options forward exist: prohibit vehicles that do not fit the system or reform the system to allow them to fit. Prohibiting vehicles on the basis that they complicate our revenue collection system is not particularly viable. New Zealand is a technology taker and banning vehicles will leave us even further behind the rest of the world. Compensating an increasing revenue deficit by

continually raising the level of Petrol Excise Duty is simple but relatively blunt and unresponsive.

A more comprehensive answer would be a new system of revenue collection for land transport that has a blanket application across the entire transport sector. The form this system could take is an immense but necessary area of work in the future.

Hybrid Vehicles

The petrol hybrid vehicles already on our roads (estimate 1300) are the main cause of the concerns. Diesel hybrids should be treated differently because they could fit directly into the existing RUC system. The problem is caused by the current petrol hybrids that use less fuel to travel further on increased fuel efficiency. As transport infrastructure is funded from an excise duty on fuel, effectively they are paying disproportionately less than comparative road users. As the number of hybrids on our roads increases, revenue collection for transport infrastructure could fall without some form of excise increase or intervention.

Plug-In Hybrid Vehicles

Plug-in hybrids are yet another complication. The current RUC system says that any vehicle that is not wholly petrol powered should be placed on RUC. The dual use of petrol and electricity in plug-in hybrids achieves this but putting it on RUC and also paying Petrol Excise Duty on the fuel it consumes would charge the vehicle twice. The introduction of petrol plug-in hybrids would require a system to refund Petrol Excise Duty, or an alternative solution.

Battery Electric Vehicles

As battery electric vehicles consume no petrol there is no issue of double taxation. Supposing no transport taxes are placed on electricity, battery electric vehicles can be placed on RUC immediately upon registration.

The Interim

Although it would be easy enough to put diesel hybrid variants and battery electrics onto a RUC system, placing any type of hybrid that uses petrol on RUC would essentially tax them twice. Theoretically a system could be designed whereby these vehicles paid RUC and the total petrol used was estimated. There would then be a rebate for the NLTF portion of Petrol Excise Duty. The administration would be technical and somewhat costly but the largest set back is that the final rebate could be an estimate. Initial research suggests that claims could be checked by comparing litres consumed with vehicle mileage.

The interim is obviously the hardest aspect of the system to control. The number of petrol hybrids on our roads is not pressing enough to require

immediate change. However, as the uptake of petrol hybrid variants increases, revenue could fall until it can no longer fund land transport infrastructure. Either this revenue loss is written off as a justification for carbon abatement or some measure of solution needs to be found.

A Full Distance Based Charging (RUC) Regime

The need to address the deficit in land transport revenue will force action in some direction. Planning possible changes before the system reaches breaking point is the logical next step.

One of the alternatives could be applying the RUC system used for diesel vehicles over all road users. It would be necessary to reduce Petrol Excise Duty and possibly adjust RUC levels to guarantee a set level of revenue but a full RUC system would solve the difficulties created by electric vehicles. Applying RUC rates to all vehicles within the fleet would also ease a transition to electronic distance charging and road pricing that could solve many problems further into our transport future. RUC is also more expensive to administer than the collection of revenue through Petrol Excise Duty.

A set back to adopting a blanket RUC will be the loss of the 18.708c per litre also attached to petrol that goes into the Crown account to help with the negative externalities associated with roading such as social, and public health costs. The cost of the negative externalities associated with roads could be factored into the calculations of an electronic RUC system.

The other important component of a revenue collection system is being able to distinguish between vehicle types. We can currently distinguish between vehicles that use petrol or diesel but there is no registration criterion for engine type. Although this is a moot point if an electronic RUC system was adopted, it is essential to regulate plug-in hybrids and battery electrics in the short-medium term. At the very least it would be useful for statistical purposes and providing a more comprehensive knowledge of the vehicle fleet.

Summary

- *Increasing petrol displacement through improved fuel efficiency could without any intervention decrease land transport revenue and create equity discrepancies*
- *Diesel electric hybrids and battery electric vehicles can be incorporated into the RUC system*
- *An additional registration classification is required to identify vehicles by engine type*
- *The problems created by petrol electric hybrid variants could be solved by swapping to an electronic RUC/distance charging system and reducing Petrol Excise Duty, but there will be costs associated with such as change (including for administration).*

7. Incentives to Encourage the Uptake of Electric Vehicles

One of the largest setbacks to the fast uptake of electric vehicles will be high price tags. Although the market will eventually offer a product that is more accessible to consumers, there are simply too many alternatives available. If we want to encourage the uptake of electric vehicles then some measure of incentive package is required from government to make electric vehicles comparatively more attractive.

