Submission No 6

NON-REGISTERED MOTORISED VEHICLES

Name: Mr Mark Walker

Date Received: 10/03/2013

Mr Greg Aplin MP
Chair
Joint Standing Committee on Road Safety
NSW Parliament 10/03/2013

Re: Inquiry into Non-registered motorised vehicles

Dear Sir

Upon becoming aware of the Committee's Inquiry via an advertisement calling for submissions in the SMH (9-10 Mar 2013), I resolved to make the Committee aware of my concerns in this regard.

As I understand it from current road and vehicle regulations:
- Mobility scooters are not allowed to travel on public roads, are limited to 10km/h and 110kg unladen mass, but otherwise are not regulated
- Electrically-assisted pedal-powered bicycles (ADR category AB) are limited to 200W motors, but are otherwise unregulated
- ICE-assisted* pedal-powered bicycles are limited to 50cc capacity, must comply with certain noise limits, but are otherwise unregulated
- Segways are currently banned
- Mopeds (being motorised pedal-assist cycles) must be registered as for 'motorcycles' whether electric or ICE-powered
- Quad bikes, pitbikes and other similar small-capacity motorised vehicles (like buggys) are restricted to 'offroad recreational vehicle' licensing for use in designated areas (such as Stockton Beach) but are otherwise unable to be registered or driven on roads and in public areas due to non-compliance with ADRs.

** ICE – Internal Combustion Engine*

As the Committee's focus in its terms of reference is 'usage' and 'impact on road safety' perhaps the latter needs to be clarified, especially in regard to those vehicles specifically designed and only 'allowed' to be used 'off-road'. Road safety measures, implicitly, apply 'on-road' – not off-road.

For example, as observed above, the use of non-registerable ICE-powered vehicles is currently prohibited in public areas – yet clearly they are being sold, and equally clearly, not always used solely "on private property", hence the inquiry.

So perhaps the Committee needs to focus on 'usage' first, and worry about the need for any regulation later? Specifically regarding the impact of injuries caused by such usage.

Get the data first, make that public, and then call for submissions based on the data, rather than calling for submissions based on speculation or 'opinion' alone.

How many are being sold, where are they being used, what accidents and injuries are ocurring as a result of that usage, and is that sufficiently concerning to warrant additional regulation such as CTP insurance, and how might that be implemented efficiently and effectively.

Having said that, I will now submit my views on what I feel is necessary and why it should be so. Since you did ask for it. ☺

[redacted]

[redacted]

[redacted]

EXECUTIVE SUMMARY

While it is clear from the terms of reference that the Staysafe Committee is attempting to focus on un-registered vehicles, it is clear that part of that debate must include the possibility of registration, and perhaps the provision of CTP insurance – of some kind – for some vehicles which are currently neither registered nor insured.

This further raises the question of vehicles which perhaps ought to be able to be registered, but are effectively prevented from such by the excessively expensive demands of full ADR compliance testing.

My conclusion from the research I have seen is that mobility scooters should remain unregistered, but it might be desirable to have some form of CTP insurance – but only if this can be proven to be essential as a result of accident and injury data – and if so, should include the rider/driver, not just 3rd Parties.

E-bike regulations should be changed such that the regulation is on the maximum speed under power, rather than the maximum motor power capacity, as the current 200W power limit is ludicrously low, and not in step with similar regulations around the world.

E-mopeds should be a separately regulated category to ICE-mopeds, thus enabling them to be marketed and used more widely. This should be coupled with a lesser licensing regime and lower registration regime to encourage uptake. Again, they should be speed limited, but also have a maximum power limit to prevent hoons from exploiting a loophole that might otherwise exist.

ICE-motor-assisted bicycles should be banned. They supply nothing but negative inputs into the community, in the form of noise, emissions and safety concerns – especially as it is impossible to determine the actual capacity of the motor without disassembly, virtually encouraging ‘overpowering’ and rorting by the type of bogans who go in for that sort of thing.

There is currently no registration category for Neighbourhood Electric Vehicles, but if we are going to re-visit the whole registration and licensing question, this is definitely an area that requires serious and calculated attention.

It’s clear that small, light weight, low-powered NEVs will struggle to meet many of the crash-test ADRs – yet they are no more, and perhaps when speed-limited, even less ‘dangerous’ from a safety aspect than most high-speed motorcycles.

As has been determined elsewhere in the world, exemptions from the more onerous ADRs are necessary to encourage such clearly environmentally-beneficial vehicles to replace ICE vehicles, at least in low-speed urban environments.

REPORT

Mobility scooters

These are rising in numbers on footpaths and public spaces as our population ages and greater numbers of older people feel the need for mobility assistance, especially those who can no longer legally drive a registered vehicle.

As they must drive on footpaths, in shopping malls and other public spaces, they cannot be registered, as registered vehicles cannot (currently) drive in these places.

However, there are plenty of places, especially in regional areas, where footpaths do not exist, or are on the wrong side of the street, or are so rough they cannot be traversed safely. In these circumstances, mobility scooter users often take to the street, which currently they are not legally allowed to do.

But they should be ‘allowed’ to do so. Such provision must be added to the existing legislation.

They must of course comply with road rules, use hand signals to indicate intentions – or perhaps mandate they all should have electrically operated turn signals and brake lights..??

But otherwise, no registration cost, test or fees. Pensioners simply can’t afford it. And the electoral backlash wouldn’t be worth the pain. Unless it can be proven that they are causing serious accidents that are creating a burden on the health system.

If so, perhaps a new body needs to be established which could ‘manage’ such claims for insurance, funds for which could be incorporated into a single charge at point of sale. Such would provide peace of mind for users also.

Electric bikes

This category would seem to be covered under the existing ADRs and road traffic regs as “electric-assist pedal cycles” with a power limit of 200W.

However it is equally clear from the debate in the EV community that the mandated maximum power figure is utterly inadequate for all but the flattest of suburbs, and the question which has not been adequately debated (but which exists under the terms of reference for this inquiry) is the “speed control” aspect.

Speed is a function of power, mass and gearing.

Limiting the speed rather than the power is a far better way to provide alternative-powered transport. As a …ahem…larger person, an E-bike limited to a 200W motor cannot move my fat arse other than on a flat, level, footpath, and then only dangerously slowly, incurring the ‘death-wobbles’, making such an effort more, rather than less, dangerous.

The same E-bike fitted with a 600W motor but speed-limited to 30km/hr would be able to shift my substantial frame, and carry a bit of shopping back from the supermarket, and thus open up an alternative to my ICE-powered car, which can only be good for the environment.

That I'd still have to do *some* pedalling would probably be of benefit to my health and girth, as I currently cannot ride a non-assisted pushbike any further than about 500m without running out of energy.

So in terms of 'safety', the bike with me on it is not going to break any speed records (in point of fact, my non-assisted pushbike with me on it is capable of 50km/hr – downhill and with a tail wind behind me), so even with a 30km/h speed limited electric-assist motor, I'd still struggle to achieve the speeds most racing bike owners attain in 'normal' no-power-assisted use, even when I'd be operating under motor-only propulsion.

So which of the two is 'safer'? The lycra-clad racer flying down Arden Street, Coogee at 60km/h? Or the health-challenged E-bike rider struggling to achieve 40km/h, even with the power-assist???

I can almost guarantee that, statistically, if an accident did occur, it would more than likely be the fault of a car driver, not either of the riders!!!

In our increasingly congested cities, bicycles, mopeds and scooters must be encouraged, as they take up less room on the roads, less parking spaces, and in the case of electrically-powered (or assisted) vehicles, have a much lower environmental footprint than any other powered vehicle, and provide additional 'mobility choices' which currently don't exist for people who require them.

It is currently possible for manufacturers to construct an E-bike capable of 60km/h – or 26km/h – using the same power-rated motor. It is the 'gearing' and the power delivery that is the key.

So an E-bike powered by a 600W motor could be 'speed limited' – electronically – to say, 30km/h, but would still be able to climb Arden Street, Coogee, or King Street from Darling Harbour, with some pedal-assistance, and without increasing the danger to any road users or pedestrians than that which exists currently.

A further suggestion would be to add a sub-category of E-bike that is not limited in the same way as that of pedal-assist bicycles; could be capable of up to 50km/h; but would be required to be fitted with signalling and braking lights; and riders required to wear a helmet; and be registered as a moped – but still look like a 'bicycle' with the ability to power the bike fully by its pedals OR by the speed-limited electric motor.

Segways

The Segway company [http://www.segway.com/] now manufactures a wide variety of personal transport vehicles, but we in Australia are most familiar with the Segway PT (of which there are now several models), all of which provide a useful way for fairly co-ordinated people to get around relatively slowly. The Segway does only 20km/h, but could easily be limited –electronically – to 10km/h, as for mobility scooters, and would offer no more danger to pedestrians than a mobility scooter. Some models do not have an automatic brake, but this again can be added electronically via software.

These should be 'allowed'; provided they are fitted with an already available 'stand-up' kit (that prevents them falling over when the user alights), and an 'automatic' brake such that they are braked and the brakes lock automatically when the rider alights.

Also, the flat restriction on these prevents them being used by Law Enforcement bodies, as many are used in the States, and these could obviously remain at 20km/hr or even be rated higher for 'Police Use Only', but while the blanket ban exists, this option is not available to them.

Mopeds

Currently mopeds – or what the Europeans call 'mopeds'; a motorised two-wheel vehicle with the capacity for pedal starting or limited pedal assist (but primarily motor-driven) – are not able to be driven unless registered as a motorcycle, thus necessarily complying with all relevant ADRs.

The problem with this approach is that it ensnares an otherwise acceptable, if not actually desirable, alternative form of transport – the electric-moped.

These relatively low-mass vehicles (generally less than 150kg) are invariably fitted with brakes and electric turn signals, but in order to comply with the harsh and overly stringent ADRs designed for much higher powered motorcycles, they are being, I believe, unecessarily penalised.

While many of the 'older style' mopeds were (and still are) powered by noisy, smelly two-stroke motors that probably wouldn't comply with the ADRs for emissions anyway, E-mopeds don't suffer this emissions problem.

It is my view that a new category of vehicles be created, or alterations to the existing regs be made, to separate the E-moped from the ICE-moped.

The former sub-category could then be restricted to a certain speed – as they are at present (but again, NOT limited by power other than an upper maximum of say, 2000W to prevent 'hoons' capitalising on a loophole) – such that they could be ridden under a special 'limited registration' and 'limited license'category as they are in Europe.

Frankly, if they and the more powerful E-bikes mentioned above, were limited to 50km/h (under motor power alone, which is the current ADR limit) – the speed most urban traffic struggles to maintain, especially in peak hour; restricted from accessing roads with speed limits over 60km/hr, and riders required to wear an AS-compliant motorcycle helmet, and complete the existing RTA motorcycle training course, suitably modified for E-mopeds – all existing concerns would be met.

They'd be marginally less safe than a bicycle, but would then be CTP insured and have trained riders.

Note I am not suggesting they be ridden on a full NSW license..!! A special "Moped License" category would be required, and, as in Europe, this category could be accessed by those over the age of 15 or 16, enabling young people to begin their driver/rider training at much safer, lower speeds, than currently exists.

ICE-powered mopeds could still be required to meet such stringent emissions requirements to prevent two-strokes ever being capable of complying, but in such a way that economical 4-stroke ICE-powered mopeds might be able to be compliant, but also be power-limited as now, and speed-restricted and use-limited as above.

ICE-powered pedal assist 'bicycles'

These need to be specifically differentiated from E-bikes, and Mopeds, as there is a growing trend for hooligans and those who like their vehicles to be LOUD, to add a noisy, smelly, multi-polluting, small-capacity, two-stroke engine to an existing bicycle. Many of these are sold, unregulated, via the internet and sites such as eBay and Gumtree.

These should be banned. Full stop.

They do nothing for the environment, add noise and emissions pollution that currently isn't regulated, and tend to be owned by the type of 'bogan' who rides unregistered trailbikes in State Forests and National Parks. And no, I'm not unhealthily biased, nor bigoted.

Believe me; I know who is buying them. They often fly past my place at speeds in excess of 40km/h – on the footpath. A serious accident looking for a place to happen.

Anecdotal evidence suggests this is the latest 'fad' for those whose lives are defined by thumbing their nose at any and all authorities.

Unfortunately, the need to check these power-assisted bikes by Police is catching legitimate, environmentally-conscious, clean-living 'regular' citizens on their legal E-bikes.

Police can't seem to tell, without getting out of their vehicles, whether a bike is powered by an ICE motor or an electric one. So make it simpler for Police. Simply ban the ICE-powered bikes.

Another option might be to have some sort of RFID tag affixed to legally sold, legally compliant E-bikes and motor kits that would 'pop up' on the COPS database in some way.

Police now have cameras in all their vehicles, negating the need for vehicle registration labels, so why not add some measure that would be required to be fitted to the motors, or the rear of the bike, so that Police could tell without having to stop them that E-bike users were in fact riding an E-bike.

OK, potentially, this might be able to be rorted, so perhaps an E-bike registration category is required. A small 'micro' number plate that would identify rider and motor type automatically (via Police in-car cameras), but be very cheap and available from RMS offices for say, $25-45, as a 'one off' lifetime charge which would remain attached to the E-bike throughout its usable life.

And perhaps the same charge re-applied as a 'transfer fee' when the vehicle ownership is transferred upon sale to subsequent owners, in order to maintain currency of the database.

As it is only for ID purposes, not 'registration road use charges purposes' this would probably be acceptable to the E-bike community if 'sold' the right way via an education campaign.

And it might shut up some of the car-driving whingers who object to sharing "their" roads with bikes of any kind! Cynical? Biased? Moi??? ☺☺

Quad bikes, pitbikes and motorised buggys

Currently these vehicles are not allowed to be driven on public roads, but clearly they are being so driven. I've witnessed pitbikes being driven in my town, but unless the Police literally 'trip over them' nothing can be easily done apart from education and stiffer penalties.

From my own experiences, many 'off-road' vehicles sold as being for 'offroad-use-only' are in fact used on public roads, or at least, are used in State Forests and currently un-patrolled or limited-patrol National Parks.

The only way to stop this is to increase the penalties; confiscate the vehicles (as for other 'hoon' activities) and penalise parents in the case of minors in charge of vehicles. Publicise and educate.

It is eminently clear from the available evidence that such vehicles do nothing for our bush environment other than destroy it and make it unpleasant for all non-motorised recreational pursuits, never mind the flora and fauna.

Personally, I'd ban ALL motorbikes and 4WD vehicles from State Forests and National Parks – unless they are operating under the auspices of an incorporated association - or licensed tourism operator - that has trained personnel well-versed in 'minimal damage' methods of driving accompanying the group, and who would be held responsible for any excesses.

As a disillusioned ex-4WD owner I can attest from personal experience that so-called 'recreational four-wheel driving' (and ipso facto, 'recreational offroad motorcycle riding') is nothing more than an excuse for hoons to beat up the bush in a quest to prove their personal 'toughness'. Note I didn't say 'manliness' as there are female bogans as well as male. I once witnessed one such change the nappy of an infant and simply drop the soiled nappy on the ground. In a State Forest. Un-be-lievable

And all their quest achieves is five minutes of personal satisfaction at the expense of the environment, biodiversity and enjoyment of the bush by everyone else. Just ban them.

You'll never get that through Parliament, though, alas. Electoral backlash. So much for 'leadership'. Cynical? Biased? Moi??? ☺☺

Neighbourhood Electric Vehicles (NEVs)

This category of vehicle has not been mentioned in the terms of reference, probably because there is currently no such category under the existing National Code of Practice and ADRs – but perhaps there should be.

NEVs are essentially a slightly more powerful and faster vehicle than a mobility scooter or similar vehicle, but often have a roof and/or doors, and look more like a very small car, and may have three, or four, wheels.

While I would not advocate allowing such vehicles to be used un-registered, un-insured, or by an un-licensed driver, it is clear that such vehicles are available now and could be purchased, registered and used on NSW roads if allowed to do so.

The stumbling block is that most such vehicles are 'experimental' in nature and not produced by massive motor corporations, so do not have access to the kind of funding that enables ready compliance with every aspect of the ADRs, especially crash-testing.

At the moment, four-wheeled NEVs are captured under the existing ADRs – designed usually for much more powerful ICE-powered vehicles.

The specific registration category of "NEV", or "low-speed vehicle"- as it is known in the USA and Europe - is designed for smaller vehicles that can carry only one or two persons; whose speed, mass and power are limited; and whose driving range is limited to restricted-speed streets. In the USA this is, broadly speaking, GVM of 1400kg (which allows for low-powered cargo-carrying NEVs, as well as purely 'personnel' transport), max speed of 72km/hr, limited to roads with posted limits less than 60km/h.

There is no reason at all why we could not add such a category to our existing ADRs and National Code of Practice and enable such vehicles to be registered as, essentially, a 'motorcycle with bodywork'. Not designed to cope with any 'crash testing' regime in the way 'normal', full-size, high-power, high-speed vehicles are, as they would be speed-limited and thus offer a much lower risk – similar to that of bicycles or small-capacity motorcycles.

As they would need to be registered, they must also have compulsory 3rd Party Bodily Injury Insurance, as for motorcycles and cars, but being speed, mass and power limited, this would likely be less costly than for a car and, as they would be cost-effective to purchase for inner-urban commuters, could have an immediate effect on the environment by reducing air pollution and carbon pollution, and being often much smaller than a traditional small car, would reduce parking requirements and congestion also.

The AECOM report on Economic Viability of Electric Vehicles (Sept 2009) for Dept of Environment, Climate Change and Water (NSW) gave clear indications that introduction of EVs would have a positive effect on the environment and see a considerable reduction in greenhouse gas emissions.

I'd also like to point out that many of these potential NEVs are what is known as a "reverse-delta three-wheeler" – with two wide-spaced wheels for steering at the front and one wheel at the back, but are less than 450kg mass – and at present there is actually no category of ADR to cover these.

The "3-wheeled vehicles under 450kg" categories in the ADRs are LEM1 and LEM2, the difference being delta or reverse-delta wheel configuration, BUT, both categories have a further restriction that there can be no permanent structure more than 200mm above and behind the driver.

The next category 'up' the ADR escalator, the LEP1 and LEP2 categories <u>do</u> allow permanent structures greater than 200mm above and behind the driver, <u>but</u> also require a mass in excess of 450kg. This covers vehicles such as the Reliant Robin or the Morgan-type three-wheeler.

I do not understand why the ADRs were limited in this way – other than to very specifically <u>prevent</u> the usage or registration of light weight small NEVs and, if so, that must be seen as a retrograde step.

Follow the logic: either we regulate ALL vehicles, and require ALL vehicles to have some form of CTP insurance and full ADR compliance, or we have to regulate the categories 'better' such that these grey areas are better covered, and road users and pedestrian safety thus better 'managed'.

So if bicycles and mopeds are capable of travelling at 50km/h, and are required to be less than 450kg, then why are we restricting NEVs that weigh less than 450kg, but have a bit of bodywork and framing around them that must, ipso facto, provide some additional degree of driver and passenger protection that a 'naked' motorcycle or trike cannot??

It just ain't logical, rational or reasonable. QED.

A 1994 study into the inclusion of low-emission NEVs by academics at UCLA determined that:

> If NEVs are to be one part of an integrated solution to the problem of improving air quality and energy efficiency, a new vehicle category must be defined along with modified or new standards that apply to the safety concepts employed in small vehicles.

In other words, we ought to be doing everything we can to <u>enable</u> the use of light-weight, low-powered, speed-limited NEVs, rather than restricting them as we currently do.

Weight, speed, and speed-limited-roads-only, with otherwise similar restrictions to LEMs (ie: brakes, brake lights, indicators, handbrake, reverse gear, safety glass, wipers, lights etc) is all we'd need to specify.

Maximum power could be 6000W (60kW), which isn't much to push a near-450kg vehicle; speed limited to 50km/h (which most neighbourhood streets are these days) and definitely only EVs!!

Think about it. You know it makes sense.

Insurance implications of injuries and fatalities sustained and caused by non-registered motorised vehicles

This is a no-brainer. As they aren't required to be registered, there is no CTP insurance, so any claims for accident damage become civil claims against the owner and/or operator.

How about calling for submissions from the CTP industry to provide cover for 'offroad non-registered vehicles', sit down with industry and experts (once the accident data has been collated) and figure out what the average cost is, then ask the industry for a minimum per vehicle (per type) amount, and add that to the purchase price/sale price of all such vehicles, including those sold over the internet.

There is no earthly reason why operators and owners of such vehicles should not have to pay some sort of insurance, and that is the simplest way to do it, without going down the politically undesirable 'full registration', full ADR-compliance route.

I'm guessing it will end up being around $150 per vehicle, but the CTP industry could be required to offer additional cover to the rider (not just passenger or 3rd party as at present) on a voluntary basis, giving the industry the option to 'up-sell' a more comprehensive policy at point of sale.

Ask them. They can only say 'no'. ☺

APPENDICES

1. AECOM Report

2. Lincoln-Rocklin Report on incorporating NEVs in CBD traffic

3. UCLA Report into Regulatory Impediments to Neighbourhood Electric Vehicles

4. Pike Research report on NEVs

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AECOM

Economic Viability of Electric Vehicles

Department of Environment and Climate Change

4 September 2009

Economic Viability of Electric Vehicles

Prepared for

Department of Environment and Climate Change

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1	04/09/2009	Final Report	David Adams Director - Economics	

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Executive Summary

The key objective of this study is to assess the economic viability of plug-in electric vehicles for the NSW Metropolitan region and to identify market and economic conditions under which such vehicles provide a net benefit to society.

AECOM developed an economic model to assess viability and a vehicle choice model to forecast take-up of different engine configurations. The economic model considers the costs and benefits to infrastructure providers, consumers (in terms of vehicle purchase and operating costs) and externalities such as greenhouse gas emissions and air pollution. The financial model considers the costs and benefits only to infrastructure providers and consumers.

The model shows that the plug-in electric vehicle market in NSW is both economically and financially viable. However, the economic and financial returns accrue over the longer term. The move towards a plug-in electric vehicle market also generates large savings in greenhouse gas and air pollution emissions.

The vehicle choice model predicts a transition to Hybrid Electric Vehicles (HEVs) in the short term (5-10 years), Plug-in Hybrid Electric Vehicles (PHEVs) over the medium term (5-20 years) and full Electric Vehicles (EVs) over the longer term (20 years plus). In the short term there is increased uptake of alternative engine configurations in the small vehicle category. However, over the longer term, as vehicle prices fall, the vehicle range increases and more charging infrastructure become available, owners of larger vehicles and vehicles that travel large distances tend to purchase a higher proportion of EVs. This is due to the fact that operating costs are more important for these vehicle owners.

Key factors affecting the take-up of plug-in electric vehicles and market viability in Australia include the supply of infrastructure, the vehicle cost (this is largely driven by battery costs) and the rate at which it converges with Internal Combustion Engine (ICE) vehicles, fuel prices (particularly higher oil prices), vehicle range and the existence of local supply constraints.

Vehicle costs and vehicle range are expected to converge over time as technology improves and production increases, therefore the removal of supply constraints and the provision of charging infrastructure are the key areas that warrant further attention if the take-up of EVS is to be encouraged.

Background and Objectives

Electric vehicle technology is likely to play an important role in the future of motor vehicles in Australia. EVs may, depending on how electricity is generated, cut greenhouse gas emissions and ambient air pollution, while reducing Australia's exposure to crude oil prices and oil import dependency.

This study assesses the economic viability of plug-in electric vehicles (both pure electric vehicles as well as plug-in hybrid electric vehicles) for the NSW Metropolitan[1] passenger vehicle, light commercial vehicle and taxi markets. The study also identifies market and economic conditions under which such vehicles provide a net benefit to society. Analysis of specific business models and financing arrangements were outside the scope of this study.

Current Technology in the Electric Vehicle Market

As of today (2009), lithium-ion EVs are on the verge of commercial viability and mass-production, with PHEVs following close behind. In the next 3 to 5 years, the industry as-a-whole plans to launch more than 30 new EV and PHEV models with global production targets set to reach almost one million units

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[1] The study area is defined as ―Metropolitan NSW" which includes the Sydney Statistical Division, Illawarra Statistical Division and the Newcastle Statistical Subdivision.

annually within this timeframe. Both EVs and PHEVs are currently in commercial production and are expected to be available to Australian motorists by 2012.

The production of EVs/PHEVs is expected to launch in all segments of the light-vehicle market, although manufacturers of EVs are showing an early preference for small vehicles in order to minimise the cost premium (since battery cost scales proportionally with vehicle size/weight, whereas mature ICE costs vary less with vehicle size/weight).

EVs/PHEVs will provide the same functionality and features as traditional vehicles, except for some obvious differences with regards to range per charge and recharging versus refuelling. The high cost of EVs/PHEVs is driven by battery costs which are typically around US$10,000.

The future evolution of lithium-ion batteries will see continuing advances in performance, range and useful life as a result of significant ongoing investment in battery R&D. It is expected that there will be significant cost reductions in vehicle prices through industry learning curves as this is still a relatively new market, and economies of scale achieved through mass-production.

Key aspects of the methodology

Scenarios to be Assessed

The economic model has been built to allow flexibility and sensitivity testing around the key variables. As such, the scenarios to be tested by the model are focused around the different levels of charging infrastructure that may be required to facilitate the electric vehicle market. All scenarios are compared against the Base Case.

Base Case: Assumes there are only ICEs and HEVs available and no PHEVs or EVs.

Scenario 1: Household Charging Only (Level 1 - over 3 hrs per 40kms).

Scenario 2: Household Charging (Level 1 and 2 - 25 minutes per 40kms) plus Public Charging Stations (car parks, hotels, shopping centres, street parking).

Scenario 3: Household Charging (Level 1 and 2), Public Charging Stations plus Electric Vehicle Service Stations (2.5 minutes per 40kms).

Market Segments

This study focused on eleven market segments: Passenger Vehicles by vehicle size (small, medium, large) and by distance travelled (low, medium and high vehicle kilometres travelled (VKT)); Light Commercial Vehicles (LCV) and Taxis. Vehicle size was considered important because prices and availability of vehicles will vary significantly between vehicle sizes. Distance travelled was considered important because high VKT vehicles benefit more from the cheaper cost of using electricity as a transport fuel.

Vehicle Choice Model

Many studies of this type do not estimate take-up of different engine configurations and instead make assumptions based on experience elsewhere. This study has decided to directly estimate take-up for two reasons. Firstly, as this is a new market, there is not a lot of information on past experience from which to draw meaningful assumptions about the future of EVs in Australia. Secondly, by directly estimating take-up it is possible to consider the impact of various potential sensitivities around prices (electricity price, fuel price, vehicle price) and how these affect take-up.

After an extensive literature review on the factors affecting the decision to purchase a vehicle, a logit model was developed which takes into account the vehicle cost, fuel costs, vehicle range, emissions, availability of charging infrastructure, multi-fuel bonus and an electric vehicle bonus.

Vehicle Prices

New vehicle prices have been estimated from a survey of 34 global EV products for the 2009-2012 model years and 28 US HEVs for the 2009-2010 model years. An equivalent ICE vehicle was used for the price of ICE vehicles to ensure a consistent comparison.

The survey of prices also revealed that, for the cars available in Australia (HEVs), there is a premium of around $10,000 over US prices. This is likely to reflect a local market penalty due to our relatively small market size, distance from large vehicle manufacturing countries, volatile exchange rate, and lack of local manufacturing of non-ICE vehicles. It has been assumed that there will be a similar small market penalty for PHEVs and EVs.

HEVs are assumed to reach price parity with ICEs in 2020. PHEV and EV purchase prices are assumed to reach price parity with ICEs in 2030.

Fuel Cost per Kilometre

Fossil fuel prices were estimated using Energy Information Agency (EIA) forecasts for crude oil prices. Their reference scenario forecasts US$74 per barrel in 2010, decreasing slightly and then increasing to US$80 per barrel by 2040. Electricity prices were estimated based on modelling undertaken by the Australian Treasury. The central price scenario sees electricity prices increasing to over 20 cents per KWh by 2040. The following assumptions on fuel efficiencies have been made:

- Efficiency of an ICE vehicle will improve due to platform engineering as well as other efficiencies such as combustion technology improvements;
- HEVs will experience continued efficiency gains over ICE however these improvements will decline over time as the potential for improvement gets eroded by improved combustion technologies;
- EVs will experience improvements in efficiency due to platform engineering and power-train improvements; and
- PHEVs will use the electric drivetrain for 50% of kilometres in 2012 increasing to 80% in 2035.

Supply Constraints

A major issue to the take-up of EVs in the short term (next 5 – 10 years) will be supply constraints. There are expected to be global supply constraints until at least 2012 and these will be exacerbated in Australia which is not seen as a key market for vehicle manufacturers. As such, a supply constraint has been built into the model to ensure it reflects current market conditions.

Cost of Infrastructure

The cost of infrastructure is broken down into the cost to physically install the different levels of infrastructure as well as any costs involved with upgrading the electricity network to support the charging infrastructure.

It has been assumed that there will be no requirements to upgrade the electricity transmission and distribution networks. This assumes the use of smart metering (so that households charge during the off peak period) and that significant investments are known in advance so can be built into investment plans with little additional costs. However, an increase in network access cost has been assumed to apply to all electricity consumed through Level 2 household charging to represent the costs of a potentially necessary upgraded household connection to the local distribution network.

The cost of the charging infrastructure will vary by the different scenarios. There are no infrastructure costs associated with Scenario 1 (household charging). The infrastructure costs for Scenario 2 and 3 are as follows:

Scenario 2: Household charging (Level 1 and 2) plus public charging stations:

- $1,000 per household for interface unit installation (equipment cost included as standard item)
- $6,000 per public charging unit

Scenario 3: Household charging (Level 1 and 2) plus EV service station:

- $1,000 per household for interface unit installation (equipment cost included as standard item)
- $6,000 per public charging unit
- $500,000 per charging station

AECOM has not considered the cost of additional generation capacity due to the use of EVs. Under the higher EV take up of Scenario 3, annual electricity consumption for EVs and PHEVs in 2039-40 (8.2TWh) represents an increase of around 10% of 2007-08 total NSW electricity demand (78.3TWh[2]). However, general growth in electricity demand between 2008 and 2040 will reduce the significance of EV electricity demand as a proportion of total demand.

Model Results

Table E-1 sets out the present value of the benefits associated with introducing EVs into the NSW market compared to the Base Case. The model shows that under all scenarios the EV market is both economically and financially viable over the long run. The net present benefit becomes positive after 2030 under all scenarios.

This is largely driven by the high vehicle purchase costs of alternative engine configuration vehicles decreasing over time and the operating cost savings increasing over time. In addition, there are large savings in greenhouse gas and air pollution emissions. Greenhouse gas emission savings total $33m under Scenario 1, $91m under Scenario 2 and $165 million under Scenario 3. Air pollution savings total $261m under Scenario 1, $710m under Scenario 2 and $1,256 million under Scenario 3.

The net benefits increase with the level of charging infrastructure provided because this increases the take-up of EVs. Higher levels of charging infrastructure also bring forward the break-even year.

Table E-1: Present Value of Benefits incremental to the Base Case*

Benefits	Scenario 1			Scenario 2			Scenario 3		
	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)
Vehicle Purchase ($m)	-$272	-$1,230	-$1,230	-$415	-$2,010	-$2,313	-$625	-$2,766	-$3,192
Vehicle Operation ($m)	$71	$461	$1,447	$133	$1,020	$4,008	$242	$1,694	$6,756
Net Charging Infrastructure ($m)**				-$1	-$15	-$37	-$3	-$26	-$65
Financial Benefits ($m)	-$201	-$769	$217	-$283	-$1,005	$1,658	-$386	-$1,098	$3,499
GHG Emissions ($m)	$3	$11	$33	$4	$21	$91	$7	$36	$165
Air Pollution ($m)	$11	$82	$261	$21	$182	$710	$40	$319	$1,256

[2] ABARE Energy In Australia, Department of Resources, Energy and Tourism 2009

Economic Benefits ($m)	-$187	-$676	$511	-$258	-$802	$2,459	-$339	-$743	$4,920
Breakeven year	2035			2032			2031		
*Based on central forecasts of oil price, electricity price and CPRS policy. A 7% discount rate has been used for all present value calculations. ** Net charging infrastructure is capital cost of charging infrastructure minus premium customers pay to cover cost of infrastructure.									

Source: AECOM

Sensitivity analysis highlighted the following:

- Results are very sensitive to the year in which EVs reach price parity with ICE vehicles. Changing the initial price does affect the results but this is not as sensitive as the year in which prices reach parity; and
- Results are sensitive to increasing oil prices but less so to electricity and the Carbon Pollution Reduction Scheme (CPRS) prices. This is mainly due to the improved efficiency of EVs over ICE vehicles. However, the combination of high oil prices with low electricity prices has large positive impact on the results.

Table E-2 summarises the total greenhouse gas and air pollution (CH_4, N_2O, NO_x, Co, BOC and PM_{10}) emission savings compared to the Base Case under each scenario.

Table E-2: Greenhouse gas and air pollution emission savings compared to the base case (tonnes)

	Scenario 1			Scenario 2			Scenario 3		
	To 2020	To 2030	To 2040	To 2020	To 2030	To 2040	To 2020	To 2030	To 2040
CO_2e	169,763	908,201	5,621,115	224,888	1,929,891	17,255,754	361,435	3,462,002	31,307,014
CH_4	4	62	316	9	139	779	18	243	1,343
N_2O	23	500	2,695	61	1,254	7,779	133	2,228	13,739
NO_x	228	1,185	4,065	313	2,314	11,529	466	3,784	20,117
CO	897	15,802	83,345	2,101	37,068	215,836	4,358	65,242	375,086
VOC	45	167	561	57	271	1,336	91	473	2,418
PM_{10}	22	186	822	36	410	2,284	61	701	4,002

Source: AECOM

Table E-3 sets out the expected lifetime cost per kilometre for the different engine configurations in 2010 and 2040. The total cost of ownership includes the vehicle price, annual fuel[3] and maintenance costs (based on average annual distance travelled as set out in **Table 4-5**) and insurance. Future costs have been discounted at 7%.

Table E-3: Lifetime cost per kilometre for each engine configuration in 2010 and 2040[4]

Engine Type	Small Passenger		Medium Passenger		Large Passenger		Light Commercial		Taxi	
	2010	2040	2010	2040	2010	2040	2010	2040	2010	2040
ICE	$0.263	$0.264	$0.286	$0.287	$0.352	$0.355	$0.277	$0.279	$0.271	$0.275
HEV	$0.299	$0.245	$0.318	$0.272	$0.380	$0.341	$0.299	$0.264	$0.321	$0.264
PHEV	$0.297	$0.217	$0.313	$0.227	$0.469	$0.274	$0.365	$0.214	$0.466	$0.234
EV	$0.260	$0.191	$0.270	$0.199	$0.416	$0.243	$0.318	$0.185	$0.438	$0.220

Source: AECOM

[3] Fuel prices are forecast out to 2040 and have been assumed to be constant after this time.
[4] The cost per kilometre is non-scenario specific as vehicle and operating costs do not change significantly across the scenarios.

In summary, the cost per kilometre for smaller EVs is already cost competitive with ICE vehicles due to the fuel cost savings outweighing the high up-front vehicle cost. As PHEVs and HEVs only achieve a proportion of the fuel cost savings, it takes longer to offset the higher vehicle cost. Conversely, large passenger vehicles and LCVs take longer to reach cost per kilometre parity with ICEs due to the high upfront price premium for large EVs, PHEVs and HEVs. However, once they reach parity, there are larger savings compared to an ICE due to the larger distances travelled. Taxis take longer to reach a cost per kilometre comparable to ICE vehicles and, even with vehicle price parity, the fuel savings are not as high as for other vehicles. This is due to the high use of LPG in taxis and the much shorter vehicle life.

Issues for Consideration

Several issues arose during the study that were not able to be incorporated into the model, but are important in understanding the electric vehicle market and how it may evolve over time. These include:

- Battery issues: There are various battery issues including the evolution towards standardisation of technology; the current high costs which are expected to reduce over time with increasing production resulting in economies of scale and industry learning curves; a lack of industry practices to ensure safe battery disposal; uncertainty about battery life; and the residual value and potential for a secondary market.
- Global supply constraints: A major issue to the take-up of EVs in the short term (next 5 years) will be supply constraints. These are likely to be exacerbated in the Australian market which is relatively small and not a key market for vehicle manufacturers.
- Market structure: The current market structure of vehicle travel is characterised by vertical separation. The business models chosen by providers of electric vehicle infrastructure can have a strong influence on customer decision-making. While this should not change the fundamental cost and benefits of electric vehicle travel, it could change the perception of relative costs and benefits by customers and hence affect their choice of vehicle. It also has the potential to create competition issues.
- Lifecycle Considerations: The lifecycle of batteries and associated electric-drive components will clearly be a determining factor for the overall sustainability of the plug-in vehicle industry. Early efforts to characterise the lifecycle of electric-drive vehicles are revealing some positive indications. However, given Australia‘s current reliance on fossil fuels, the ongoing use of these fuels for manufacturing process energies and electric power generation will be a critical factor, and further lifecycle assessment will be required based on Australia‘s unique local context.
- Electricity issues: The most significant electricity issue arises in respect of how electric vehicle charging infrastructure is priced and how consumers respond. Clearly there is interplay between cost of charging and convenience, which will affect the take-up of EVs.
- The role of government policies: Governments all around the world have developed policies to encourage the take-up of EVs. Some policies are designed to support industry (charging infrastructure, development of technology) whilst other policies are to encourage increased demand through subsidising the purchase and operating costs for consumers. It is important to consider the applicability of government policies in Australia.
- Wider economic impacts: This study is a partial equilibrium model and as such there are a range of other effects that may occur as a result of changes in the vehicle market that have not been considered in this study.

Conclusions

The model shows that the plug-in electric vehicle market in NSW is both economically and financially viable. However, the economic and financial returns accrue over the longer term. The move towards a plug-in electric vehicle market also generates large savings in greenhouse gas and air pollution emissions.

The vehicle choice model predicts a transition to HEVs in the short term (5-10 years), PHEVs over the medium term (5-20 years) and EVs over the longer term (20 years plus). In the short term there is increased uptake of alternative engine configurations in the small vehicle category. Significantly, despite the high vehicle price, small EVs are around the same lifetime cost per kilometre as ICE vehicles in 2010 due to large fuel cost savings over the life of the vehicle. As vehicle prices fall, the vehicle range increases and more charging infrastructure becomes available, owners of larger vehicles and vehicles that travel large distances tend to purchase a higher proportion of EVs. This is due to the fact that operating costs are more important for these vehicle owners.

Higher levels of charging infrastructure (as represented in the different scenarios) significantly increase the take-up of plug-in electric vehicles and hence increase the viability of the market. Other key factors affecting both take-up and viability include the vehicle cost and rate at which it converges with ICE vehicles (this is largely driven by battery costs), fuel prices (particularly higher oil prices), vehicle range and the existence of local supply constraints.

Vehicle costs and vehicle range are expected to converge over time as technology improves and production increases, therefore the removal of supply constraints and the provision of charging infrastructure are the key areas that warrant further attention if the take-up of EVS is to be encouraged.

1.0 Introduction

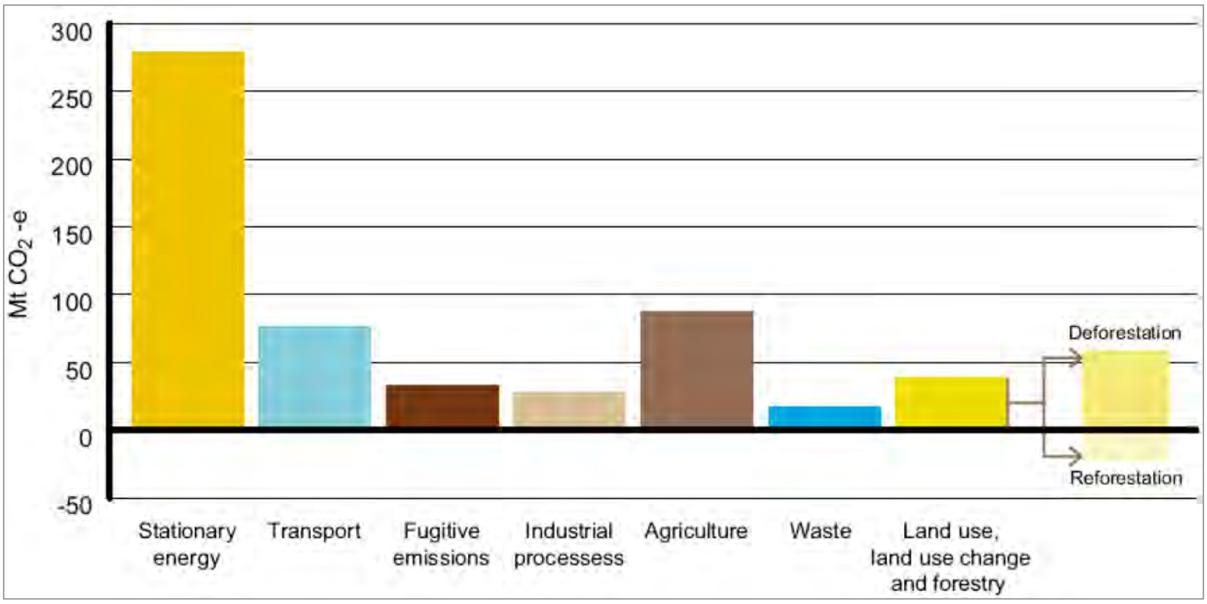
1.1 Background

Electric vehicle technology is likely to play an important role in the future of motor vehicles in Australia. Electric vehicles (EVs) may, depending on how electricity is generated, cut greenhouse gas emissions and ambient air pollution, while reducing Australia's exposure to crude oil prices and oil import dependency.

Increasing concerns over climate change has spurred the development of alternative fuel cars in the last decade. The International Panel for Climate Change (IPCC) Fourth Assessment Report in 2007 presents a clear case that climate change exists and it is very likely that greenhouse gas increases related to human activity have caused most of the rise in global mean temperature since the mid-20th century. The Garnaut Review (2008) suggests that emissions are tracking at the upper bounds of the scenarios modelled by the IPCC.

In 2006, Australia's net greenhouse gas emissions using the Kyoto accounting provisions were 576 million tonnes of CO2-equivalent (Mt CO2-e)[5]. **Figure 1-1** shows the sectoral breakdown of these emissions. A relatively high level of car ownership in Australia has meant that transport contributes around 14% of Australia's emissions and is the second fastest growing source of emissions[6]. Of this, road travel contributes 89% of total transport greenhouse gas emissions. The use of alternative fuels may help reduce these emissions.

Figure 1-1: Australia's national emissions profile in 2006



Source: National Greenhouse Gas Inventory 2006, Department of Climate Change

Rising oil prices and the security of fuel supply are other issues that have encouraged alternative fuels and vehicle development. The finite supplies of crude oil which tend to be concentrated in a small number of countries create risks around the security of supply. As oil supplies are run down, fuel prices will rise to reflect the increasingly difficult and expensive extraction process. Thus alternative fuels will become increasingly important to ensure domestic supply and maintain more stable prices.

[5] Green Paper on the Carbon Pollution Reduction Scheme, Department of Climate Change July 2008
[6] The Future of Transport Fuels: challenges and opportunities, Future Fuels Forum, CSIRO June 2008

Electric vehicles (EV) or plug-in hybrid electric vehicles (PHEV) use electricity as their main energy source. The increased use of EVs or PHEVs is likely to address both the climate change and energy supply problems raised above. The main climate benefit of EV use is that there are no tailpipe emissions at the point of consumption, unlike existing internal combustion engines. Depending on the source of electricity (coal, hydro, wind, etc.), a net emissions reduction for the transport sector could be achievable through the use of EVs.

The development of a plug-in EV market in Australia could face some significant hurdles, including:

- Cost: The competitiveness of all-electric vehicles is dependent on the cost comparison with petrol vehicles. The cost of a vehicle is dependent on the upfront cost of purchasing the vehicle as well as ongoing operating costs (predominantly fuel). The cost of the required battery technology is currently making EVs more expensive to purchase than a comparable petrol vehicle. Whilst electricity is cheaper than petrol resulting in operating cost savings it is not enough to outweigh the high capital costs at present.
- Infrastructure: EVs would also require the support of new infrastructure, such as battery recharge points and changeover stations, or facilities for home charging.

In addition, there are other potential impacts that need consideration, including the impact of EVs on the electricity network.

1.2 Study Objectives

The key objective of this study is to assess the economic viability of plug-in electric vehicles (both pure electric vehicles as well as plug-in hybrid electric vehicles (PHEVs) for the NSW Metropolitan passenger, light commercial vehicle and taxi markets. The study will also identify market and economic conditions under which such vehicles provide a net benefit to society.

Overall, the project aims to develop a model that will help address the following questions:

- What is the current and likely future state of technology for electric vehicles?
- What type of infrastructure is required to support electric vehicles?
- What are the factors that influence the economic viability of electric vehicles, i.e. under which circumstances are electric vehicles economically viable?
- What are the risks and barriers to adopting electric vehicles in New South Wales (more broadly, in Australia) and how might government policy address these?

Analysis of specific business models and financing arrangements were outside the scope of this study.

1.3 Project Scope Issues

This study is primary work in the area of electric vehicle take-up and economic impact in Australia. As such, it is intended to gather information relevant to Australia and provide a base from which further work can be undertaken. There are many factors that will influence the take-up of EVs including technological development, vehicle prices, and government policies on environmental issues. This study has made assumptions using the best available data about these issues to provide an indication of their importance. The model has been designed to be updated as new data becomes available that may affect the future of the electric vehicle market.

1.4 Engine Configuration

As well as the standard internal combustion engine (ICE) vehicle, this report focuses on three new engine configuration types, each of which are described in **Table 1-1.**

Table 1-1: Engine configurations

Engine Configuration	Description
Hybrid electric vehicles (HEV)	Hybrid electric vehicles combine both an internal combustion engine with an electric engine, with electrical energy stored in batteries. Vehicle propulsion is a mix of the ICE and electric drivetrains typically dependent on vehicle speed (urban/non-urban use). HEVs are more fuel efficient than regular ICE vehicles as they take advantage of the complementary power generating characteristics of the two technologies.
Plug-in hybrid electric vehicles (PHEV)	Plug-in hybrids (PHEVs) are similar to regular hybrids in that they combine the use of combustion and electric motors, however PHEVs are capable of being recharged by plugging in to the electricity grid. Charging can be achieved through a conventional household wall socket and at charging stations similar to existing petrol stations. The batteries in a PHEV are typically larger than those in a HEV leading to a greater all-electric range that is sufficient for average metropolitan use. The trade off for larger batteries and greater range is increased battery cost, size and weight. The ICE is used to extend driving range beyond battery capacity for longer distances and to recharge the battery itself.
Electric vehicles (EV)	Fully electric vehicles are powered only by electricity stored in batteries. EVs face similar limitations as HEVs and PHEVs due to the need for batteries. In EVs, battery shortcomings are highlighted as there is no ICE to boost range and acceleration, for example. To increase range, more or larger batteries are required with costs and weight also increasing. Improvements in battery technology will gradually address these issues.

Source: AECOM 2009

1.5 Report Structure

The report is structured as follows:

- **Chapter 2** outlines the current technology in the electric vehicle market and how this is expected to change;
- **Chapter 3** sets out the supply chain and infrastructure requirements;
- **Chapter 4** sets out the methodology for undertaking this study along with the key input variables;
- **Chapter 5** sets out the results of the vehicle choice model;
- **Chapter 6** sets out how the externalities will be quantified and valued;
- **Chapter 7** sets out the key assumptions in this study and the suggested sensitivity analysis;
- **Chapter 8** sets out the economic and financial results;
- **Chapter 9** sets out issues for consideration; and
- **Chapter 10** sets out market failures that may exist in the market now and in the future.