Many countries internationally are using incentives for low/zero emissions vehicles as an aspect of their wider climate change policies. As such, there is a raft of precedent that can be examined if New Zealand chooses to adopt incentives to encourage the uptake of electric vehicles.

A common incentive is to decrease the purchasing price of new battery electric vehicles to make them more attractive to consumers. California, Japan and France all offer tax rebates or end user subsidies for the purchase of battery electric vehicles at up to US\$4000 (NZ\$5700), US\$2600 (NZ\$3700) and €3200 (NZ\$6000) respectively. Monaco currently offers the highest rebate of 30% of the purchase price of a battery electric vehicle. The UK, Norway and Italy all offer electric vehicles exemption from sales tax.

Some countries lead by example and use electric vehicles in government and municipal fleets. Famous examples can be seen in English milk trolleys and Italian Rubbish Collectors. France has imposed a minimum 20 percent of public transport to be electric and California has passed air quality regulations that require a minimum percentage of the government fleet to be below a specified “low [harmful] emissions” target. Fleet procurement policy is a powerful market influence and our Govt³ fleet assessment could look to electric vehicles where price and purpose render them appropriate.

The last raft of incentives aims to decrease the daily operating costs of these vehicles. These measures are most effective in dense urban areas with congestion issues. Examples of this are free or preferential parking in some cities in the United States, United Kingdom, Switzerland, Germany, Austria and France. London offers exemption from congestion charges and road taxes, Norway lets electric vehicles drive on designated bus lanes, Italy offers substantial insurance subsidies and France offers tax-free charging. Both France and the United Kingdom also offer 100% depreciation for businesses.

Any financial incentives adopted by New Zealand should be chosen to relate to specific objectives. For our purposes, electric vehicles align with our climate change policy to reduce oil consumption and decrease CO₂ emissions from the transport sector. Most countries that introduce electric vehicle incentives do so to tackle specific air quality and traffic congestion problems. As these issues are not a pressing concern for us outside of Auckland, it may be that market uptake will be sufficient, with no extra need for electric vehicle demand incentives in this country.

As these vehicles require new production facilities, there may be an opportunity to partner with industry and incentivise a local manufacturing industry for electric vehicles. This would be a new development for New Zealand, but it is not unimaginable. An electric vehicle plant would be a major endeavour and contains both numerous advantages and setbacks.

Summary

- *Financial incentives can be used by government to encourage the uptake of electric vehicles*
- *Most international precedent for electric vehicle incentives are designed to help alleviate specific air quality and traffic congestion problems*
- *Market forces may be sufficient to warrant no extra demand incentive measures in New Zealand*
- *An opportunity could exist for government to partner with industry and incentivise the construction of a local manufacturing industry*

8. Additional Limitations on Electric Vehicle Uptake

New Zealand has several extra limitations to restrict the uptake of electric vehicles that should be noted in calculations to project the changing profile of the fleet in the short, medium and long terms.

Cost

These vehicles will be expensive. Buying a new car is already financially beyond many and electric vehicles are not at the low end of the cost scale. A new Toyota Corolla costs \$29,990 but to upgrade to the Prius CVT Hybrid costs \$43,650. An additional Plug-in conversion, currently only performed in California, costs an extra US\$10,000 (NZ\$14300). Buying a purpose-built urban quadricycle is no cheaper with the Reva G-Wiz AC retailing for £8299 (NZ\$24,000). This is the bottom of the battery electric price range with the high end Venturi Fetish sports car carrying a €450,000 (NZ\$850,000) price tag.

Unless prices fall dramatically or second hand Japanese imports start appearing, the current generation of vehicles is simply too expensive to allow a widespread uptake.

Charging Capability

Without public charging infrastructure, these vehicles are only available to people with access to a closed garage with internal power sockets. Households without garaging will be practically barred from obtaining electric vehicle technology.