1.6 Acronyms

Below is a summary of commonly used acronyms throughout this report.

- A - ampere
- CPRS - carbon pollution reduction scheme
- EV - electric vehicle
- GST - goods and services tax
- HEV - hybrid electric vehicle
- ICE - internal combustion engine
- kW - kilo watt
- kWh - kilo watt-hour
- LCV - light commercial vehicle
- LPG - liquefied petroleum gas
- PHEV - plug-in hybrid electric vehicle
- VKT - vehicle kilometres travelled
- V - volt

2.0 Current State of Technology

2.1 Commercial History of Plug-in Vehicles

EVs first arose at the end of the 19th century, following the invention of the electrochemical battery. For example, one of the first vehicle prototypes built by Ferdinand Porsche was a battery-powered electric vehicle and, at the turn of the 20th century, EVs were a leading technology candidate for the propulsion of personal automobiles.

Initial interest in the technology stemmed from its ―push-button start" capability – which compared favourably with the intimidating hand-crank of combustion engines and slow warm-up cycle of steam engines. Furthermore, since the competing technologies were less mature and also had limited performance, EVs could potentially hold their own. However, combustion vehicles quickly improved to offer greater performance, and once the electric starter motor was invented for convenient starting, electric vehicles lost their key selling point and quickly lost favour in the market.

During the oil shocks of the 1970s and 1980s, there was a resurgence of interest in EVs and a flurry of R&D efforts including the demonstration of many prototypes. However, the next major commercial deployment of EVs came in the 1990s, spurred-on by air quality concerns in California. Controversial legislation – the Zero Emission Vehicle (ZEV) Mandate – was enacted to require a compulsory number of EVs to be sold in the Californian market. These first-generation EVs were mostly equipped with lead-acid or nickel-metal-hydride batteries, offering less performance than the EVs being considered today. Since California was the world‘s largest single automotive market at the time, the impacts of this effort were felt globally. Similar government-led deployments of EVs were also initiated in Asia and Europe. While automakers rushed to meet the ZEV Mandate requirements, they also launched a concerted lobbying effort (in conjunction with oil companies) to roll-back the mandate and alleviate the pressure for them to deliver EVs to market. They claimed that both industry and consumers were not ready to manufacture and buy these EVs (due to a variety of techno-socio-economic factors), and that there were alternative strategies for achieving California‘s air quality goals.

Hindsight has shown that while these arguments may have been partly true, they were also misleading in some ways. The automakers only made available a small number of products to a limited segment of the market. In contrast, there is significant anecdotal evidence to suggest that those customers who did gain access to EVs were extremely receptive to the technology and reluctant to give them up. In any case, the ZEV mandate was not a successful commercial deployment of EV technology. Several thousand EVs were manufactured and sold/leased but all these products had been removed from the market by the end of the 2003 model year.

Meanwhile, the industry shifted its focus to non-plug-in hybrid-electric vehicles (HEVs) and then fuel cell vehicles until a new breed of EVs began to emerge in the mid 2000s equipped with next-generation lithium-ion batteries. Furthermore, the commercial success of non-plug-in hybrid vehicles and advances in lithium batteries also enabled the prospect of mass-market PHEVs using component technologies leveraged from these other powertrains. As a result, there are now currently two candidate plug-in vehicle technologies – EVs and PHEVs – that must be evaluated for the future automotive industry.

2.2 Current State of Technology

2.2.1 Lithium-Ion Plug-in Vehicle (EVs and PHEVs) Market Entry

In 2006 the California Air Resources Board (CARB) commissioned an expert panel to determine the market readiness of full-function lithium-ion battery-powered plug-in vehicles. The expert panel concluded positively that ―high energy Li-Ion technology has good potential to meet all performance requirements of EVs with batteries of modest weight…cell and battery technology designed for these applications are likely to also meet cycle life goals." **Table 2-1** demonstrates several automotive lithium-ion battery packs with targets established several years ago by the US Department of Energy. They were similarly optimistic about the viability of PHEVs. The expert panel did, however, temper their enthusiasm with concerns about battery costs and the likely timeframes for delivery of EVs and PHEVs to market and the scaling of production volumes.

Table 2-1: Specifications for automotive lithium-ion battery packs under development (2006)

Vehicle	Battery Supplier	Type	Energy (kWh)	Peak Power (kW)	Weight (kg)	Specific Energy (Wh/kg)	Specific Power (W/kg)
FPBEV	*DOE goal*[1]	*n/a*	*25-40*	*50-100*	*250*	*100-160*	*200-400*
Tesla Roadster	**Tesla Motors**	**Li-Ion**	**53**	**230**	**450**	**118**	**511**
TH!NK City	A123 Systems[2]	Li-Ion	19	no data	260	73	no data
	EnerDel[2]	Li-Ion	26	no data	260	100	no data
n/a	JCS[1]	Li-Ion	24	55	265	90	210
n/a	GAIA[1]	Li-Ion	22	50	200	115	250
n/a	LitCel[1]	Li-Ion	20	155	170	118	912
n/a	Lamilion[1]	Li-Ion	9.2	62	150	60	400
n/a	Kokam[1]	Li-Ion	30	130	265	110	490

[1] Data extracted from Tables 3-2 and 3-6 of the Expert Panel Report
[2] Data reported by Green Car Congress [11]

Source: A. Simpson (2008) ―Response to the CARB ZEV Expert Panel Position on Lithium-Ion Full-Performance Battery Electric Vehicles", expert testimony on behalf of Tesla Motors Inc. to the California Air Resources Board review of the Zero Emission Vehicle Program, available at: www.arb.ca.gov/regact/2008/zev2008/zev2008.htm, 23 March.

The current rate of advance within the EV and PHEV industry indicates that the CARB's expert panel were overly-conservative in their predictions. As of today (2009), lithium-ion EVs are on the verge of mass-production and commercial viability, with PHEVs following close behind. EV products have once again become available in limited volumes supplied by proactive start-up companies. However, in the next 3 to 5 years, the industry as-a-whole plans to launch more than 30 new EV and PHEV models with global production targets set to reach almost one million units annually within this timeframe. **Table 2-2** highlights some of the EV and PHEV products that are already in production or planned for launch in the next few years. This deployment is being further accelerated by the green stimulus packages now being implemented by governments globally. Although the initial supply of EVs and PHEVs may be limited with correspondingly high introductory prices, it is anticipated that the rapid growth in production volumes will allow the industry to drive costs down quite quickly.

Table 2-2: EVs/PHEVs currently in production or planned for launch in the near future

Make	Model	Segment	Type	Elec Range (km)	Battery	Capacity (kWh)
Blade	Electron	small	EV	120	LFP	16
Energetique	evMe	small	EV	200	LMP	40
Ford	Focus	medium	EV	130	Li-Ion	23
Ford/Smith	Ampere	commercial	EV	160	LFP	24
Mini	E	medium	EV	240	Li-Ion	35
Mitsubishi	iMiEV	small	EV	125	Li-Ion	16
Nissan	no data	small	EV	160	Li-Ion	35
Smart	ed	small	EV	115	Zebra	13
Subaru	Stella	small	EV	90	Li-Ion	9
Tesla	Model S	large	EV	260	Li-Ion	42
Tesla	Roadster	large	EV	395	Li-ion	53
TH!NK	City	small	EV	180	LFP	26
BYD	F3DM	medium	PHEV	100	LFP	13
Chevy	Volt	medium	PHEV	65	LFP	16
Daimler	Sprinter	commercial	PHEV	30	Li-Ion	14
Fisker	Karma	large	PHEV	80	Li-Ion	23
Ford	Escape	large	PHEV	50	Li-Ion	10
Toyota	Prius	medium	PHEV	20	Li-Ion	no data

Battery nomenclature:
LFP = lithium-ion iron-phosphate
LMP = lithium-metal polymer
Li-Ion = other lithium chemistries
Zebra = sodium nickel chloride

Source: AECOM study team (Dr Andrew Simpson,) June 2009

The production of EVs/PHEVs is expected to launch in all segments of the light-vehicle market within the next few years. Manufacturers of EVs are showing an early preference for small vehicles in order to minimise the cost premium (since battery cost scales proportionally with vehicle size/weight, whereas mature ICE costs vary less with vehicle size/weight) and in recognition that EV attributes are better-suited to smaller, urban-commuter vehicles rather than larger multi-purpose vehicles. PHEVs are universally applicable across all segments, although EVs are possibly more competitive in the smaller segment. Furthermore, the proliferation of PHEV models may lag behind EVs since PHEV battery requirements are more stringent and PHEV batteries are less-mature and less-proven than EV batteries. In any case, both technologies are currently (as of 2009) in commercial production and are expected to be available to Australian motorists by 2012.

2.2.2 Plug-in Vehicle Functionality and Performance

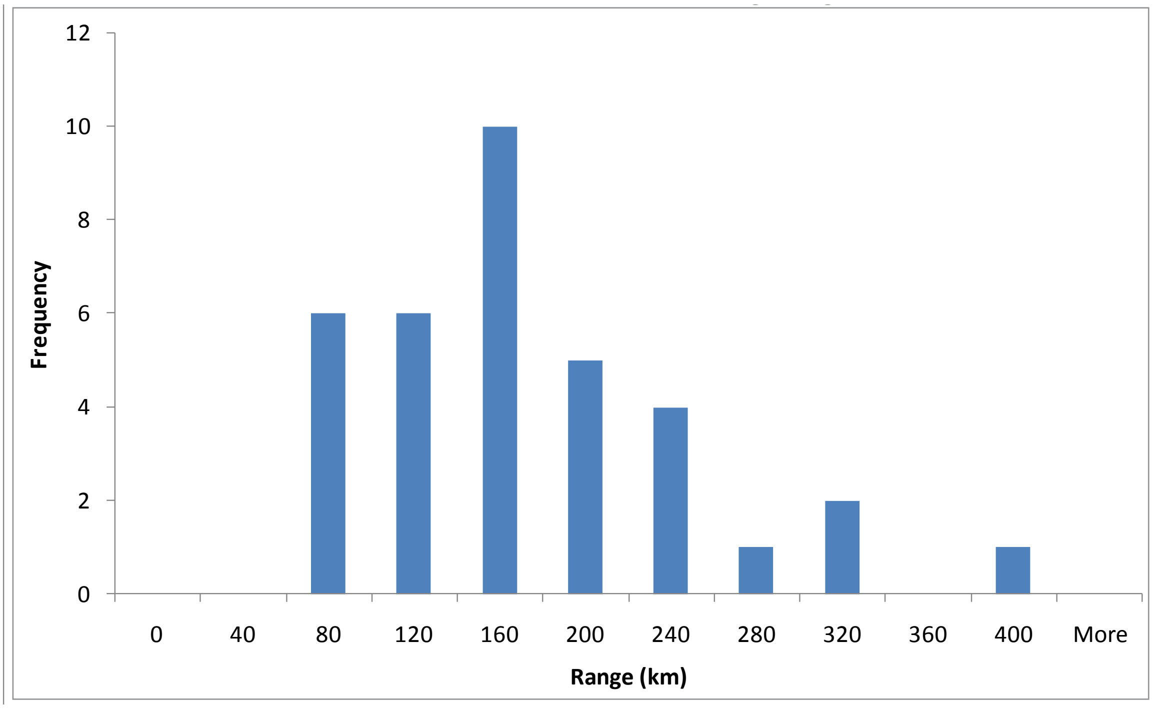
There are some misperceptions regarding the performance of plug-in vehicles with respect to traditional vehicles (e.g. speed and acceleration) but these have arisen largely from the attributes of non-highway-capable EVs (also known as neighbourhood electric vehicles). Highway-capable EVs/PHEVs will provide the same functionality and features as traditional vehicles, except for some obvious differences:

- Range per charge (in the case of EVs as demonstrated in **Figure 2-1**);
- Recharging versus refuelling;
- Novel user interfaces based on unique powertrain components and features;
- Regenerative braking;

- No/less transmission shifting; and
- Less noise during operation (due to engine-off mode or lack of engine, but EVs/PHEVs are definitely not ―silent").

Figure 2-1 highlights the vehicle range of the EV and PHEV products that are already in production or planned for launch in the next few years based on data in **Table 2-2**.

Figure 2-1: Distribution of EV driving ranges based on models in production or planned for release by 2012



Source: Table 2.2, Based on 36 EV and PHEV models

2.2.3 Plug-in Vehicle Maintenance and Reliability

There is little empirical data available to characterise the maintenance schedules and costs of EVs/PHEVs (not including batteries) however it is generally expected that these vehicles will require less servicing and cost less to maintain.

Electric powertrain architectures are generally simpler with fewer moving parts. Many of the consumable items found in combustion engines (belts, seals, filters, sparkplugs, valves and some lubricants) do not exist in EVs. Maintainable parts that are common for EVs include electronics, cooling fluids and radiators, fans and pumps, driveline lubricants, wheel/axle bearings, brake pads and tyres, and air-conditioning systems. For some parts such as brake pads, the maintenance frequency may be reduced. Generally speaking, EV/PHEV powertrain batteries require no maintenance whatsoever and come equipped with charge-balancing and thermal-management systems to maximise their performance and useful life.

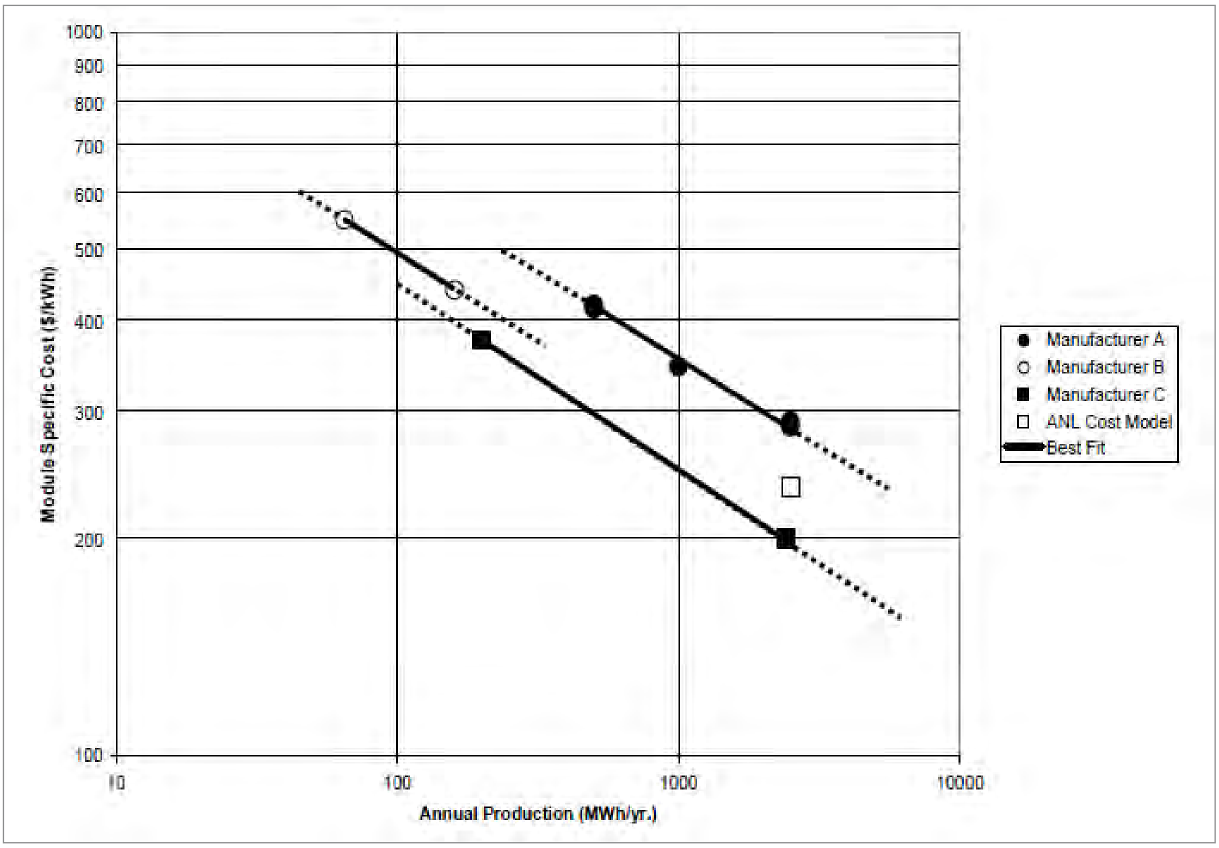
Predicted EV/PHEV battery lifetimes are approaching the life of the vehicle, although the life does still vary widely depending on cell chemistries, cell architectures and methods for pack integration. It should also be noted that the typical ―end-of-life" criterion for automotive batteries is 80% of original performance (a substantial amount), and motorists who forgo a battery replacement at this point can expect ongoing utility from the battery even as it continues to decline. Unfortunately, battery lifetimes are difficult to predict without several years of accelerated cell and battery testing – both in laboratories and on the road. For this reason, it is possible that manufacturers will bring EV/PHEV products to market before battery lifetime issues are fully understood and resolved. At this time, there are not enough products on the market to gauge how EV/PHEV powertrain warranties will compare with conventional vehicles. On the other hand, alternative business models are also emerging (such as battery leasing currently offered by TH!NK) to shield the consumer from the responsibility of battery monitoring, maintenance and replacement.

2.2.4 Battery Costs

Since the supply chain for automotive lithium-ion batteries is underdeveloped, the process of estimating battery costs is still a very inexact science. Cost estimation is made more difficult by the fact that the automotive industry holds its proprietary battery costs in strict confidence. Nevertheless, a number of studies and surveys have attempted to quantify and project the cost of automotive lithium-ion batteries now and into the future. A common feature of these studies is the use of industry learning curves to model the reduction of battery costs with increasing production volumes.

The CARB expert panel report included a battery cost model based on data obtained through surveys and interviews with key personnel in the automotive battery industry. **Figure 2-2** shows the learning curves from various battery manufacturers. The raw data was also processed into a scalable, generic battery cost model to predict the costs of various battery configurations at a range of production volumes, as shown in **Table 2-3**.

Figure 2-2: Learning curve of battery manufacturers



Source: Kalhammer F., Kopf B., Swan D., Roan V. & Walsh M. (2007) "Status and Prospects for Zero Emissions Vehicle Technology", State of California Air Resources Board, Sacramento.

Table 2-3: Estimated cost of automotive lithium-ion batteries at various production volumes (US $)

Vehicle Type	Battery Capac. (kWh)	Cell Capac. (Ah)	500MWh/year 20k Batteries/year			2500 MWh/year 100k Batteries/Year		
			Product. Rate (MWh/y)	Module Cost ($/kWh)	Battery Cost ($)	Product. Rate (MWh/y)	Module Cost ($/kWh)	Battery Cost ($)
FPBEV	40	120	500 800	285 255	13,680 12,240	2500 4000	195 175	9,285 8,395
Small EV	**25**	**45**	**500** **20**	**380**	**11,875**	**2500** **100**	**260**	**8,150**
PHEV-40	14	45	500 280	380 435	7,075 8,350	2500 1400	260 300	4,850 5,585
PHEV-20	7	30	500 140	435 595	4,305 5,190	2500 700	295 405	2,750 4,025
PHEV-10	4	15	500 80	575 880	3,265 4,990	2500 400	395 605	2,240 3,445
Full HEV	2	7	500 40	805 1,465	2,420 4,395	2500 200	550 1,010	1,650 3,025

Source: Kalhammer F., Kopf B., Swan D., Roan V. & Walsh M. (2007) ―Status and Prospects for Zero Emissions Vehicle Technology", State of California Air Resources Board, Sacramento.
For each application, the table lists module specific and battery total cost projections for limited production rates (left half of table) and in mass production (right half). For each of these two levels of commercialization, cost projections are given for capacity production rates (MWh/year, upper numbers) and for battery production rates (batteries/year, lower numbers).
FPBEV means a full-performance battery electric vehicle and PHEV-40 means a PHEV whose battery provides 40 miles of all-electric operation before the combustion engine turns on.

Other key technologies that are essential for commercial deployment of EVs/PHEVs include electric drivetrain technologies (electric motors and inverters) and onboard/offboard recharging systems.

2.2.5 Electric Drivetrain Technology

Automotive electric drivetrains are approaching technical maturity and have moved significantly down their industry learning curves and production cost curves. Today's electric drivetrain technologies provide very high levels of performance and efficiency with continually-lowering costs and, although there is still scope for further improvement, these components are quite adequate for their task of providing EV/PHEV propulsion. This is largely due to nearly twenty years of development and commercial application in 1st generation EVs, then HEVs, then fuel cell EVs and now lithium-ion EVs and PHEVs. In parallel, a significant Tier-1 supplier base has been established to provide high-volume, high-quality electric drivetrain components to vehicle manufacturers.

2.2.6 Recharging Systems and Charging Efficiencies

Recharging technology has not required as much development to support the coming wave of mass-market plug-in vehicles. Consumer charging systems were developed for 1st- generation EVs and these have been gradually improved upon since. The industry now seems to be converging on common architectures and standards for charging systems that will provide for universal compatibility across the plug-in vehicle fleet. Most notably, the industry seems to have largely abandoned inductive (magnetic) charging systems in sole favour of conductive (electric) charging systems.

Recharging of EVs/PHEVs will require approx 0.15-0.25 kWh/km depending upon vehicle size and powertrain efficiency. Recharging generally varies depending upon the size and weight of the vehicle, as well as its powertrain efficiency and charging circuit topology.

Another positive development has been the definition by the Society of Automotive Engineers of tiered ―levels" of charging capability around which industry is harmonising. These levels are defined in **Table 2-4.**

Table 2-4: Charging levels as defined by the Society of Automotive Engineers

Charger	Circuit Rating	Power	Charging Rate	Charge Time (for 40km)
Level 1	120V/20A (240V/10A for Australia)	2.4kW	0.2 km/min	200mins
Level 2	240V/80A[7]	19.2kW	1.6 km/min	25mins
Level 3	480V/400A 3-phase	192.0kW	16.0 km/min	2.5mins

Source: AECOM / Dr Andrew Simpson

Level 1 charging utilises standard electrical circuits and power outlets and all charging electronics required to support Level 1 can be carried onboard the vehicle. Level 2 charging requires a ―charging interface" to be wired into a building's electricity supply to provide protection from higher voltage/power, and these systems typically involve the use of a specialised plug and socket. Level 2 charging can therefore be performed at home, but only if the appropriate equipment has been installed by an electrician. Level 3 charging greatly exceeds the capabilities of typical residential (and in many cases, commercial) circuits and therefore will not occur at home. It will most-likely only be performed in purpose-built commercial or industrial facilities.

2.2.7 Plug-in Vehicle Safety

Some lithium-ion batteries can be quite hazardous when mis-handled or poorly engineered, and some instances of this have been observed for certain brands of laptop batteries. Fortunately, the use of large-format lithium-ion batteries in vehicles requires a totally different level of focus on system integration including design for safety, crashworthiness and serviceability. Furthermore, the preferred automotive lithium-ion chemistries (e.g. lithium-ion iron-phosphate) are either less-prone to or unable to go into thermal runaway.

Plug-in vehicles for-the-most-part have been and will continue to be engineered to be just as safe to operate, service and transport as conventional vehicles. Established automakers take their safety requirements very seriously in order to avoid liabilities arising from their products, and they have the engineering know-how and resources to guarantee this safety. However, the industry is also acutely aware of the risk that new, small and inexperienced vehicle providers (with fewer resources) may attempt to market products that are not as safe. The use of lithium-batteries in automotive applications is therefore strictly regulated overseas and their safety is promoted via numerous standards for EV/PHEV design. However, the Australian Design Rules have not yet been brought into line with international standards for plug-in vehicle safety.

2.2.8 Plug-in Vehicle Standards

The existence of standards is another key indicator of the commercial readiness of EVs/PHEVs and these have been established by respected industry bodies in North America, Europe and Asia. While these standards are not yet fully-harmonized, the industry is clearly moving in this direction. Locally, the standards for EVs/PHEVs are currently being considered by Standards Australia and it is expected that these will soon be derived from the existing overseas standards.

For example, EV/PHEV standards exist and continue to evolve in the following areas:

- Range, efficiency and emissions testing and labelling;
- Battery design and testing for safety and durability including destructive testing;
- Safety and serviceability of high-voltage electrical systems;

[7] Even though Level 2 charging circuits are single-phase by definition, it is possible that these higher power levels might require a 3-phase supply in some circumstances which would require upgrades to the household service and possibly the street.

- Crashworthiness including destructive testing; and
- Cargo transport of lithium batteries – both within vehicles and as standalone components.

2.3 Likely Evolution of Technology

The future evolution of lithium-ion batteries will see continuing advances in performance, range and useful life as a result of significant ongoing investment in battery R&D. These advances will be enabled by new chemistries as well as innovative re-application of existing chemistries (for example, via nano-engineering). It is quite possible that plug-in vehicles will improve to the point that they achieve the same performance (in terms of driving range and recharging rate) as conventional vehicles. Regardless, it has been determined that the current state of technology is sufficient to enable the commercialisation of these vehicles.

Another significant evolution will be the economies of scale achieved through mass-production, which will drive-down component and vehicle costs. It is also expected that there will cost reductions through industry learning curves as this is still a relatively new market (as illustrated in **Figure 2-2**).

2.4 Uptake of Electric Vehicles

The uptake of plug-in vehicles to-date has been relatively low, but this has been constrained in a large part by the limited availability of EV/PHEV products to consumers.

Hundreds (if not thousands) of 1st-generation EVs from the 1990s are still in use in North America, Europe and Asia today. As lithium-ion EVs and PHEVs become available, it is clear that demand will greatly exceed supply. For example, Tesla Motors is still working to fill approximately 1200 backorders for its Roadster and meanwhile has received over 1000 reservations for its Model S sedan prior to its release. There is also a small but vibrant and growing market for aftermarket plug-in vehicle conversion/retrofit systems.

It is too soon to tell if or when the market for EVs and PHEVs will plateau as the customer base shifts from early adopters to mainstream consumers. However, it is very clear that two key factors will determine the rate of uptake of EVs and PHEVs:

1) Consumer acceptance and demand for EVs/PHEVs based on product attributes of performance, cost, emissions etc. There is significant anecdotal evidence to suggest that consumer appeal is not the limiting factor at this time (as of 2009). Also, in most major automotive markets, governments provide significant consumer incentives (e.g. a $7,500 tax credit in the US) for plug-in vehicles in recognition of their many societal benefits (See **Section 9.6** for further information on policies Governments around the world have adopted to increase the take-up of EVs).

2) Growth in production volumes for EVs/PHEVs driven by industry investment in expansion of manufacturing capacity for vehicles and supply chain for components. There is significant anecdotal evidence to suggest that this factor is currently limiting and will continue to limit the availability and supply (thereby increasing the price) of EVs/PHEVs – particularly due to constraints in the battery supply chain. A secure battery supply has been identified as a strategic issue for many automotive economies with the result that government funding via the current economic stimulus packages in the US and Europe are being used to address this issue.

It is important to recognise that plug-in vehicles are coming to market at a time when consumer and government awareness and receptiveness to alternative vehicle technologies is at an all-time high due to concerns about oil depletion, petroleum prices, air pollution and climate change. These motivating factors are likely to encourage a faster uptake of EVs/PHEVs as an alternative compared to the uptake observed for HEVs and other alternatives in preceding decades.

2.4.1 Comparison with Hybrid-Electric Vehicles

For reference, it is useful to understand the historical uptake of HEVs.

HEV market entry occurred in Japan in 1997 and the US in 2000. Today, the current total market for HEVs in the US is approximately 320,000 vehicles sold annually, composed of approximately 20 different HEV models. Globally, as of February 2009, the total cumulative HEV sales by Toyota and Honda exceeded two million vehicles, and these two automakers have been responsible for the vast majority of HEV sales to date.

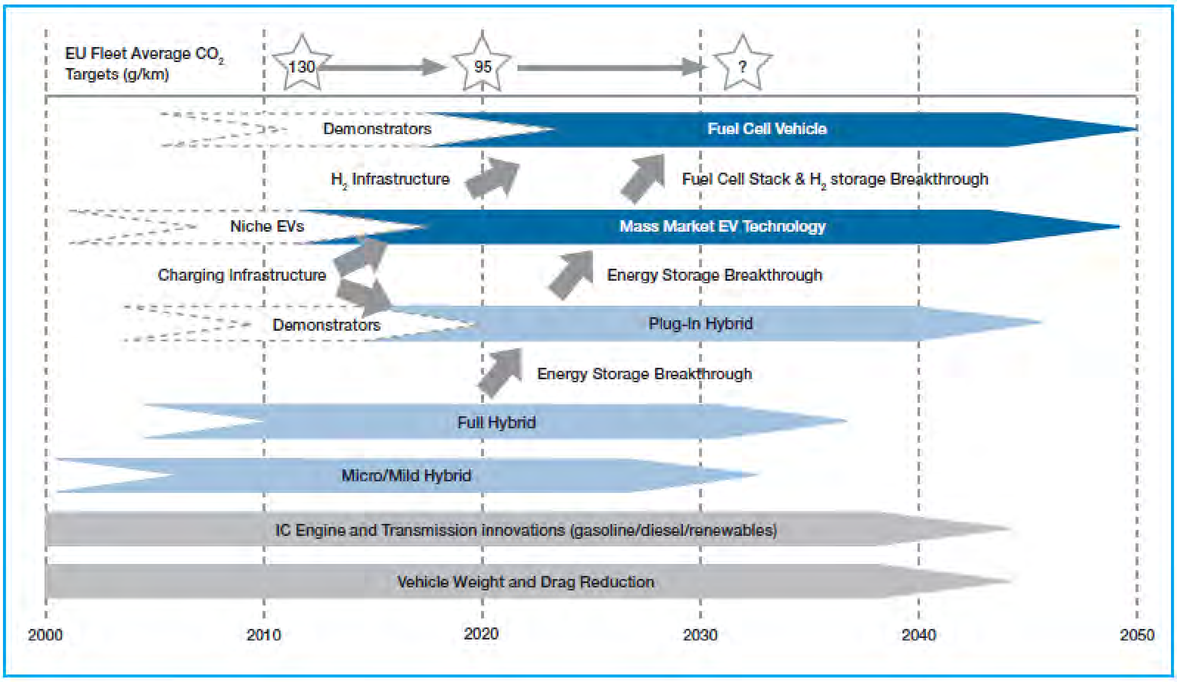
In Australia, almost 12,000 Toyota Priuses have been sold since they were launched here in 2001. The success of HEVs in Australia has been limited by low import volumes and the resulting high price differentials compared to other vehicles.

2.4.2 Other Forecasts of Take-Up of Electric Vehicles

A number of studies have been undertaken to forecast the take-up of EVs. Some recent studies include:

- The UK Government forecast mass production of HEVs by 2010, PHEVs by 2020 and EVs by around 2018 (see **Figure 2-3**);
- Frost & Sullivan[8] estimates that the European market for EVs is likely to be about 480,000 units by 2015 (see **Figure 3-3**);
- Boston Consulting Group forecast that ICE vehicles will remain the dominant technology in 2020. In that year, HEVs, PHEVs and EVs will achieve market penetration rates of between 12-45%, with a steady pace scenario at 28%[9] (Note this relates to total fleet not new vehicles).

Figure 2-3: UK Government expectation of the future of low carbon vehicles in the UK



Source: Ultra–Low Carbon Vehicles in the UK, UK Government 2009

[8] Concerted Government Support Critical for Powering the Electric Vehicle Market, Frost & Sullivan, May 2009
[9] The Comeback of the Electric Car? How real, how soon, and what must happen next, The Boston consulting Group, 2009

3.0 Nature of the Supply Chain and Infrastructure

3.1 Overview of Supply Chain for Vehicles

3.1.1 Plug-in Vehicle Manufacturing and Prices

The supply chain capacity for mass-market plug-in vehicles is currently building in preparation for the market introduction of more than 30 products within the next 3 to 5 years. The plug-in vehicle manufacturers include both established automakers as well as new brands (a complicated mix of new industry joint ventures and start-up companies). **Table 3-1** summarises a selection of EVs/PHEVs for which production plans and initial pricing have been announced.

Table 3-1: Production plans for various EV/PHEV models in the near team

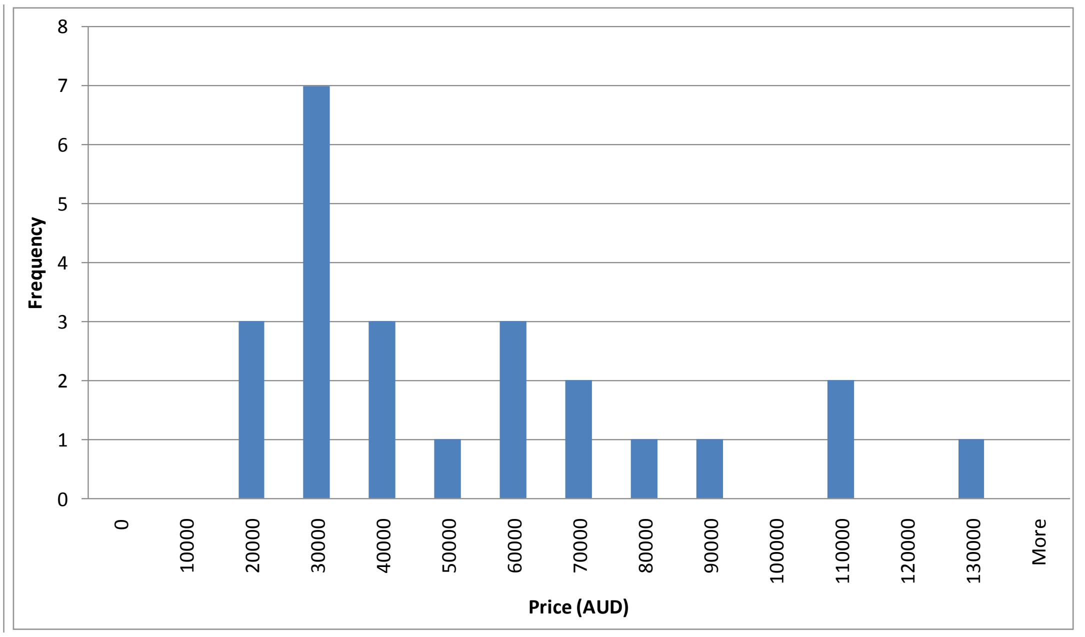
Make	Model	Launch	Initial Pricing	Markets	Production Volumes (Annual)
smart	Ed	2007	US 26,000	EU, NA, Oz	1,000 (pilot)
TH!NK	City	2007	US 44,000	EU, NA	7,000 up to 70,000 in 2012
Blade	Electron	2008	AU 43,000	Oz	200 up to 5,000 in 2011
BYD	F3DM	2008	US 22,000	Asia, EU, NA	6,000 up to 24,000 in 2010
Tesla	Roadster	2008	US 109000	NA, EU	1,500-2,000
Energetique	evMe	2009	AU 70,000	Oz	build-to-order
Mini	E	2009	US 850 p.m.	NA	500 (pilot)
Mitsubishi	iMiEV	2009	US 48,000	Asia, EU, NA, Oz	2,000 up to 30,000 in 2013
Subaru	Stella	2009	US 48,000	Asia	170 (pilot)
Chevy	Volt	2010	US 40,000	NA	10,000 up to 100,000 in 2011
Fisker	Karma	2010	US 88,000	NA	up to 15,000 in 2012
Nissan	EV	2010	US ~30,000	Asia, EU, NA, Oz	50,000
Toyota	Prius PHEV	2010	Unknown	Asia, EU, NA	500 (pilot)
Ford	Focus EV	2011	Unknown	NA	8,000
Renault	Fluence EV	2011	Unknown	EU	40,000 up to 80,000 in 2012
Tesla	Model S	2011	US 57000	NA, EU, Asia	20,000 in 2013
Ford	Escape PHEV	2012	Unknown	NA	5,000
NA = North America, EU = Europe, Oz = Australia and New Zealand					

Source: AECOM study team (Dr Andrew Simpson,) June 2009

The supply of vehicles to Australia could be quite limited in the near term – with vehicles available soon from Mitsubishi and local conversion companies in limited quantities, to be followed by increasing production and other products from Nissan, Smart and other manufacturers. However, the bulk of plug-in vehicles produced in the next few years will be allocated to markets other than Australia. Furthermore, the introductory pricing in Australia for these vehicles will be relatively high – expected somewhere in the range of AU $40,000-$70,000 although for many vehicles Australian pricing has yet to be announced.

Figure 3-1 surveys the announced pricing forecasts across the industry, however it should be noted that these early predictions are frequently subject to change. The prices vary widely from around $20,000 up to over $100,000 reflecting the different vehicle sizes and performance characteristics.

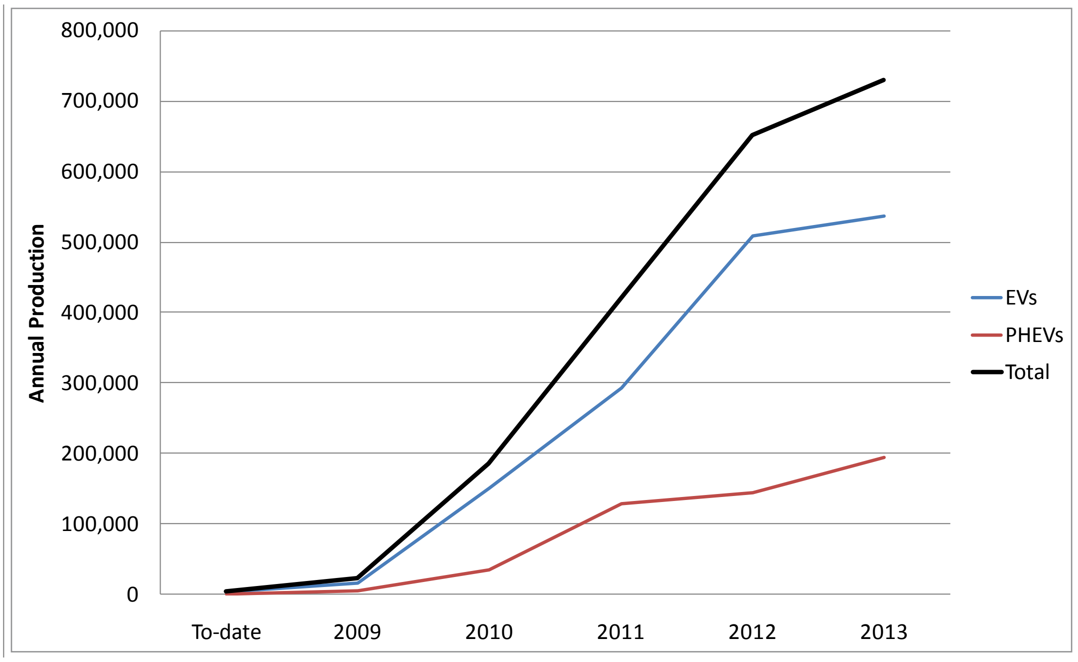
Figure 3-1: Distribution of forecast prices for global production of EVs/HEVs (model launches during 2009-2012)



Source: Table 3.1

Figure 3-2 charts the projected cumulative volumes for EV/PHEV production using announcements made in the automotive media. These targets should be considered as being at the optimistic end of the spectrum but, if true, would see global production volumes approaching one million plug-in vehicles within five years from now.

Figure 3-2: Industry plans for global production of EVs and PHEVs

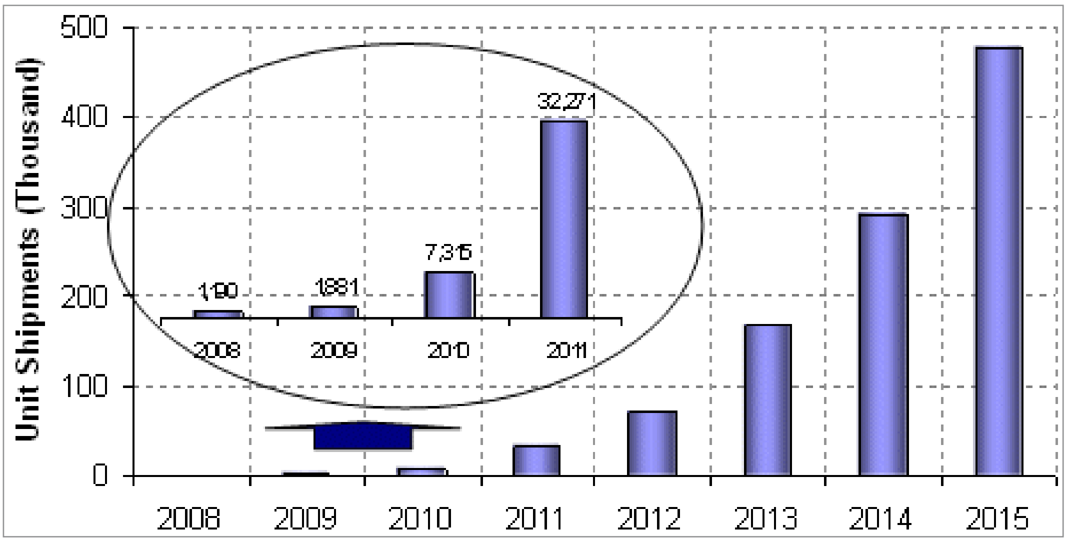


Source: AECOM study team (Dr Andrew Simpson,) using announcements made in the automotive media

This is supported by a study from Frost & Sullivan which estimates that the European market for EVs is likely to be about 480,000 units by 2015. The European market currently accounts for around 30% of global production.[10]

[10] International Organization of Motor Vehicle Manufacturers (OCIA), global survey of production 2007

Figure 3-3: European electric vehicle market forecast, 2008 – 2015



Source: Concerted Government Support Critical for Powering the Electric Vehicle Market, Frost & Sullivan, May 2009

3.1.2 Battery Supply

It was beyond the scope of this study to provide a detailed review of developments in the battery supply chain, however, some general comments should be made.

The majority of today‘s automotive lithium-ion batteries are produced by vendors in Asia (Japan, Korea and China). In most cases, these vendors fall under the umbrellas of the vertically-integrated automotive corporations that is common in the Asian automotive industry. For example, Toyota, Nissan/Renault, Mitsubishi and BYD all effectively assert total control of their battery suppliers – providing them with strategic advantage by denying access to the technologies for their competitors. New battery companies are continually emerging to serve the growing supply-gap, however, these too are often tied-up in strategic joint-ventures with established automakers.

As a result, the variety and quantity of mass-produced automotive lithium-ion batteries available in the open market is actually quite limited. This poses a major barrier for new entrants into the plug-in vehicle industry, and also limits the scalability of aftermarket retrofit plug-in vehicle solutions. The United States has recognised domestic battery supply as an issue of strategic importance and has begun pouring its stimulus funding into expansion of US domestic battery manufacturing facilities.

3.2 Overview of Supply Chain for Charging Infrastructure

As vehicle manufacturers expand their production lines for plug-in vehicles, a number of companies are emerging in parallel to provide private and public recharging infrastructure.

3.2.1 Charging Interfaces

In private locations (residential or commercial), Level 1 charging can occur directly from standard power outlets and specialised charging interfaces are not required, although some customers may choose to install Level 1 interfaces that provide ―smart” charging or other advanced features.

Prominent providers of public Level 1 solutions include Coulomb Technologies (Charge Point) in the US and Australia and Elektromotive in Europe. Each of these companies is currently participating in pilot deployments of plug-in vehicles in North America and Europe. Most PHEVs are equipped to be compatible with Level 1 charging interfaces. The cost of most Level 1 charging interfaces falls in the realm of US$5,000 (for example, Toyota just announced it would begin installing charging stations in Japan at a cost of US$4,560 a piece).

Level 2 options are more limited at this time – and are primarily targeted at EVs with their larger batteries. For example, Tesla Motors provides a Level 2 charging interface as a standard feature in its Roadster (as well as an optional Level 1 charging adapter). Most other EVs come equipped with a Level 2 charging port – although it is not clear which interface solutions will be provided with these products in their commercial deployment, nor is the cost of these Level 2 interfaces well known nor whether they will be included as a standard feature. In terms of open-access infrastructure, Better Place plans for its private/public charge spots to have Level 2 interfaces. With the recent consensus reached in North American and Europe on Level 2 charging standards, there are likely to be many more developments in relation to Level 2 infrastructure in the near future.

Level 3 charging solutions are highly specialised and only exist at the pre-commercial stage. Level 3 charging has been proven in demonstrations by companies such as Nissan, Mitsubishi and Subaru (working with the Tokyo Electric Power Company (TEPCO)) in Asia and Phoenix Motorcars in the USA. Battery swap stations are at a similar stage of pre-commercial development – Better Place recently demonstrated a battery swap station in Japan, but are yet to proceed with their commercial deployment.

Evoasis is a San Diego, California and London, UK based company which develops full service Fast-Charge, EV and PHEV Charging Station Facilities (EVSTAT) for deployment in metro areas and roadway access points in both the public and private sector. EVSTAT Stations are electrical ―Sub-Stations" in their own right, using utility power stored during off-peak generation to supply EV and PHEV battery power at peak demand hours, thereby reducing the load placed on energy utilities during these periods. EVSTAT Stations also generate on-site power from green energy sources built into the structure, with over 6000 square feet of photovoltaic (PV) panels, further reducing station energy dependency during sunrise-to-sunset operating hours.

3.2.2 Electric Utilities

Many electric utilities outside Australia are proactively supporting the deployment of plug-in vehicles. Rather than being concerned by the additional load these vehicles might impose on the grid, they see plug-in vehicles as a lucrative new business opportunity. Some of the more-prominent electric utilities in the plug-in vehicle industry include Southern California Edison (SCE), Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDGE), Xcel Energy in Colorado, Austin Energy in Texas, Electricite de France (EDF) in Europe and TEPCO in Japan. All of these utilities have ongoing participation in pilot commercial deployments of plug-in vehicle fleets, and provide incentives in the form of discounted, plug-in-vehicle-specific tariffs. Most utilities advocate smart-charging technology as a favoured method for managing the charging loads imposed by plug-in vehicles on the grid.

This summary of the benefits of plug-in vehicles to utilities was recently published by Austin Energy:

1. Additional electricity sales
   a) Revenue for the utility or possibly for a third-party service provider.
   b) Higher grid utilization (more energy over same infrastructure) should result in lower rates for customer (also has the potential to impose costs on the utility to enable higher utilization).
2. Distributed resource potential: functioning as either capacity or load
   a) Ancillary services: benefits for both the electric grid and the car owner/customer.
   b) Energy storage: can provide system support or enable a higher penetration of intermittent (solar and wind) generation resources.