Availability

New Zealand is a relatively insignificant player on the global new car market and our small demand will not gain us access to an immediate supply of new electric vehicles. Limited worldwide electric vehicle supply, including hybrids, will make it difficult for us to obtain these cars in large numbers.

Range of Battery Electric Vehicles

New Zealand is a very geographically spread out country with most trips covering relatively large distances (e.g. equating to an expected vehicle range of 150-200 kms). Current technology limits battery electric vehicles to short trips and this mechanically bars our rural population and those living in distant suburbs and lifestyle blocks. Initial uptake will be limited to applications within the city limits of our main centres.

Summary

- *Cost, charging facilities, global supply and range limitations will significantly inhibit the uptake of electric vehicles over the next decade*
- *The current generation of battery electric vehicles will have limited application in New Zealand*

Conclusions: Electric Vehicles and New Zealand

Research and development has now progressed to the extent that electric vehicles are a viable reality. It is all but inevitable that they will eventually enter our fleet with sufficient product advancement and adequate market pressure.

The numerous benefits of electric vehicles have been well recognised by the government. It is now a publicly stated intention that electric vehicles should become an important component of the private transport system in the near future (draft NZES, page 34).

This document creates two distinct directions that electric vehicle policy should progress towards achieving. The first is how to reduce the present barriers and encourage a faster uptake. The second is how to pre-emptively manage the problems that having an electric vehicle fleet will inevitably create.

Barriers and Incentives

Contrary to common perception, there are no physical barriers currently restricting the entry of electric vehicles onto New Zealand roads. Providing the vehicle is fully safety compliant it can register and begin driving immediately. Confusion has been caused by specifically built urban electric passenger vehicles (quadricycles) used extensively across Europe and Asia but these vehicles are designed for very limited operating environments that are not

directly compatible with the New Zealand roading network. They are currently prohibited from entry because they do not pass minimum safety requirements. Choosing to allow these vehicles on our roads will come at the expense of our safety standards and the removal of this particular barrier may not be in the best interest of New Zealand citizens.

Two more barriers will limit uptake in the short term: vehicle servicing and cost. Work will have to be undertaken to ensure that adequate servicing and repair infrastructure exists to support an electric fleet and not limit uptake to confined service areas.

Although servicing should be relatively easy enough to overcome, addressing vehicle cost is considerably more difficult. The main benefits to consumers will be reduced running costs and the green benefit associated with producing less emissions. These benefits come with an expensive price tag until a mass produced product is readily available. Even so, they will still be the price of a new car until a second hand market can establish itself. A raft of incentive measures may be needed to facilitate uptake.

Extra issues surround how to convince New Zealanders of the environmental benefits provided from electric vehicles and how to manage volatile demand responses that would eventuate with a volatile oil price. The limited range of electric vehicles will also ensure use is limited to urban centres for the first few vehicle generations of battery electrics.

The preliminary conclusion is that present barriers are not insurmountable. The importance that price will have on restricting uptake should not be underestimated and future policy should incorporate this. If uptake is to be assisted then electric vehicles need to become comparatively more attractive.

Managing Future Considerations

Today's electric vehicles use technology that has evolved outside previous vehicle parameters. The other aspect of electric vehicle policy will be to manage the compatibility difficulties that electric vehicles will create.

The single largest problem is caused when attempting to charge electric vehicles equitably for the roading infrastructure they utilise. Hybrids and plug-in hybrids achieve more fuel efficiency than conventional petrol engines and as such pay equivalently less in Petrol Excise Duty. This may prompt a suitable time to apply an electronic distance based charging/RUC regime for all vehicles. (As noted in the draft New Zealand Energy Strategy, the increasing fuel economy of vehicles generally, not just hybrid electrics, supports the need to consider adapting our current charging regime.)

The other major issue concerns peak electricity demand. There is sufficient electricity available for recharging if it is utilised at off-peak times during the night but anytime charging will place pressure on peak demand. Coupled with electricity demand from transport (plug-in hybrids and battery electrics) a system of peak demand management is required.

Although all of the problems caused by electric vehicles will be exacerbated with uptake, the problems associated with peak electricity demand and income for land transport infrastructure need to be pre-emptively tackled to mitigate problems before they occur. Additional issues of battery disposal and possible infrastructural requirements are considerably more reactive and do not demand such urgent attention.

Conclusion

The benefits provided from electric vehicles are superbly suited to New Zealand. Adopting electric vehicles will gradually remove our dependence on imported oil and allow us to take advantage of our natural endowment of renewable electricity more efficiently. Running costs to consumers will fall, national production of CO₂ emissions will potentially reduce dramatically and the air quality in major centres will improve. Combined with a relatively small requirement of supporting infrastructure, electric vehicles are a very attractive means of supporting a pathway to a “low-carbon”, sustainable energy future in New Zealand.

The government has a role to play. Although the wheels have been set in motion sufficiently that electric vehicles will reach the market en masse eventually, action is required to speed up and smooth this transitional period.

New Zealand is now presented with a unique opportunity to dictate the terms of arrival of electric vehicle technology and we should use this to maximise potential benefits and mitigate future problems. This paper has attempted to identify the main considerations electric vehicles will create in advance. The current climate of political support and international focus on climate change and energy security is likely to keep electric vehicles on the agenda and facilitate a fast and appropriate uptake.

This paper investigated electric vehicles that will enter the light fleet. There are opportunities to further develop use of electricity by heavy road vehicles (building on the Wellington electric trolley buses, and Christchurch’s small number of inner city electric buses), but these are not covered here. It should be noted, however, that a number of matters covered in this report (such as electricity supply capacity, battery disposal) are directly applicable to both.

Predicting Uptake

This last section is a rough outline of how uptake will pan out. Taking into account our current knowledge level, some semblance of how electric vehicles will enter the fleet can be estimated.

Research from industry to improve electric vehicles capacity will continue. Parallel research will continue to be undertaken into the commercial viability of other alternative fuels but hybrids already hold a strong presence and plug-in hybrids and battery electric vehicles should be the first mass produced

alternatively fuelled vehicles on the market. The relative lack of infrastructural requirements, zero emissions and cheap running costs should continue to gather strong political backing internationally.

Improvements in clean, super-efficient diesels will continue but so too will an increasingly large range of hybrids (and diesel hybrids) and these will become more attractive to consumers as oil prices continue to rise.

Consumer demand will drive growth in electric plug-ins until they capture a large market segment. The ability to run on electric power for daily driving, coupled with the conventional internal combustion when required is an important stepping stone for the electric vehicle market. As battery development allows a greater daily driving range, oil consumption will reduce dramatically. Plug-ins could potentially be the most important development in the history of personal motoring. However, uptake will depend on manufacturers being able to develop market-friendly products.

Full battery electrics will develop in tandem, with mass produced models entering the market within the next five years. Growth will follow battery technology and improvements will directly lead to increased vehicle performance. It is important to note that the first generation of new battery electrics in the form of “quadricycles” will be fit for purpose and have extremely limited application outside of urban areas. Reliable battery electric heavy trucks should not be expected before 2030.

Where to From Here?

This paper has merely identified the major issues. The next step is to extrapolate these further to begin making some stronger policy decisions on required actions. Pre-emptively undertaking this work before electric vehicles arrive on mass will mitigate future problems and maximise potential benefits.

Further work is required in the following areas:

1. Electricity Supply:
 - Modelling uptake scenarios on potential impact to the electricity sector
 - Identifying methods of managing peak electricity demand
 - Calculating and costing the associated infrastructural requirements

2. Understanding Benefits
 - Quantifying gains in air quality, reduction in CO₂ emissions and oil displacement
 - Assessing the possible implications of electric vehicles for Auckland – noting its air quality problem and urban motorway network, as well as its status as New Zealand’s largest metropolitan area.

3. Assisting Appropriate Uptake- Demand

- Assessing the role of electric vehicles in government procurement policy
- Making a formal decision on how to manage quadricycle style electric vehicles
- Examining possible initiatives to further encourage consumer demand

4. Necessary Supporting Measures

- Identifying the future servicing requirements of an electric vehicle fleet
- Finding solutions to the impending reduction in revenue for land transport infrastructure
- Investigating the issues surrounding the disposal of large volumes of Lithium Ion batteries

It is recommended that a work program is established to formulate an electric vehicle policy that will remove barriers and encourage uptake. This work can be coordinated by the Ministry of Transport.