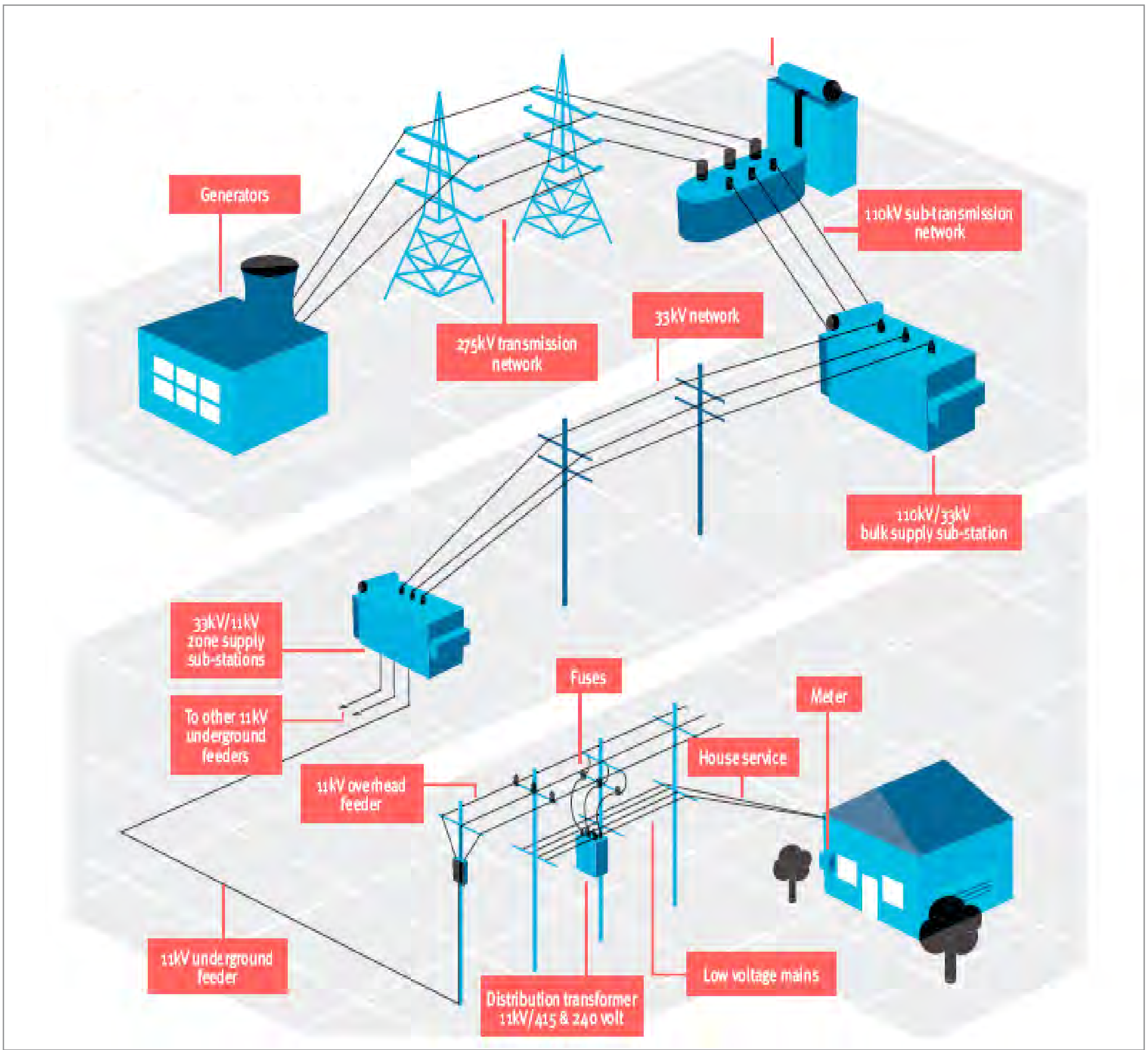
Source: Austin Energy et al (2009) ―Testing of Charge-Management Solutions for Vehicle Interaction with the Austin Energy Electric Grid", technical report, available at:
http://www.v2green.com/news/Austin%20Energy%20PHEV%20Trial%20%20Final%20Report%20-Feb%2009.pdf

Electricity distribution network businesses in Australia have a strong interest in possible deployment of EVs. The vital issue is the extent to which the network may need to be strengthened to supply the additional load that might be due to electric vehicle charging (in the medium term) and to accommodate possible feed back into the grid from a distributed battery system.

The electricity supply system in New South Wales has been separated into different components, as illustrated in **Figure 3-4** below. The main components are:

- Internal wiring within premises, which is the responsibility of the owner;
- Meter, which is generally owned by the network although usage is billed by the retailer;
- Distribution network (low voltage in street back to 110 kV subtransmission), which is the responsibility of the distribution business;
- Transmission network (linking subtransmission and generators), which is the responsibility of the transmission business, TransGrid in New South Wales; and
- Generation, which in eastern Australia is managed through the competitive National Electricity Market.

Figure 3-4: Schematic of electricity supply system



Electric vehicle charging will affect different parts of the supply system differently. Services within the premise are likely to be most affected. Upstream services are less likely to be affected provided that diversity of charging behaviour evens out loads rather than adding to peak load. In fact, overnight charging may improve the shape of the system load by increasing the average but not the peak. It will be important to provide strong incentives for charging outside peak periods.

As set out in **Table 2-4** there are three levels of charging capability for EVs.

Current Level 1 charging infrastructure can be provided through a standard 10 amp power point. This should not require any changes to household wiring or to upstream infrastructure. However it may be desirable to add a basic time-clock so that charging happens outside peak periods when prices are higher (for premises that have time-of-use metering).

Level 2 charging infrastructure will require special wiring within the premise because the connection is greater than 10 amp. In fact a 19.2kW / 80A outlet would probably require an upgrade to the supply service connecting to the low voltage network within the street – possibly even 3-phase connection. This may in turn require an upgrade to the wiring in the street and then in turn back to the 33 kV substation. It is unlikely that any upgrade would be required upstream of the 33kV substations. Clearly significant upgrades to the distribution network would be expensive and the question would arise as to whether such costs should be passed on to all customers or only to those customers requiring Level 2 charging. This issue would need to be considered by the Australian Energy Regulator. That said, upgrades that could be incorporated into long term planning would presumably be included in general price determinations rather than charged only to level 2 customers.

Level 3 charging infrastructure will also require special wiring within the premises and an upgrade to the supply service connecting back to 33 kV substations. High charging loads may also require upgrades back to 110kV subtransmission and possibly even back to the transmission network. Clearly such upgrades to the distribution and transmission network would be expensive and such costs should be passed on those customers requiring Level 3 charging. Current approaches to network pricing already allow customer specific pricing for large customers. Depending on the size and timing of loads, changes in generation dispatch and even investment may also be required. However the Australian National Electricity Market is designed to provide appropriate price signals for dispatch and generation.

There has been some discussion about whether electric vehicle owners would prefer to charge with electricity from renewable sources rather than from the standard mix from the NEM. The supply system allows for customers to purchase ‗GreenPower', which is accredited as having been matched against production of electricity from renewable sources. However the price is higher than ‗black' power that has been used for the modelling in this report and may affect take-up rates.

4.0 Methodology and Assessment Framework

4.1 Overview

As set out in the objectives, the key study aim is to develop an economic model to help address many of the issues surrounding the future of the electric vehicle market. **Figure 4-1** provides an overview of the AECOM methodology. Each of these steps is discussed in more detail below.

4.2 Key Assumptions and Parameters

The key parameters used throughout this study are defined below:

Economic and Financial Evaluation:

This study includes both an economic and a financial evaluation.

The economic evaluation considers the project from a society wide perspective and considers all of the costs and benefits including some effects that are not quantified in monetary terms such as greenhouse gas emissions and air pollution.

The financial evaluation concentrates on the costs and benefits which accrue within the market, including to consumers of vehicles and the vehicle industry.

Discount rate:

A 7% per annum real discount rate is adopted in the economic evaluation to calculate present values. This study also undertakes sensitivity tests at the discount rates of 4% and 10% (NSW Treasury guidance[11]). As real prices have been used in the financial evaluation the same discount rates were used[12].

Price Year:

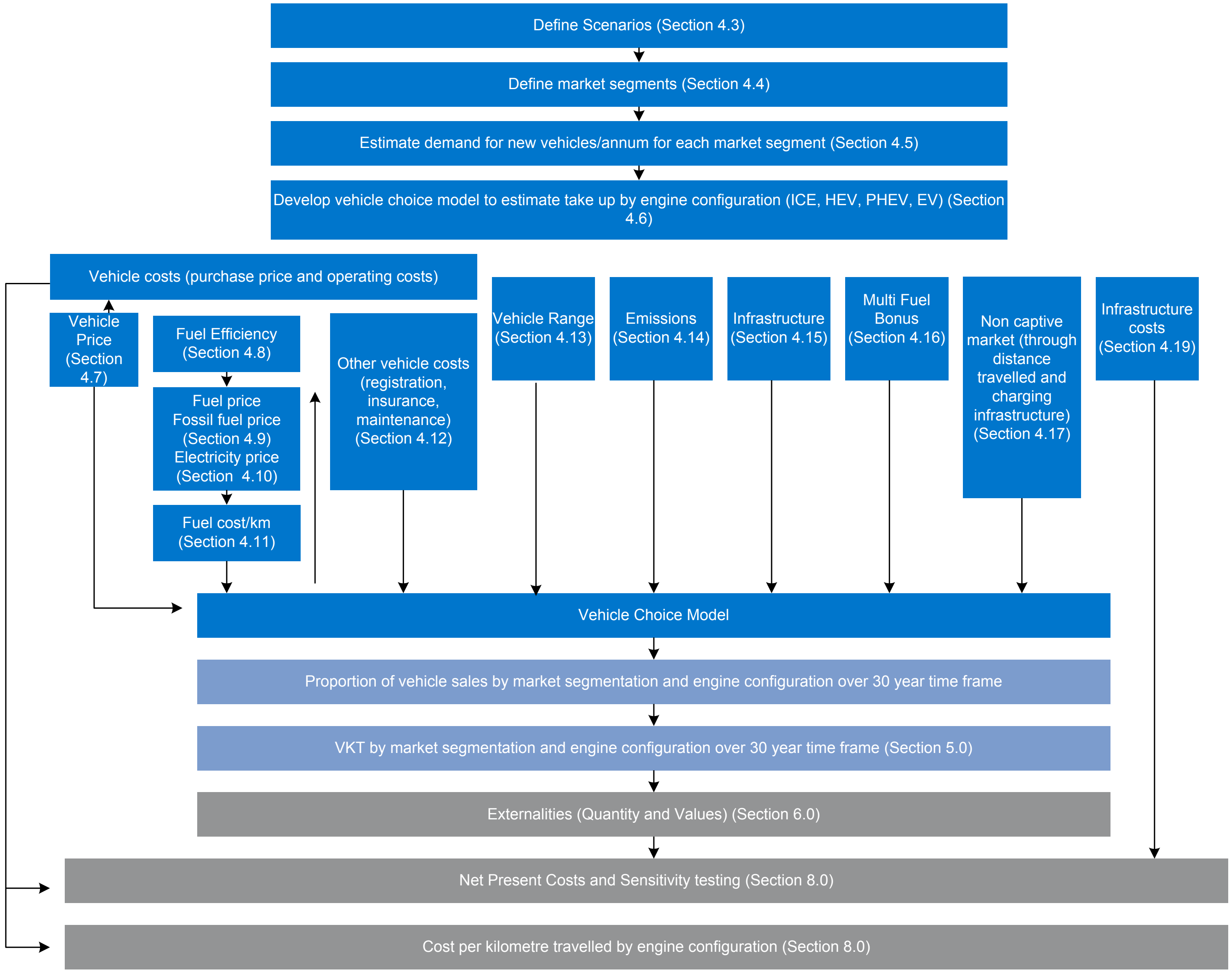
All costs and benefits in the evaluation are presented in 2009 constant prices. Where prices were not in 2009 prices they have been adjusted using the ABS Consumer Price Index (CPI)[13].

Evaluation period:

An evaluation period of 30 years will be applied to this study. The electric vehicle market is expected to see significant changes (in terms of technology, prices and take-up) over the next 30 years. Due to this long time frame anything less than 30 years may not provide meaningful results. 30 years is also the standard timeframe for evaluation of transport infrastructure projects (see Australian Transport Council guidelines[14]).

[11] NSW Government Guidelines for Economic Appraisal (TPP07-5), 2007
[12] The Weighted Average Cost of Capital (WACC) was not used as this evaluation considers costs from both industry and consumers. In addition, the charging infrastructure industry is a new market with no comparable WACC benchmarks available.
[13] ABS Consumer Price Index (Cat. 6401).
[14] National Guidelines for National Transport System Management in Australia, 2006, section 3 Appraisal of Initiatives, 2.2.4 Set the appraisal period, p54.

Figure 4-1: Overview of methodology



4.3 Scenario Specification

This section sets out the scenarios to be tested by the economic model. The model has been built to allow flexibility and sensitivity testing around the key variables. As such, the scenarios are focused around the different levels of infrastructure that may be required to facilitate the electric vehicle market. The level of infrastructure will affect the demand for EVs through charging convenience and cost. It will also be a significant factor in the cost side of this cost benefit analysis.

The charging requirements of EVs will vary depending on a number of factors including the size of the battery, how depleted it is, and the rating for the charging circuit. As such, it is best to think about battery recharging times is in terms of ―kilometres-per-minute". As set out in **Section 2.2.6**, there are currently three different charging levels available for EVs:

- **Level 1** charging only requires a standard power outlet, since all charging electronics required to support Level 1 can be carried on board the vehicle.
- **Level 2** charging requires a ―charging interface" to be wired into a building's electricity supply to provide necessary protections from the higher voltages/powers. Level 2 charging can therefore be performed at home, but only if the appropriate equipment has been installed by an electrician.
- **Level 3** charging greatly exceeds the capabilities of typical residential (and in many cases, commercial) circuits and therefore will not occur at home. It will most-likely only be performed in purpose-built commercial or industrial facilities.

4.3.1 Base Case

The Base Case, is the scenario against which the other scenarios will be compared. The base case will assume there are only ICEs and HEVs available and no PHEVs or EVs.

4.3.2 Scenario 1: Household Charging Only (Level 1)

Scenario 1 assumes that there is Level 1 household charging only.

4.3.3 Scenario 2: Household Charging (Level 1 and 2) plus Public Charging Stations

Scenario 2 assumes that there is Level 1 and Level 2 household charging (it is possible to switch between a slow and fast charge) and Level 1 and Level 2 public charging available within the NSW Metropolitan region[15]. Public charging at this level typically takes place in car parks, hotels, shopping centres, street parking. Level 1 public charging is available in California and many cities in Europe, as highlighted by **Figure 4-2** and **Figure 4-3**. With the recent consensus reached in North American and Europe on Level 2 charging standards, there are likely to be developments in relation to Level 2 infrastructure in the near future.

[15] It is possible that Level 2 charging will require 3-phase which would require upgrades to the household service and possibly the street.

Figure 4-2: Public charging facilities, California

Source: Zoomlife, sourced 1 June 2009

Figure 4-3: NCP car park, London

Source: Zoomlife, sourced 1 June 2009

4.3.4 Scenario 3: Household Charging, Public Charging Stations plus Electric Vehicle Service Stations

Scenario 3 assumes that there is Level 1 and Level 2 household charging (it is possible to switch between a slow and fast charge), Level 2 public charging available within the NSW Metropolitan region and electric vehicle service stations that offer quick charge or battery replacement.

Whilst electric vehicle service stations are not currently available, many companies are indicating they plan to move into this space:

- EVOASIS, an American firm, recently announced plans to convert abandoned petrol stations in London to electric charging stations for EVs (see **Figure 4-4**);
- In May 2009, the first public high voltage charging station for EVs was installed at the Gateway Center in East Woodland California; and
- Better Place recently demonstrated a battery swap station in Japan, but are yet to proceed with their commercial deployment.

Figure 4-4: Proposed charging stations in London

Source: Zoomlife, sourced 1 June 2009

4.4 Define Market Segmentation

4.4.1 Define Study Area

The study area is defined as "Metropolitan NSW" which includes the Sydney Statistical Division, Illawarra Statistical Division and the Newcastle Statistical Subdivision. As a result, all rural areas are excluded from the analysis.

4.4.2 Define Market Segmentations

The model to assess the cost and benefits of EVs needs to balance practicability and accuracy. In order to ensure accuracy, a number of different market segments have been defined. As CSIRO (2008)[16] observed:

"In theory one could construct a model of the Australian transport sector which included every make of existing vehicle and possible future vehicles. In practice, modellers will always seek to reduce the size of the vehicle fuel/technology set in order to make the model manageable in terms of data, model structure and mathematical solution speed and reliability". (CSIRO, 2008)

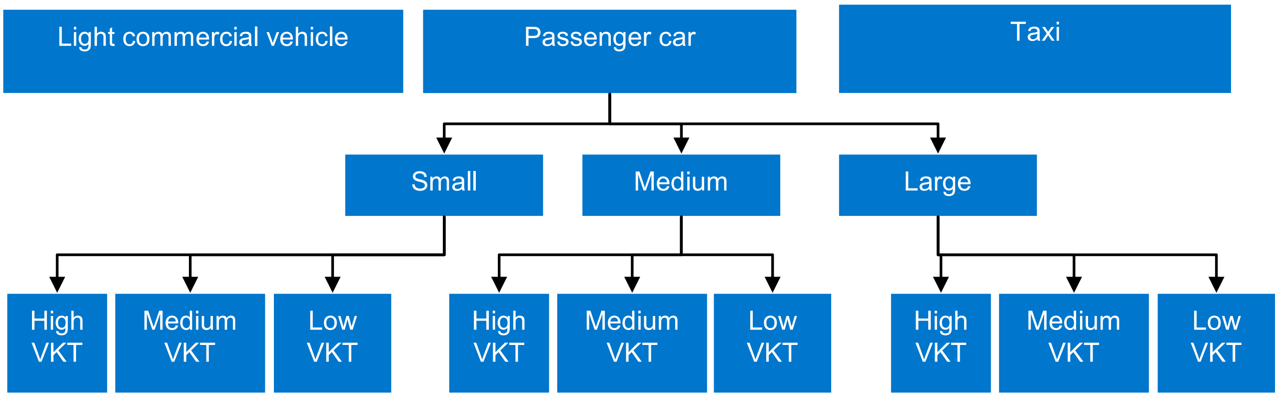
For simplicity, the vehicle market is segmented according to:

- Vehicle type;
- Vehicle size; and
- Distance travelled.

Figure 4-5 provides an overview of the market segmentation. In total, there are eleven market segments and each of these is discussed in more detail below.

[16] Modelling of the future of transport fuels in Australia – A Report to the Future Fuels Forum, CSIRO 2008

Figure 4-5: Overview of market segmentation



Vehicle Type

This study has focused on three vehicle types where EVs have the biggest potential impact:

- Passenger car;
- Light commercial vehicle; and
- Taxi.

Note that engine size and VKT ranges are not distinguished for light commercial vehicles or taxis. This is considered reasonable as the VKT distribution for these types of vehicles is likely to be more narrowly grouped around the average. For example, taxis are generally used around the clock. Moreover, engine size variations are not expected to be as significant for light commercial vehicles and taxis as they are for passenger cars. In addition, the number of vehicles in these categories is considerably smaller than in the passenger car category.

It has been assumed that in the majority of fleets individuals make the purchase decision instead of the purchaser and most fleet vehicles are taken home at night. As such, fleet vehicles have not been treated separately.

Vehicle Size

For passenger cars, vehicles are distinguished according to size. Vehicle size is an important category to consider as it will impact on the potential externality emissions. Also, as highlighted in Section 2, there are likely to be variations in the availability of PHEVs and EVs depending on vehicle size as well as different market take up between different sized vehicles.

While size can be measured by both weight and engine size, for the purposes of the model it was considered more practical to differentiate by engine size. This better captures differences in externality emissions and allows distribution of distance travelled to be modelled. In addition, weight categories do not easily translate to EVs/PHEVs since they are typically heavier than conventional technologies. Three engine sizes are distinguished:

- Small engine – up to 1.8 litres;
- Medium engine – between 1.8 and 3.0 litres;
- Large engine – above 3.0 litres.

Distance Travelled

Passenger vehicles have also been distinguished by the average vehicle kilometres travelled. This is an important factor as the expected VKT, and hence fuel efficiencies, will influence the financial viability of buying different types of vehicles.

Data from TDC's Household Travel Survey[17] was used to assess the distribution of VKT for each vehicle size. As a result, daily vehicle kilometres travelled for passenger vehicles are distinguished as:

- Low – 1 to 20 km ;
- Medium – 21 to 60 km; and
- High – above 61 km.

4.4.3 Define Engine Configuration

In addition to the market segmentation according to vehicle type, size and VKT, different types of engine configurations have to be distinguished, namely:

- ICE vehicles – internal combustion engines such as petrol, diesel, gas;
- HEV – non plug-in hybrid vehicles;
- PHEVs – plug-in hybrid vehicles; and
- EVs – electric vehicles.

4.5 Estimate Demand for New Vehicles per Annum

4.5.1 Methodology

Demand for new vehicles has been projected from historical new vehicle sales. It has been assumed that future growth in new vehicle sales is consistent with historical growth. Trend estimates for annual growth are calculated from new vehicle sales data spanning 2000 to 2008. Vehicle sales for each vehicle type are then projected forward to 2040 growing from the initial (actual) 2008 value. For the passenger vehicle market, demand for new vehicle sales in individual segments is calculated as a proportion of total passenger vehicle demand based on assumptions for market share by vehicle size and historical VKT.

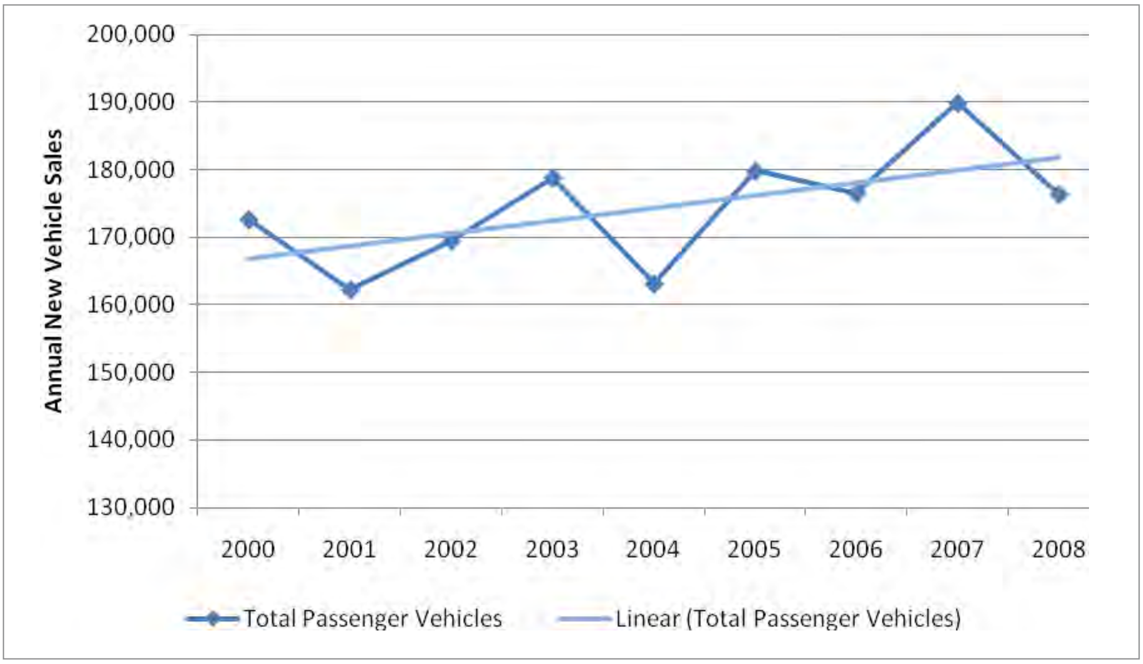
It is therefore assumed that the decision of whether or not to buy a car is independent of the available engine configuration technologies.

4.5.2 Historic Data and Total Passenger Vehicle Projections

Figure 4-6 provides an overview of total passenger sales of new vehicles for the Sydney, Newcastle and Wollongong metropolitan area. The data provided by the NSW RTA shows large annual fluctuations in vehicle sales.

[17] 2006 Household Travel Survey Summary Report - 2008 Release, TDC 2008

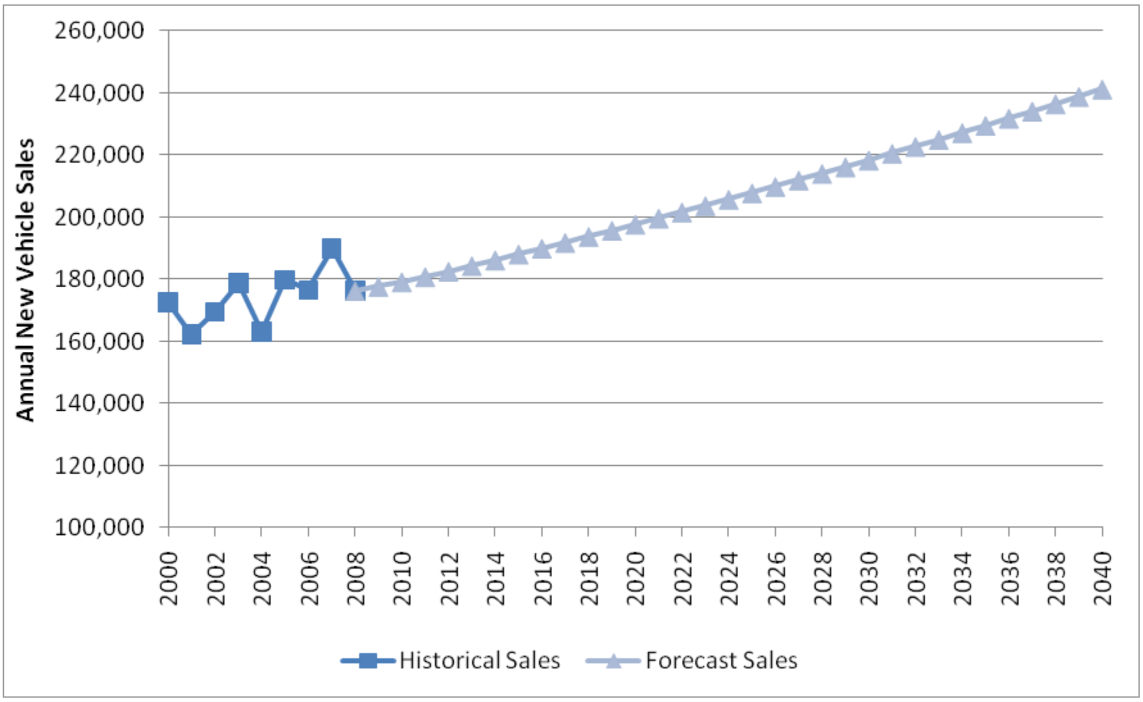
Figure 4-6: Annual new passenger vehicle sales



Source: AECOM calculations based on data provided by RTA.

By analysing the trend in growth of vehicle sales over these nine years it was seen that the growth in vehicle sales was increasing by around 1% per annum It was decided to cap the growth rate at this level as an accelerating rate could not be justified with the limited data available. **Figure 4-7** shows forecast passenger vehicle sales in relation to historical vehicle sales.

Figure 4-7: Forecast Passenger Vehicle Sales



Source: AECOM calculations based on data provided by RTA.

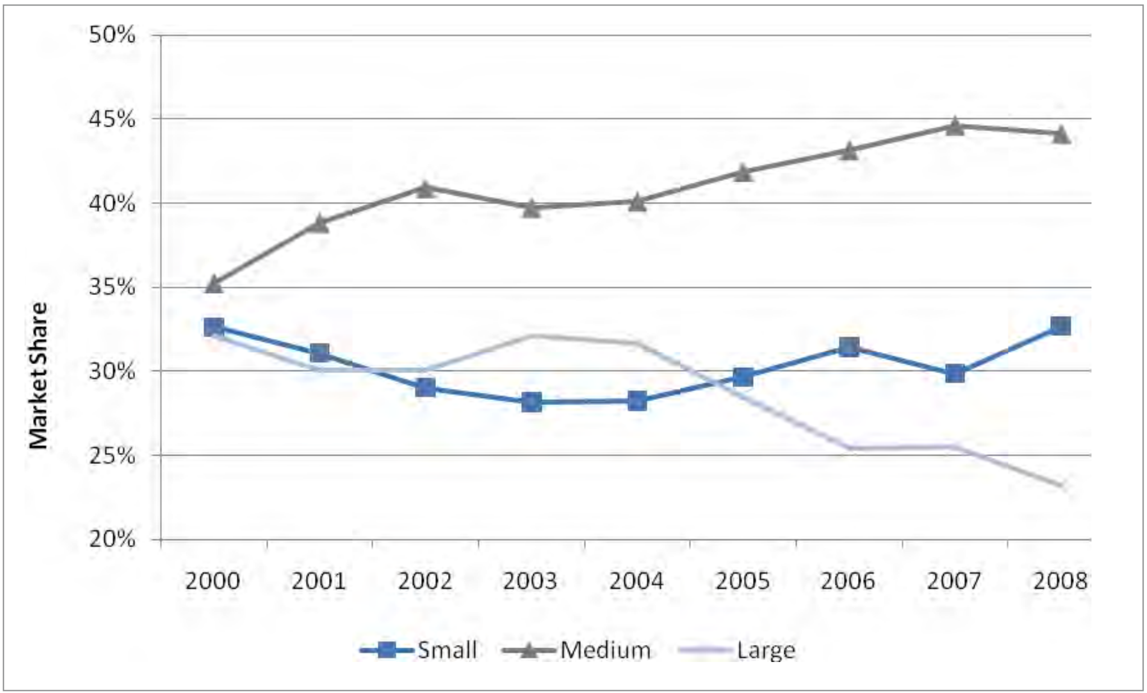
4.5.3 Projections by Size and VKT

There are two reasons why total projections of new vehicles need to be differentiated by vehicle size and the VKT driven:

- PHEVs and EVs will not be available in all vehicle sizes at the same time; and
- The demand for PHEVs and EVs is likely to differ when considering different vehicle sizes and anticipated VKT. For example, high VKT vehicles benefit more from the cheaper cost of using electricity as a transport fuel.

Figure 4-8 shows annual vehicle sales by vehicle size. The data shows there has been a shift in demand away from large passenger vehicles to medium sized passenger vehicles in the last decade. As consumer preferences for different size vehicles are changing and will likely continue to change over time it has been assumed that the current market share for each vehicle size will continue to change over the forecast years.

Figure 4-8: Annual new passenger vehicle sales by vehicle size



Source: AECOM calculations based on data provided by RTA.

Extrapolating the current trend in sales away from large vehicles towards medium sized vehicle, the market share in 2020 would be 30%, 55% and 15% for small, medium and large vehicles respectively. It is assumed that the shift in demand will stabilise at this point as there will always be a segment of the market who prefer large vehicles. **Table 4-1** shows assumptions for shares of the passenger vehicle market by vehicle size.

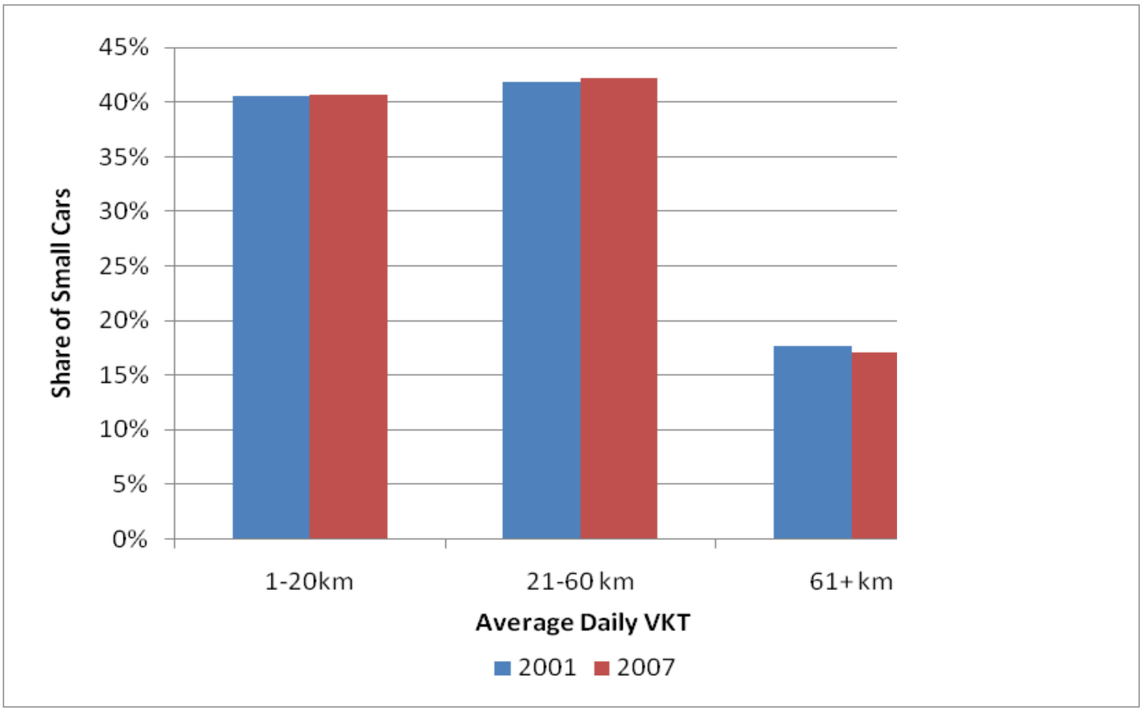
Table 4-1: Passenger vehicle market share by vehicle size assumptions

Vehicle Size	2000	2008	2020	2030	2040
Small	30%	30%	30%	30%	30%
Medium	37%	45%	55%	55%	55%
Large	33%	25%	15%	15%	15%

Source: AECOM

VKT data for each vehicle size was sourced from the Household Travel Survey (Transport Data Centre) for 2001 and 2007. This allowed the three vehicle size market segmentations of the passenger vehicle market to be further disaggregated into low, medium and high daily VKT. For each vehicle size there was no significant change in the share of vehicles in each average daily VKT group. **Figure 4-9** shows the average daily VKT travelled by small cars in 2001 and 2007.

Figure 4-9: Average daily VKT travelled by small vehicles



Source: NSW Transport Data Centre

With historical data showing no clear increase or decrease in the average daily VKT for passenger vehicles, the proportion of each vehicle size category in each VKT range was assumed constant at the 2007 level. As a result the total VKT travelled by each vehicle category will increase only with an increase in total number of vehicles, as VKT for individual vehicles is assumed to be constant. **Table 4-2** shows the proportion of VKT ranges in each vehicle category.

Table 4-2: Proportion of VKT ranges in each vehicle size category

VKT range	Small (0-1.8L engine)	Medium (1.8 -3L engine)	Large (greater than 3L engine)
Low (1-20km)	41%	37%	35%
Medium (21-60km)	42%	43%	42%
High (above 61km)	17%	20%	24%

Source: NSW Transport Data Centre

The projections of overall passenger vehicle sales shown in **Figure 4-7** can therefore be combined with the proportions of vehicles in each size and VKT category. It is assumed that VKT proportions will be unchanged in the future. **Table 4-3** provides the projections of new registrations by size and VKT range.

Table 4-3: Projections of new passenger vehicle sales by size and VKT

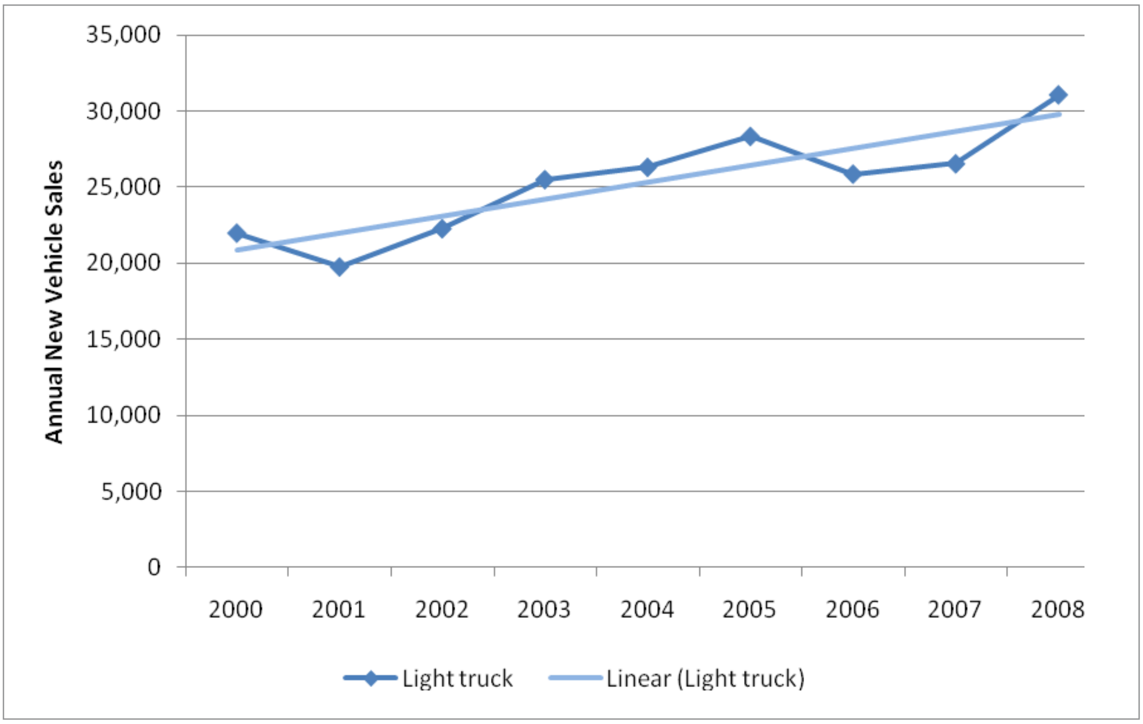
Year	Small (0-1.8L engine)			Medium (1.8 -3L engine)			Large (greater than 3L engine)		
	Low VKT	Medium VKT	High VKT	Low VKT	Medium VKT	High VKT	Low VKT	Medium VKT	High VKT
2010	21,858	22,715	9,181	30,814	36,295	16,509	14,457	17,459	9,893
2015	22,928	23,826	9,631	35,207	41,470	18,863	12,456	15,043	8,524
2020	24,097	25,041	10,122	40,036	47,158	21,450	10,246	12,373	7,011
2025	25,327	26,319	10,638	42,078	49,563	22,545	10,768	13,004	7,369
2030	26,618	27,661	11,181	44,225	52,091	23,695	11,317	13,668	7,745
2035	27,976	29,072	11,751	46,481	54,749	24,903	11,895	14,365	8,140
2040	29,403	30,555	12,351	48,852	57,541	26,174	12,501	15,098	8,555

Source: AECOM

4.5.4 Projections for Light Commercial Vehicles

As with passenger vehicles, projections for demand for new light commercial vehicle sales are estimated from historical sales data. Historical light truck sales are presented in **Figure 4-10.**

Figure 4-10: Historical sales – light trucks



Source: AECOM calculations based on data provided by RTA.

The average annual growth in vehicles sales between 2000 and 2008 was around 5%. This strong growth is expected to continue in the medium to long term. BITRE (2007) observed that

"Annual growth in total VKT by LCVs has averaged between 3 and 4 per cent for well over 20 years, and the base case essentially continues this trend to 2020, with continued (projected) economic growth leading to continued VKT growth. This relatively high level of commercial traffic growth is predicated on the assumption that there will be no decoupling of activity in the freight and service sectors from overall income trends (i.e. GDP per person) during the projection period." (BITRE, 2007)

As data from the NSW Transport Data Centre shows no significant changes in the average VKT travelled by individual LCVs, the increased total VKT would be related to the increase in the total fleet size. Therefore the growth in LCV sales has been assumed to remain high at 5% per annum, as per the trend for the past eight years, declining annually to 3% per annum by 2030, as per BITRE's long run growth projections. Projected sales figures are shown in **Table 4-4**.

Table 4-4: Projections for new light commercial vehicle

Year	LCV
2010	34,193
2015	42,781
2020	52,467
2025	62,919
2030	73,651
2035	85,382
2040	98,981

Source: AECOM

4.5.5 Projections for Taxis

According advice from the Ministry of Transport, there are currently 6,571 taxis licensed to be on the road in NSW. It is estimated that around 80% are in Sydney and 85% are in the Greater Metropolitan Region (GMR). Metro taxis must be replaced when they reach six and a half years.

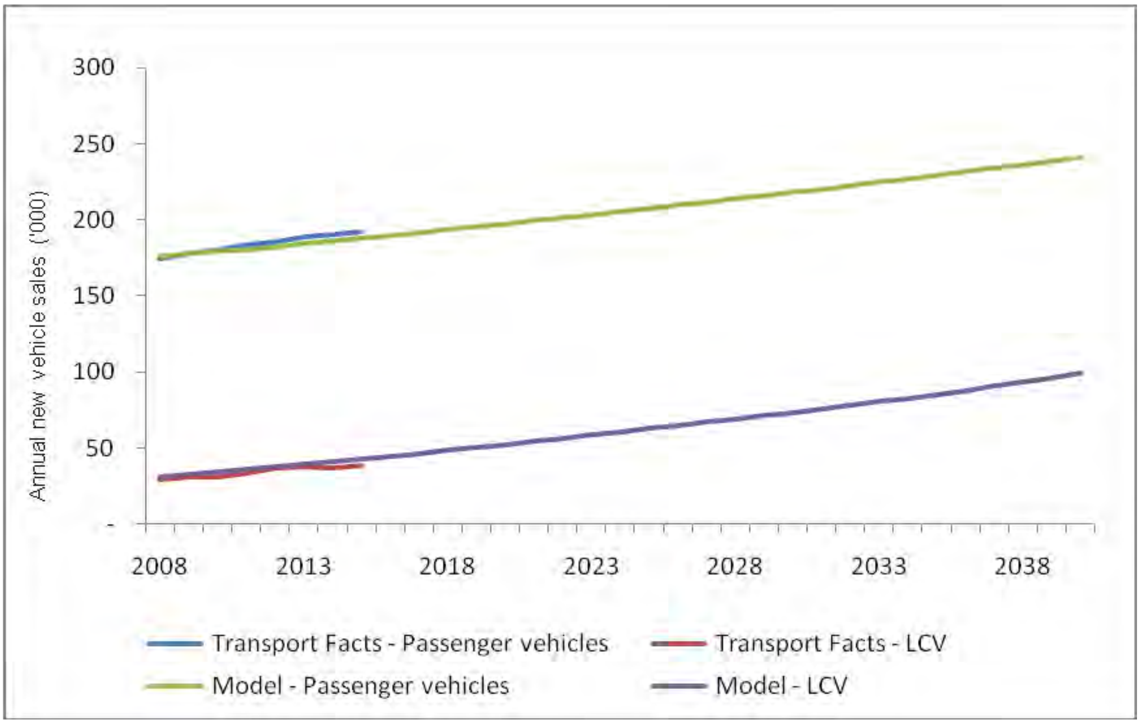
This has been used to estimate the number of new vehicles per annum. It has been assumed that there will be no growth in total taxi vehicles as the licences are regulated.

4.5.6 Validation of Projections

The NSW Transport Facts 2007 report[18] forecasts new vehicle sales out to 2015 for NSW. Passenger sales for the Greater Metropolitan Region (GMR) have averaged around 71% of total NSW sales since 2000 and light commercial vehicles have averaged around 60%. **Figure 4-11** shows the NSW projections scaled down to the GMR are consistent with the GMR forecasts using the assumptions set out above.

[18] NSW Transport facts 2007, Apelbaum Consulting, April 2007

Figure 4-11: Forecast comparison



Source: NSW Transport Facts 2007, AECOM

4.5.7 Average VKT

In order the derive the total VKT by vehicle type, the projected number of vehicles in each size and VKT category is multiplied by the average annual VKT. **Table 4-5** sets out the average daily vehicle kilometres travelled for each of the market segments.

Table 4-5: Average VKT

	Small Cars	Medium Cars	Large Cars	LCV	Taxi
Average daily VKT					
Low VKT (1-20km)	11.4	11.3	11.6	64.4	356[19]
Medium VKT (21-60km)	39.3	40.3	40.2		
High VKT (61+km)	111.2	116.3	125.7		
Average annual VKT					
Low VKT (1-20km)	4,158	4,132	4,217	23,502	130,000
Medium VKT (21-60km)	14,332	14,708	14,655		
High VKT (61+km)	40,570	42,446	45,875		

Source: AECOM calculations based on passenger and light commercial vehicle data from household travel survey, Taxi data from IPART Review of Taxi fares in NSW

[19] IPART 2008 Review of Taxi fares in NSW assumes an average VKT of 130,000 in Urban areas.

4.6 Estimate Number of Vehicles Purchased by Type (ICE, HEV, PHEV, EV)

Many models do not estimate take up of different engine configurations and instead make assumptions based on experience elsewhere. This study has decided to directly estimate take up for two reasons. Firstly, as this is a new market there is not a lot of information on past experience with which to draw meaningful assumptions about the future of electric vehicles in Australia. Secondly, by directly estimating take up it will be possible to consider the impact of various potential sensitivities around prices (electricity price, fuel price, vehicle price) and how these affect take up.

Much of the research on electric vehicles has focused on the US market. Although the US has the lowest retail fuel prices, US motorists have greater exposure to fuel price fluctuations in proportional terms as fuel taxes and excises make up a low proportion of the pump price. Arguably, this trait is a key contributing factor to a relative wealth of research undertaken in the US.

4.6.1 The Role of Stated Preference

In the absence of an established market for electric vehicles, research has focused on the collection of stated preference data in order to estimate relative demand for electric vehicles. However, it is becoming increasingly recognised that choice modelling based on stated preference data alone may not accurately predict choices made within a real market. This disparity is mainly attributable to the fact that respondents react differently under hypothetical situations, whereby they may:

- Not completely understand the attributes associated with a new product/service;
- Consider information that may not have had perfect information on or accounted for in a real market; and
- Consider information outside the experiment in making their choices;

Stated preferences may also be subject to various types of biases. For instance, Brownstone et al. (2000)[20] found that respondents tended to choose sports cars and low emission vehicles under a stated preference exercise. By contrast, after reviewing revealed preference data, these respondents were purchasing non-luxury cars and high emission vehicles.

However, without a large scale electric vehicle market in which revealed preference data can be used to calibrate vehicle choice models, stated preference techniques will continue to predominate.

4.6.2 The Impact of Heterogeneity in Preferences

In contrast, more progress has been achieved in capturing the heterogeneity in the vehicle decision making process. In terms of *vehicle type*, consumers have a wide range of vehicles to choose from. Vehicle models vary by:

- Size (small, medium, large);
- Chassis (sedan, wagon, ute, 4WD, sports etc);
- Fuel type (petrol, diesel, LPG, CNG etc); and
- Power and acceleration etc.

Not only are there various types of models but the factors that influence the choice of one vehicle type over another are also widely varied. Apart from capital, maintenance and operating costs, vehicle choices may be influenced by:

- Brand;
- Range;
- Fuel economy;

[20] Brownstone, D., Bunch, D.S. & Train, K. (2000), *Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles*, Transportation Research Part B, Volume 34, Issue 5, pp. 315-338

- Emissions; and
- Socio-economic factors (income, gender, age, household size, education).

Hence, in order to capture the large heterogeneity in vehicle choice, vehicle choice models have become increasingly sophisticated, both in terms of the modelling techniques and the range of explanatory variables used.

Nested and mixed logit models have been used to capture heterogeneity in preferences:

- Bunch et al (1993)[21] estimated nested logit models in which a two level nest, electric versus non-electric, was found to be statistically significant
- Brownstone et al. (2000) estimated mixed logit models and found that alternative specific constant for electric vehicles and alternative fuel vehicles, whilst being negative, had a large range (some people like them whilst many people dislike them)

There is emerging evidence to suggest that sensitivity to various attributes differs by group. Whilst mixed logit provides a possible environment to explore these variations in sensitivity, work undertaken by ANL (2005)[22] and Mau et al. (2008)[23] suggest that early adopters of electric vehicle cars will have different purchasing habits to mainstream purchasers:

- ANL (2005) finds that early adopters have different purchasing habits to the majority (e.g. are less price sensitive or value fuel savings higher)
- Mau et al. (2008) find a neighbourhood effect whereby EV price sensitivity increases whilst EV ―bonus" decreases significantly with time as mainstream purchasers enter the market.

4.6.3 Review of Current Literature

As a first step towards the development of an electric vehicle choice model, a literature review of key electric vehicle choice models has been undertaken. This literature review uncovered that key factors influencing vehicle choice, be it electrically powered or not, include:

- Purchasing cost;
- Operating cost/fuel costs;
- Availability of refuelling facilities;
- Range; and
- Multi-fuel capacity.

Parameters in multinomial logit models are best interpreted when interpreted as relative values. When parameter values are compared appropriately against a cost parameter, other parameter values can be interpreted as willingness to pay values. These values show the additional vehicle purchase price consumers are willing to pay in order to secure improvements in certain vehicle attributes.

Willingness to pay (in terms of an increase in the purchase price) for improvements in electric vehicle attributes by study is outlined in **Table 4-6**. All estimates are in 2009 prices and in Australian dollars.

[21] Bunch, D.S., Bradley, M., Golob, T.F., Kitamura, R. & Occhiuzzo, G.P. (1993), *Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Pilot Project*, Transportation Research A, Vol 27A, No. 3, pp 237-253.
[22] Santini, D.J. and Vyas, A.D. (2005), Suggestions for a New Vehicle Choice Model Simulating Advanced vehicle Introduction Decisions (AVID): Structure and Coefficients, Argonne National Laboratory Report ANL/ESD/05-1.
[23] Mau, P., Eyzaguirre, J., Jaccard, M., Collins-Dodd, C. & Tiedemann, K. (2008), *The `neighbor effect': Simulating dynamics in consumer preferences for new vehicle technologies*, Ecological Economics, Volume 68, Issues 1-2, pp. 504-516

Table 4-6: Willingness to Pay (In 2009 $A)

Study *Country*	**Improvement in fuel efficiency by 1c per km**	**Improvement in range from 100km to 200km**	**Decrease in emissions to 90% of ICE emissions**	**Increase in recharging facilities from 10% to 20% of petrol stations**	**Multi-fuel capacity**
Bunch et al. (1993) *USA*	$1,800	$16,400	$1,200	$3,600	$10,400
TRESIS (undated)[24] *Australia*	$500	$1,900			
Brownstone et al. (2000) *USA*	$2,500	$14,700	$400	$400	
Dagsvik et al. (2002)[25] *Norway*	$1,000	$3,600			
Ewing & Sarigollu (1998)[26] *Canada*		$1,600	$400		
Golob et al. (1996)[27] *USA*	$3,300	$11,200		$1,800	
Average	$1,820	$8,233	$667	$1,933	$10,400
Midpoint	$1,900	$9,000	$800	$2,000	$10,400
Minimum	$500	$1,600	$400	$400	$10,400
Maximum	$3,300	$16,400	$1,200	$3,600	$10,400

Source: AECOM

4.6.4 Model Development

In emerging markets such as electric vehicles, establishing vehicle market shares requires the development of primary data from stated preference surveys.

In the absence of such data, one common practice is to adopt parameter values from previous stated preference studies. In this context, AECOM have chosen to develop a synthetic multinomial logit choice model to forecast future market shares for ICE, HEVs, PHEVs and EVs. Notwithstanding that heterogeneity in vehicle choice is a well established phenomenon, AECOM have chosen to use a multinomial logit structure as it is transparent, easily understood by stakeholders and does not require assumptions on the degree of heterogeneity in choice, which would be required if a more sophisticated choice model were developed.

AECOM's synthetic multinomial logit model uses the following variables in its vehicle choice model, for which AECOM has developed projections into the future:

[24] TRESIS (undated), available at http://www.itls.usyd.edu.au/__data/assets/pdf_file/0014/30830/ITS-RR-01_01.pdf
[25] Dagsvik J.K., Wennemo T., Wetterwald D.G., Aaberge R. (2002), *Potential demand for alternative fuel vehicles*, Transportation Research Part B, Vol. 36, Iss. 4, pp. 361-384.
[26] Ewing G.O., Sarigollu E. (1998), *Car fuel-type choice under travel demand management and economic incentives,* Transportation Research Part D, Vol. 3, Iss. 6, pp. 429-444.
[27] Golob, T.F., Torous, J., Bradley, M., Brownstone, D., Crane, S.S. (1996), Commercial Fleet Demand for Alternative Fuel Vehicles in California, Transportation Research A, Vol 31, No. 3, pp 219-233.

- Vehicle price;
- Running costs;
- Vehicle range;
- Tailpipe emissions;
- Availability of recharging infrastructure;
- A multi-fuel vehicle constant; and
- Constants for each vehicle type.

Parameters for each of these variables have been based on judgments on:

- Relative parameter values guided by willingness to pay values extracted from previous studies;
- The scale of the parameter values guided by known elasticities; and
- Initial market shares by existing vehicle classes.

As a first step to developing these parameters, AECOM have assumed a set of willingness to pay values in relation to fuel efficiency, range, emissions, recharging infrastructure and multi-fuel capacity. These assumptions are shown in **Table 4-7** and are within the bounds estimated in **Table 4-6**

Table 4-7: AECOM Willingness to Pay Values for Five Vehicle Attributes (2009 $A)

Measure	Improvement in fuel efficiency by 1c per km	Improvement in range from 100km to 200km	Decrease in emissions to 90% of ICE emissions	Increase in recharging facilities from 10% to 20% of petrol stations	Multi-fuel capacity
Value	$1,050	$3,000	$500	$2,000	$5,000

Source: AECOM

In developing this set of willingness to pay assumptions, it should be noted that that there is significant variance in willingness to pay for improvements to vehicle attributes and for conservatism, have assumed lower willingness to pay values. The following points have also guided our thinking:

- Willingness to pay for fuel efficiency assumes that Australian drivers clock up on average 15,000km p.a. A 1c/km saving equates to a saving of $150 p.a. A $1,050 upfront payment is equivalent to 10 years of fuel savings, discounted at 7 percent p.a.
- Willingness to pay for range seems to be quite high in the US – typical of the long distance driving patterns that are typical in the US – a slightly lower WTP has been assumed for Australian conditions – set closer to the Norway figure.

As the next step to developing parameters for each variable, the absolute value of the fuel cost parameter was established. In multinomial logit models, direct price elasticities can be estimated using the values of the beta parameter, price (as represented by X) and the market share (as represented by p) as shown in **Equation 4-1**.

Equation 4-1: Multinomial Logit Direct Price Elasticity

$$\eta = \beta X (- p)$$

Rearranging **Equation 4-1**, the beta parameter can be established as shown in **Equation 4-2**.

Equation 4-2: Estimating the Beta Parameter

$$\beta = \frac{\eta}{X(1-p)}$$

AECOM have made assumptions on current elasticities, current fuel prices and ICE market share to estimate the fuel cost parameter, which are summarised in **Table 4-8**.

Table 4-8: Fuel Cost Parameter Assumptions

Parameter	Description	Value
η	ICE fuel price elasticity[28]	-0.25
X	ICE fuel cost rate	10c/km
p	Assumed initial ICE market share	85%
$\frac{\eta}{X(1-p)}$	AECOM's beta estimate	-0.25 ÷ (10 × (1 – 0.85)) = -0.167

With the absolute value of the fuel cost parameter established, the willingness to pay assumptions shown in **Table 4-7** can then be used to establish the absolute values for all other parameters. Parameter values for the model are highlighted in **Table 4-9**.

Table 4-9: Assumed Parameters Values Based on Table 4-7 Willingness to Pay Values

Parameter	Units	Value
Vehicle cost	$	-0.000159
Fuel cost	c/km	-0.166667
Range	km	0.004762
Tailpipe emissions	Proportion of ICE	-0.793651
Infrastructure	Proportion of ICE	3.174603
Multi-fuel bonus	Dummy	0.793651
EV constant	Dummy	0.000000

The vehicle choice model requires information on all of the above parameters. Each of these is discussed in more detail below.

4.7 Vehicle Price

New vehicle prices, by engine configuration and vehicle size, have been estimated from a survey of 34 global EV products for the 2009-2012 model years and 28 US HEVs for the 2009-2010 model years. An equivalent ICE vehicle was used for the price of ICE vehicles to ensure a consistent comparison.

There was limited information on the expected price of PHEVs. A report by the International Energy Agency (IEA, 2008) concludes that EVs will cost around US$10,000 more than a comparable PHEV. Applying this figure to our estimates makes PHEVS cheaper than HEVs which does not seem realistic. As such, it has been assumed PHEVs will be similarly priced to EVs. The basis for this assumption is that the cost reduction from a smaller battery (compared to EV) is offset by the cost of the internal

[28] Based on the median fuel price elasticity in the meta-analysis undertaken by Goodwin, P., Dargay, J. & Hanly, M. (2003), *Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review*, Transport Reviews, Vol. 24, No. 3, pp. 275–292.

combustion engine. In addition, the cost of batteries per kWh is higher for PHEVs compared to EVs. A large proportion of taxis in NSW are Ford Falcons and as such prices for taxis are assumed to be equal to prices for large passenger vehicles.

The survey of prices also revealed that. for the cars available in Australia (HEVs), there is a premium of around $10,000 over US prices. This is likely to reflect a local market penalty due to our relatively small market size, distance from large vehicle manufacturing countries, volatile exchange rate, and lack of local manufacturing of non-ICE vehicles. It has been assumed that there will be similar small market penalty for PHEVs and EVs. **Table 4-10** sets out the prices assumed in the model for the different market segmentations and engine combustion types.

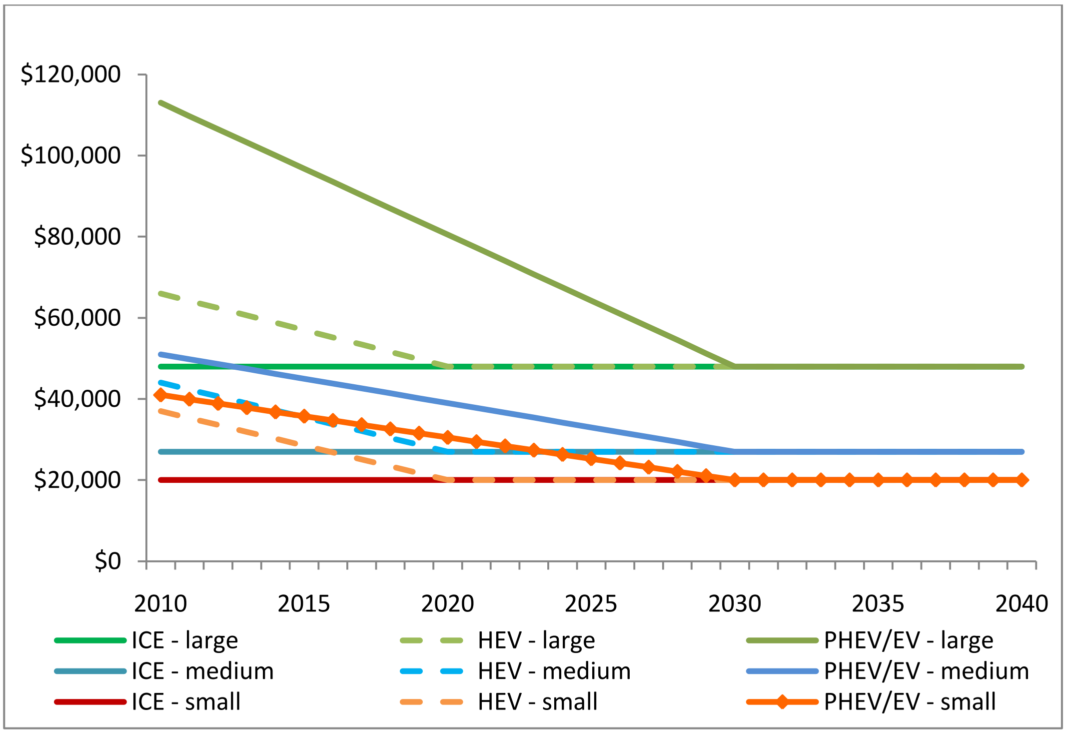
Table 4-10: New vehicle purchase prices including Australian price premium in 2010 (AUD)

Vehicle type	ICE	HEV	PHEV	EV
Passenger Small	$20,000	$37,000	$41,000	$41,000
Passenger Medium	$27,000	$44,000	$51,000	$51,000
Passenger Large	$48,000	$66,000	$113,000	$113,000
Commercial	$40,000	$60,000	$104,000	$104,000
Taxi	$48,000	$66,000	$113,000	$113,000

Source: AECOM

Going forward, it has been assumed that there is no real growth in the price of ICE vehicles. Prices for HEV, PHEVs and EVs are estimated relative to the ICE price. HEVs are assumed to reach price parity with ICEs in 2020. This is in line with industry expectations, such as Toyota, that by 2020 HEVs will be the prominent engine configuration type in their fleet. PHEV and EV purchase prices are assumed to reach price parity with ICEs in 2030. Sensitivity analysis will be undertaken on these years**. Figure 4-12** sets out the assumptions on vehicle prices and how these change over time.

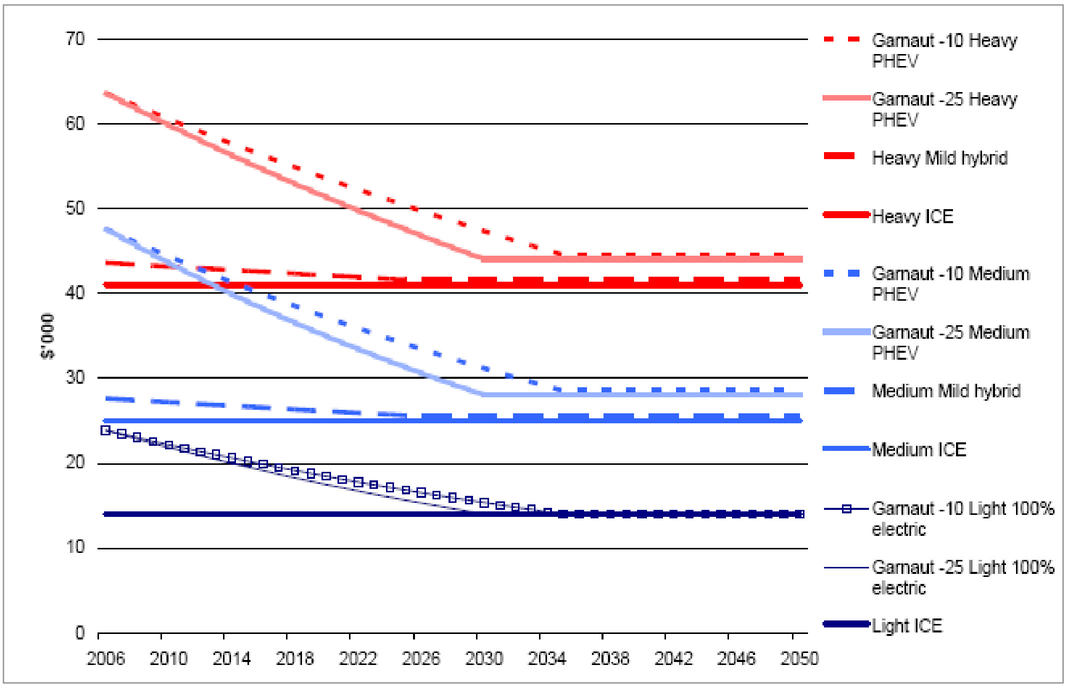
Figure 4-12: Assumed vehicle price for small and large vehicles by different engine configurations



Source: AECOM

Figure 4-13 sets out the assumptions on vehicle prices (and how these change over time) used in the CSIRO/Treasury modelling of the emissions trading scheme. Although our starting prices are higher than the assumptions used in the Treasury modelling the change in prices over time are consistent. The starting prices are different because the market segment definitions are different. Also, the CSIRO study only considers light EVs as a viable option.

Figure 4-13: Vehicle price by different engine configurations – Treasury modelling



Source: Modelling the road transport sector and its response to an Emissions Trading Scheme: A report to the National Emissions Trading Taskforce, CSIRO (2008)

4.8 Fuel Efficiency

BITRE and CSIRO prepared a report in October 2008 for the Treasury on modelling the transport sector for the Treasury's modelling of the introduction of emissions trading in Australia[29]. The report reviewed the literature on expected changes to energy efficiency and concluded:

- Fuel intensities for ICEs are expected to decline by up to 37% between 2006 and 2050;
- HEVs will achieve a 5% improvement in fuel efficiency starting in 2006, increasing to 30% by 2050;
- PHEVs fuel efficiency depends on proportion of time using the electric drivetrain. Assumes that the efficiency of the electric drive train will be constant as any improvements will provide for better amenity (room, instruments) rather than fuel savings (see next bullet). Assumes that PHEVs will use the electric drivetrain for 50% of kilometres in 2006, increasing to 80% by 2035 as battery technology improves allowing for longer use of the electric drivetrain. A weighted average fuel efficiency is calculated based on ICE drivetime and electric drivetime; and
- Fully EVs have a fuel efficiency of 0.2kWh/km for light vehicles and this remains constant over time.

This study agrees with some of these conclusions such as the ICE efficiencies and that PHEVs will use the electric drivetrain 50% of kilometres in 2006 increasing to 80% by 2035. However, the latest

[29] http://www.treasury.gov.au/lowpollutionfuture/consultants_report/downloads/Modelling_the_road_transport_sector.pdf

data suggests that the efficiencies of HEVs and EVs may behave differently. This is discussed below in more detail.

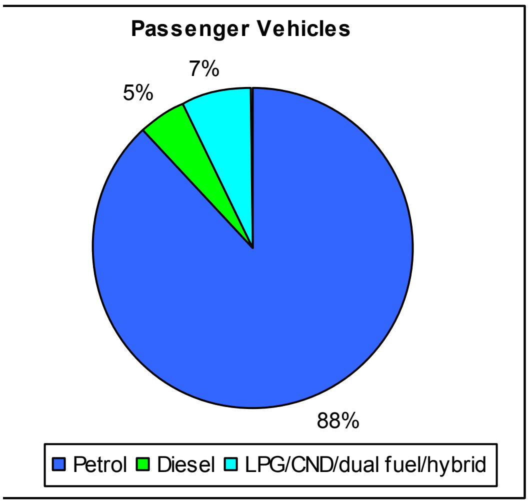
It is worth noting that published fuel efficiencies are traditionally underestimates of real world fuel efficiencies. The test cycle is typically different from how people drive in the real world resulting in lower actual fuel efficiencies. This is true for all vehicle types.

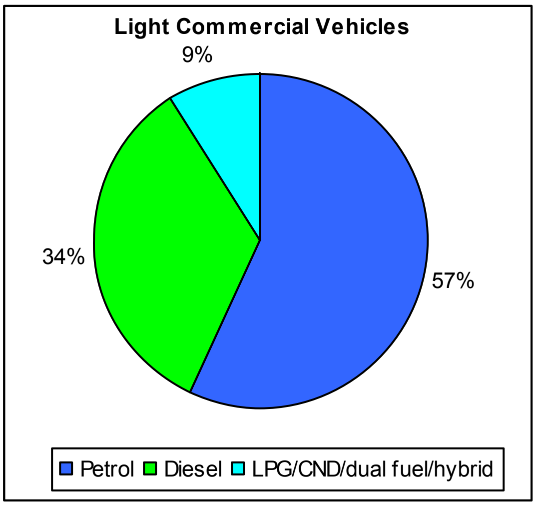
4.8.1 ICE Efficiency

The fuel efficiency for an ICE vehicle depends on the fuel used.

As highlighted in **Figure 4-14**, 88% of fuel used in passenger vehicles is petrol, 5% diesel and 7% other fuel such as LPG/CND/dual fuel and hybrid. These proportions have remained fairly consistent over the past five years. Light commercial vehicles use a lot more diesel with 57% of fuel use being petrol and 34% diesel. IPART undertakes an annual review of taxi fares in NSW. As part of this review it assumes the main fuel type for taxis is LPG. For this study it has been assumed that taxis use only LPG.

Figure 4-14: Fuel usage in Australia





Source: Survey of motor vehicle use, ABS, 2007

The survey of vehicles (used to identify vehicle prices) also identified vehicle fuel efficiencies for petrol vehicles. The ratio of efficiencies between petrol and diesel, and petrol and LPG have been determined from reported ABS values[30] (see **Table 4-11**). These ratios are then applied to the petrol efficiency as identified in the vehicle survey, to obtain fuel efficiencies for diesel and LPG. The taxi efficiency has been taken from the IPART 2008 review of taxi fares in NSW which assumes a fuel efficiency of 5 kilometres per litre of fuel or 20 L/100km[31]. **Table 4-12** shows the fuel efficiencies for ICE vehicles.

[30] *Survey of Motor Vehicle Use – 12 Months Ended 31 October 2007*. ABS Catalogue 9208.0
[31] http://www.ipart.nsw.gov.au/files/2008%20Review%20of%20Taxi%20Fares%20in%20NSW%20-%20Draft%20Report%20and%20Draft%20Recommendations%20-%20April%202008%20-%20WEB.PDF

Table 4-11: ABS reported fuel efficiencies

Vehicle Category	Petrol (L/100km)	Diesel (L/100km)	LPG (L/100km)	Diesel to Petrol Ratio	LPG to Petrol Ratio
Passenger (all sizes)	11.1	12.3	16.6	1.108	1.495
LCV	13.2	12.5	16.0	0.947	1.212
Taxi	-	-	20.0	-	-

Source: ABS (9208.0), AECOM

Table 4-12: ICE fuel efficiency by vehicle category in 2010

Vehicle Category	Petrol (L/100km)	Diesel (L/100km)	LPG (L/100km)	Weighted Fuel Efficiency (L/100km)
Passenger small	7.8	8.6	11.7	8.1
Passenger medium	9.7	10.8	14.5	10.1
Passenger large	13.8	15.3	20.6	14.4
LCV	11.2	10.6	13.6	11.1
Taxi	-	-	20.0	20.0

Source: AECOM

As in the CSIRO study, it has been assumed that the efficiency of an ICE vehicle will improve by 37% between 2006 to 2050. It has been assumed that 15% of this is due to platform engineering (and hence will apply to the EV) and 22% through other efficiency measures (including combustion technology improvements). This corresponds to an annual change of 0.84%, thereby allowing fuel consumption to decrease over time as shown in **Table 4-13**.

Table 4-13: ICE fuel efficiency for small passenger vehicles over time

Year	Petrol (L/100km)	Diesel (L/100km)	LPG (L/100km)	Weighted Fuel Efficiency (L/100km)
2010	7.80	8.64	11.66	8.1
2015	7.48	8.29	11.18	7.8
2020	7.17	7.94	10.72	7.5
2025	6.87	7.61	10.28	7.1
2030	6.59	7.30	9.85	6.9
2035	6.32	7.00	9.44	6.6
2040	6.05	6.71	9.05	6.3

Source: AECOM

4.8.2 Hybrid Electric Vehicle (HEV) Efficiency

As highlighted above, the CSIRO report concluded that HEVs will achieve a 5% improvement in fuel efficiency starting in 2006, increasing to 30% by 2050.

The evidence on existing HEVs suggests there are currently bigger efficiency gains than 5%[32]. Investments in HEV technology are expected to generate continued efficiency gains over ICE. However these improvements will decline over time as the potential for improvement gets eroded by improved combustion technologies. **Table 4-14** shows the expected fuel efficiencies of HEVs over time. Changes in taxi fuel efficiency are assumed to be equal to that of large passenger vehicles.

[32] The Toyota Prius has a fuel efficiency of 4.4L/100km compared to 6L/100km for the most efficient Toyota Yaris and 7.3L/km for the most efficient Toyota Corolla, with 36% and 66% respective efficiency improvements. (www.greenvehicleguide.gov.au)

Table 4-14: HEV fuel efficiencies over time (L/100km)

Year	Passenger Small	Passenger Medium	Passenger Large	LCV	Taxi
2010	5.31	7.35	11.22	8.42	11.22
2020	5.05	7.02	10.75	8.04	10.75
2030	4.81	6.72	10.31	7.69	10.31
2040	4.59	6.44	9.92	7.37	9.92

Source: AECOM / Dr Andrew Simpson

4.8.3 Electric Vehicles (EV) Efficiency

The fuel for EVs is electricity. Current electricity consumption efficiency values are identified from the vehicle survey of current or planned electric vehicles and presented in **Table 4-15**. Taxi fuel efficiency is assumed to be equal to that of large passenger vehicles.

Table 4-15: EV electricity efficiency by vehicle category in 2010

Vehicle Category	Electricity (kWh/100km)
Passenger small	19.0
Passenger medium	16.5
Passenger large	21.5
LCV	18.5
Taxi	21.5

Source: Survey of current planned EVs

As highlighted above, the CSIRO report concluded that light (small) EVs have a fuel efficiency of 0.2kWh/km which is consistent with this study. However, the CSIRO study assumes that this remains constant over time as any efficiencies will be used to enhance the performance of the vehicle.

This study assumes there will be improvements in efficiency. Consumption efficiency is assumed to improve by 15% due to platform engineering (as with ICEs) and by 10% through powertrain improvements as the technology matures. However efficiency is assumed to decrease by 5% due to increased range and performance. Therefore, there is a total gain of 20% between 2010 and 2050. This corresponds to an annual change of 0.45%, thereby allowing electricity consumption to decrease over time as shown in **Table 4-16**.

Table 4-16: EV electricity efficiency by vehicle category over time (kWh/100km)

Year	Passenger Small	Passenger Medium	Passenger Large	LCV	Taxi
2010	19.0	16.5	21.5	18.5	21.5
2020	18.2	15.8	20.5	17.7	20.5
2030	17.3	15.1	19.6	16.9	19.6
2040	16.6	14.4	18.8	16.1	18.8

Source: AECOM / Dr Andrew Simpson following review of current or planned vehicles

4.8.4 Plug-in Hybrid Electric Vehicles (PHEV) Efficiency

The fuel efficiency for PHEVs is a combination of electricity consumption efficiency and liquid fuel efficiency. It has been assumed that the liquid fuel efficiency is equal to that for ICE petrol, while electricity efficiency is assumed to be equal to that for EVs.

Overall, the efficiency of a PHEV is dependent on the proportion of distance travelled propelled by the ICE drivetrain or the electric drivetrain. We have assumed that PHEVs will use the electric drivetrain for 50% of kilometres in 2012[33] increasing to 80% in 2035. **Table 4-17** shows the annual change.

Table 4-17: PHEV proportions on ICE and electric drivetrains (all vehicles)

Year	2012	2035	Annual Change
% EV drivetrain	50%	80%	1.03%
% ICE drivetrain	50%	20%	-1.03%

Source: AECOM

4.9 Conventional Fuel Costs

The forecasts of fuel price were estimated using world forecasts of oil price and the past relationship to retail prices for petrol and diesel.

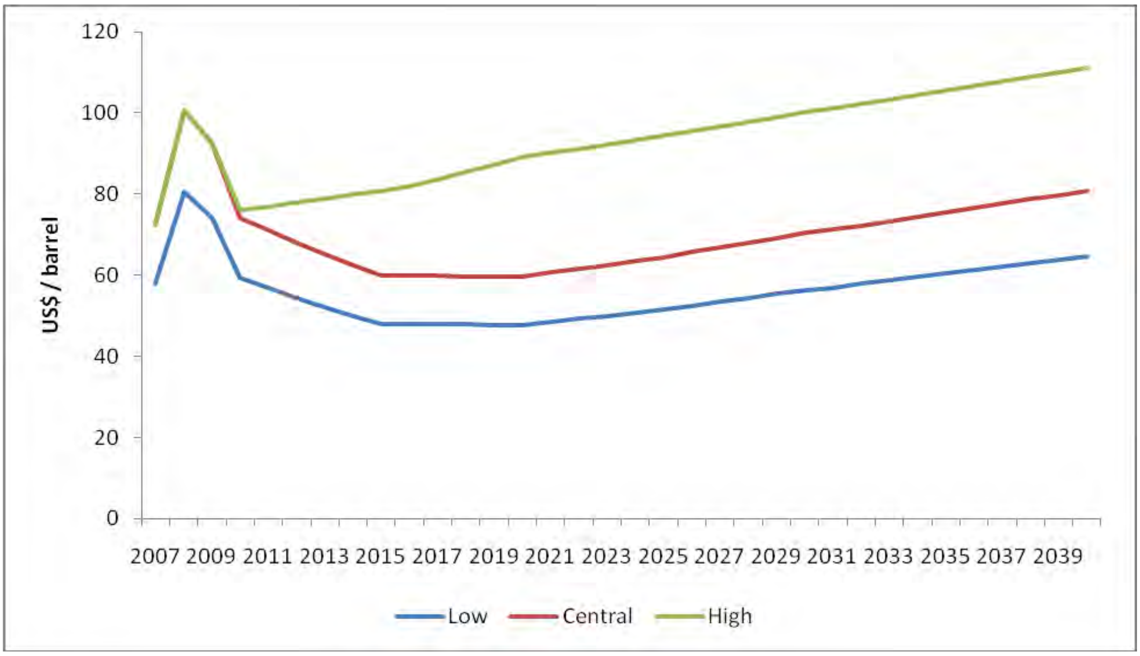
4.9.1 Crude Oil and Liquid Fuels Prices

World published forecasts for crude oil prices have been used from the Energy Information Agency (EIA). There are three crude oil price scenarios, low, medium and high, that have been used to estimate the price of liquid fuels (and are illustrated in **Figure 4-15**):

- High – corresponds to EIA (Energy Information Agency) high price scenario;
- Reference – corresponds to the EIA reference scenario; and
- Low – equal to a 20% discount from the reference scenario.

[33] When PHEVS are assumed to be available in Australia

Figure 4-15: Crude Oil price scenarios



Source: AECOM based on EIA oil forecasts

The relationship between crude oil and petrol has been determined by regressing the medium (reference) oil price against historical average metropolitan Sydney petrol prices (at the pump) obtained from FuelTrac for the period 1999 to 2008. This final pump price has then been broken down into components: a base price, excise, Carbon Pollution Reduction Scheme (CPRS) and GST as shown in **Table 4-19** and discussed below.

Base Prices

Base prices for diesel, biofuels and LPG have been calculated as a proportion of the petrol base price. Diesel base price is assumed to be 100% of the petrol base price as suggested by current prices where petrol and diesel are approximately on par. Data from FuelWatch suggests that LPG prices are approximately 40% of petrol price. The IPART annual review of NSW taxi fares states that LPG prices can vary significantly year to year and they are difficult to estimate too far into the future. As fuel prices are a small part of the total fuel mix for this study it has been assumed that they increase in line with petrol prices.

Excise

The current fuel excise is $0.381 and is applied to petrol and diesel. It should also be noted that while LPG does not presently have an excise, a fuel tax is scheduled to begin on 1 June 2011. However no legislation has yet been passed; in the absence of a stated value, it is assumed that the value of the LPG tax from 2011 onwards is equal to the current petrol excise. Excise values are assumed to remain constant.

Carbon Pollution Reduction Scheme (CPRS)

The CPRS is assumed to increase the price of fossil fuels. The CPRS component for each fuel is calculated as the product of the CPRS price and the fuel emissions factor. For further discussion on the CPRS price see **Section 4.10.1**.

The current CPRS guidance suggests that any increase in fuel prices due to the cost of carbon may be offset by a reduction in fuel excise in the short term. Fuel taxes will be cut on a cent for cent basis to offset the initial price impact on fuel associated with the introduction of the CPRS and allow motorists three years to plan for potentially higher fuel prices. This will be periodically assessed for three years and this offset adjusted accordingly. At the end of this three year period, the Government will review this adjustment mechanism. As such, there has been no CPRS price effect on fuel for the first three years of its introduction.

Emissions factors (in kg CO2e per litre) for each fuel have been calculated from the energy content and emissions factor (in kg CO2e per GJ) as given by the National Greenhouse Account (see **Table 4-18**). Energy content and emissions factors are assumed to remain constant over time.

Table 4-18: Emission factors for fuel

Fuel	Energy Content Factor (GJ/kL)	Emission Factor (kg CO_2e/GJ)	Emissions Factor (kg CO2e/L)
Petrol/gasoline	34.2	66.7	2.29
Diesel	38.6	69.2	2.69
LPG	26.2	59.6	1.58

Source: National Greenhouse Accounts (NGA) Factors, November 2008

GST

GST has been applied at 10%.

Table 4-19: Calculation of petrol price under reference oil price scenario (AUD unless stated)

Year	Crude Oil (US$ / barrel)	Petrol Price Components ($ / L)				
		Base	Excise	CPRS	GST	Total
2010	US$74.03	$0.76	$0.38	$0.00	$0.11	$1.25
2015	US$59.85	$0.65	$0.38	$0.07	$0.11	$1.22
2020	US$59.70	$0.65	$0.38	$0.09	$0.11	$1.24
2025	US$64.49	$0.69	$0.38	$0.11	$0.12	$1.30
2030	US$70.45	$0.73	$0.38	$0.13	$0.12	$1.37
2035	US$75.51	$0.77	$0.38	$0.17	$0.13	$1.45
2040	US$80.88	$0.81	$0.38	$0.20	$0.14	$1.53

Source: AECOM

4.10 Electricity Price

Electricity prices paid by consumers are modelled as the sum of wholesale electricity prices, network costs and retail margins, and any carbon pricing component (selected through the carbon emission policy options). The individual components of future electricity prices are not independent of one another. Higher emission permit prices will make alternate energy sources more viable compared to coal fired power generation, which will in turn change the mix of installed generation and result in changes in wholesale electricity prices and potential differences in distribution network changes, as well as a general reduction in the grid emission intensity.

The Australian Treasury has produced a white paper, *Australia's Low Pollution Future - the Economics of Climate Change Mitigation*, containing modelling of Australia's electricity generation under different scenarios. The results of this modelling have formed the basis for consumer electricity price forecasts produced by AECOM.

The alternative scenarios modelled in the Treasury white paper are as follows:

- Reference case – no additional emission reduction measures (also excludes the expanded national renewable energy target (NRET));

- CPRS-5 – 5% reduction from 2000 emission levels by 2020 (includes NRET); and
- CPRS-15 – 15% reduction from 2000 emission levels by 2020 (includes NRET).

In addition to retail electricity supply costs, the price paid by electric vehicle consumers varies by point of charging under the different scenarios (see section 4.10.4 to 4.10.6).

4.10.1 Carbon Emissions Policy

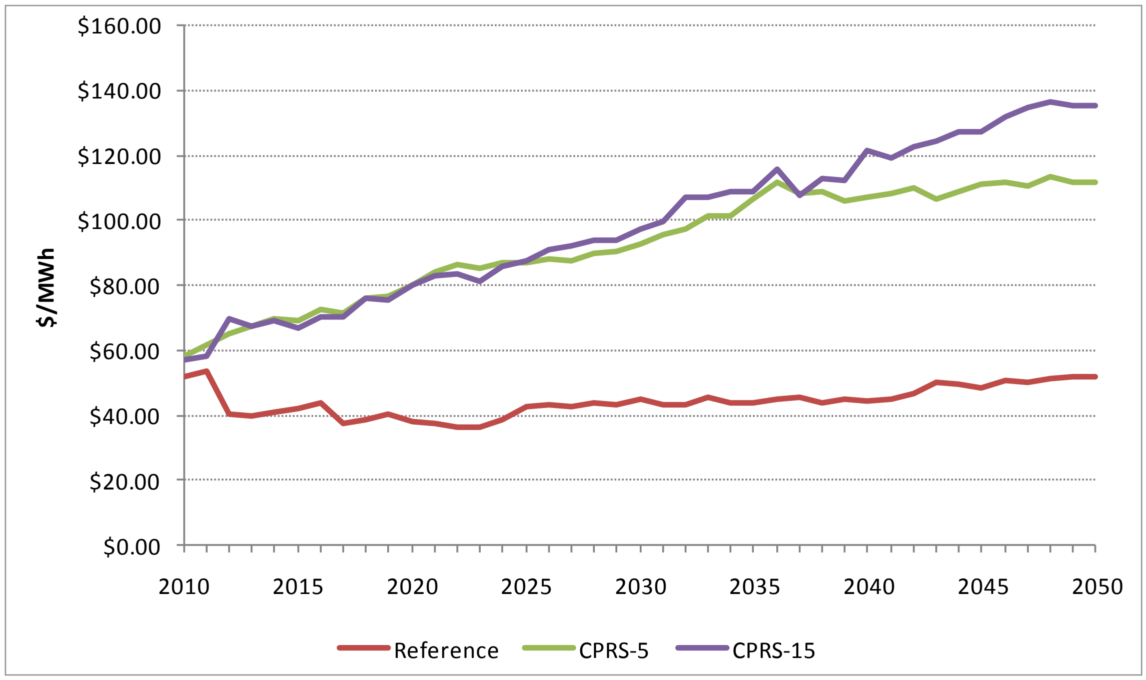
The Government has committed to introducing a Carbon Pollution Reduction Scheme (CPRS) as a key part of its climate change strategy. The Government's Carbon Pollution Reduction Scheme will place a limit, or cap, on the amount of carbon pollution industry can emit. It will require affected businesses and industry to buy a ‗pollution permit' for each tonne of carbon they contribute to the atmosphere, providing a strong incentive to reduce pollution.

The price of the CPRS permits will impact on electricity prices, fuel prices and the electricity emission factors. In order to ensure consistency with CPRS prices, electricity prices and electricity emissions factors, this study has used the Treasury modelling forecasts for all three series, with minor adjustments to account for recent policy announcements including the one year delay to the commencement of the scheme and the $10 fixed permit price in the first year of operation.

4.10.2 Wholesale Electricity Costs

Forecasts of wholesale electricity prices, as detailed in the Treasury white paper[34] are shown in **Figure 4-16**. There is considerable variation in wholesale electricity prices between the reference case (no emission reduction measures) and the CPRS scenarios considered.

Figure 4-16: Forecast Australian wholesale electricity prices (2007$)



Source: Australia's Low Pollution Future, The Economics of Climate Change Mitigation, 2008

AECOM have updated the results to 2009 prices[35] and estimated wholesale electricity prices, excluding CPRS permit costs to allow for adjustments for changes to government policy relating to CPRS since the Treasury modelling was undertaken.

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[34] Australia's Low Pollution Future, The Economics of Climate Change Mitigation, 2008
[35] Using CPI

4.10.3 Network Charge and Retail Margin

Distribution network charges and retail supply margins have been estimated as the difference between the Treasury retail price forecasts and wholesale supply price forecasts. There is some limited variation in network costs and margins for each of the scenarios considered.

4.10.4 Upgraded Residential Network Connection Charge

To allow for Level 2 charging at residential properties, it is likely that the residential electricity network will need to be upgraded at the point of connection to the premises and possibly the local distribution network as well.

To account for the pass through of these costs to consumers, a 20% increase in network access charges and retail margin has been assumed for electricity supplied to residential premises with Level 2 charging available. As discussed in **Section 3.2.2**, the Australian Energy Regulator may make a determination on how costs of any network upgrade required for Level 2 charging should be passed on to customers.

4.10.5 Commercial Charging Station Network Charge

Commercial charging stations are expected to recover their capital costs through higher electricity prices paid by consumers charging at the station. To determine the additional cost per MWh supplied, assumptions regarding the capital cost ($500,000), economic life (25 years), charging capacity (192 kW), utilisation or time for which the station is supplying electricity (10%) and expected return on capital (7% real) have been made. For the stated assumption values, the premium charged by the charging station operator in addition to retail electricity costs has been estimated at $255 per MWh, or approximately $2 per charge (based on 8 kWh consumed per charge).

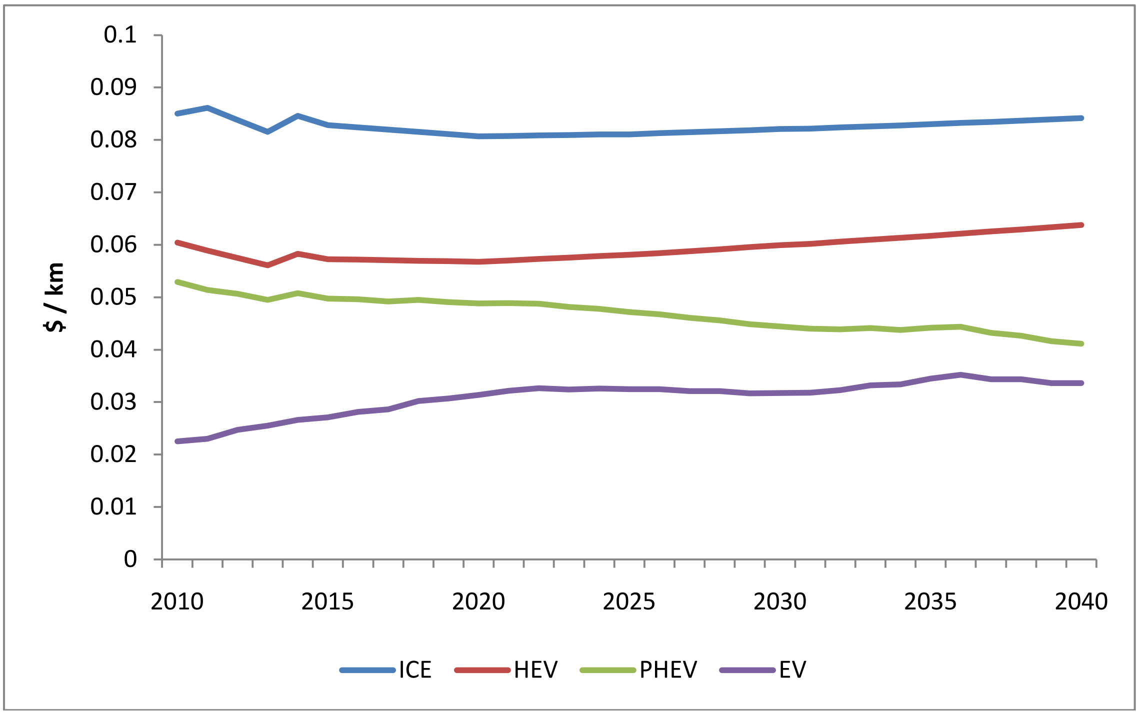
4.10.6 Public Charging Point Network Charge

Similar to commercial charging stations, public charging points are expected to recover the upfront capital cost of installation through higher electricity prices paid by users. The additional cost per MWh supplied was estimated based on assumptions of capital cost ($6,000), economic life (10 years), charging capacity (19.2 kW), utilisation or time for which the station is supplying electricity (20%) and expected return on capital (7% real). For the stated assumption values, the premium charged to users of the public charging point, in addition to retail electricity costs has been estimated at $25 per MWh, or approximately $0.20 per charge (based on 8 kWh consumed per charge).

4.11 Fuel Cost per Kilometre

Figure 4-17 brings together the fuel efficiencies and forecast prices for fossil fuels and electricity into a cost per kilometre. The cost advantage of electricity reduces slightly over time but remains significantly below fossil fuel prices.

Figure 4-17: $/KM for different engine configurations – small vehicle, central price estimates



Source: AECOM

4.12 Other Vehicle Costs

Other vehicle costs include:

- Registration;
- Insurance; and
- Maintenance.

4.12.1 Registration

Registration costs were obtained from NSW Roads and Traffic Authority (RTA) website.

Table 4-20 sets out the annual costs by vehicle type and size. It has been assumed that the registration cost will not vary by the engine configuration type. In practice, government policy may reduce registration costs for low emission technologies. However, given registration costs are a small proportion of the total cost of operating a vehicle and there is no policy to distinguish between engine configuration types at the moment it has been assumed to remain the same.

Table 4-20: Registration costs by vehicle type and size

Year	Passenger* ($/annum)			Light Commercial Vehicles ($/annum)			Taxi ($/annum)
	Small	Medium	Large	Small	Medium	Large	
2009	$223	$245	$334[36]	$223 – private use $329 – business use	$245 – private use $336 – business use	$334- private use $507[37] - business use	-
*Car, station wagon or small bus for private use Small = Up to 975 kg; Medium = 976 – 1154 kg; Large = >1155 kg							

Source: NSW Roads and Traffic Authority

4.12.2 Insurance

In order to estimate insurance costs, typical vehicles were defined within each market segment. The typical vehicles focused on the top 3 car sales manufacturers in Australia – Toyota (20% of NSW sales), Holden (19.5%) and Ford (15.4%) who together capture around 55% of total sales in NSW[38]. A small passenger vehicle was classified as a Toyota Yaris, A Ford Fiesta or a Holden Barina. A medium passenger vehicle was classified as a Toyota Corolla, a Ford Focus or a Holden Astra. A large passenger vehicle was categorised as either a Toyota Aurion, a Ford Falcon or a Holden Commodore. A Light Commercial Vehicle was assumed to be either a Toyota Hiace or a Ford Transit.

Greenslip and comprehensive insurance costs for these vehicles were obtained from the websites of the Motor Accidents Authority and NRMA respectively. These costs were then averaged to obtain a common figure for all vehicles within a particular category as shown in **Table 4-21.** It has been assumed that insurance costs do not vary by distance travelled or engine configuration. In reality, they may do but it is a small amount and still a fixed cost. Costs for taxis have been obtained from IPART's annual taxi fare review.

Table 4-21: Average greenslip and insurance costs

Category	Greenslip ($ p.a.)	Comprehensive insurance ($ p.a.)
Passenger Small	460	884
Passenger Medium	460	902
Passenger Large	460	762
LCV (business use)	605	958
Taxi	3,697	7,228*

Sources: Motor Accidents Authority; NRMA; IPART

* includes workers' compensation insurance of $2228

4.12.3 Maintenance Costs

The Vehicle Operating Cost (VOC) per kilometre represents the cost of operating a vehicle on a kilometre basis and varies with the distance travelled. This includes tyres, oil and maintenance. The RTA Economic Analysis Manual[39] recommends a value of 13.45 cents/km[40].

[36] RTA also has an extra large category which is combined with the large category in this analysis. The above price is an average of both prices (Large = $275, Extra Large = $393)
[37] RTA also has an extra large category which is combined with the large category in this analysis. The above price is an average of both prices (Large = $415, Extra Large = $599)
[38] NSW Driver and Vehicle Statistics 2007, RTA
[39] RTA Economic Analysis Manual, Appendix B economic parameters for 2007
[40] 2007 prices, converted to 2009 prices for model using CPI

Maintenance costs are generally broken down into engine/brake related, non engine/brake related and tire related. Electrical components such as traction motors and controllers require very little maintenance. AN EPRI study[41] estimate that the maintenance cost of a HEV are around 88% of an ICE and maintenance costs of a PHEV are around 75% of an ICE. These differences are largely driven by a reduction in the frequency of brake pad replacements. For EVs, the study assumes maintenance costs are around 50% of an ICE vehicle and only include the non/engine/brake related and tire related costs. These assumptions have been used in this study.

No battery replacement cost was included in the modelling because battery life is expected to equal or exceed vehicle life within the near future. There are, however, still uncertainties surrounding the life of electric vehicle batteries, as discussed in **Section 2.2.3**. Any battery replacement costs that do occur are unlikely to occur within the first decade, which will be discounted, and it is expected that there will be significant cost reductions over the next through years through economies of scale and industry learning curves (see **Section 2.2.4** for more information).

The maintenance costs are summarised in **Table 4-22**.

Table 4-22: Vehicle maintenance costs

Engine Configuration	Cents per km
ICE	13.45
HEV	11.84
PHEV	10.09
EV	6.73

4.13 Range

The vehicle range influences the sales of new vehicles through the choice model. Vehicle range assumptions for 2010 are shown in **Table 4-23**. The electric vehicle range comes from the survey and is supported by the information in **Table 2-2**.

The vehicle range for all vehicles grows over time linked to fuel efficiency improvements. ICEs and HEVs vehicle range increases in line with fuel efficiency improvements. EVs are assumed to grow due to fuel efficiency as well as battery improvements. It is assumed a battery storage capacity improvement of 5% per annum, equivalent to a doubling in vehicle range every 12-13 years. This is consistent with industry expectations which expect a doubling in vehicle range every 10 years.

PHEV's vehicle range will increase due to both increases in the ICE range and the EV range. It has been assumed to be the maximum of either the ICE range or EV range.

Table 4-23: Vehicle range assumptions (km)

Category	ICE	HEV	PHEV	EV
Passenger Small	500	500	500	120
Passenger Medium	550	550	550	200
Passenger Large	550	550	550	300
LCV	550	550	550	160
Taxi	550	550	550	300

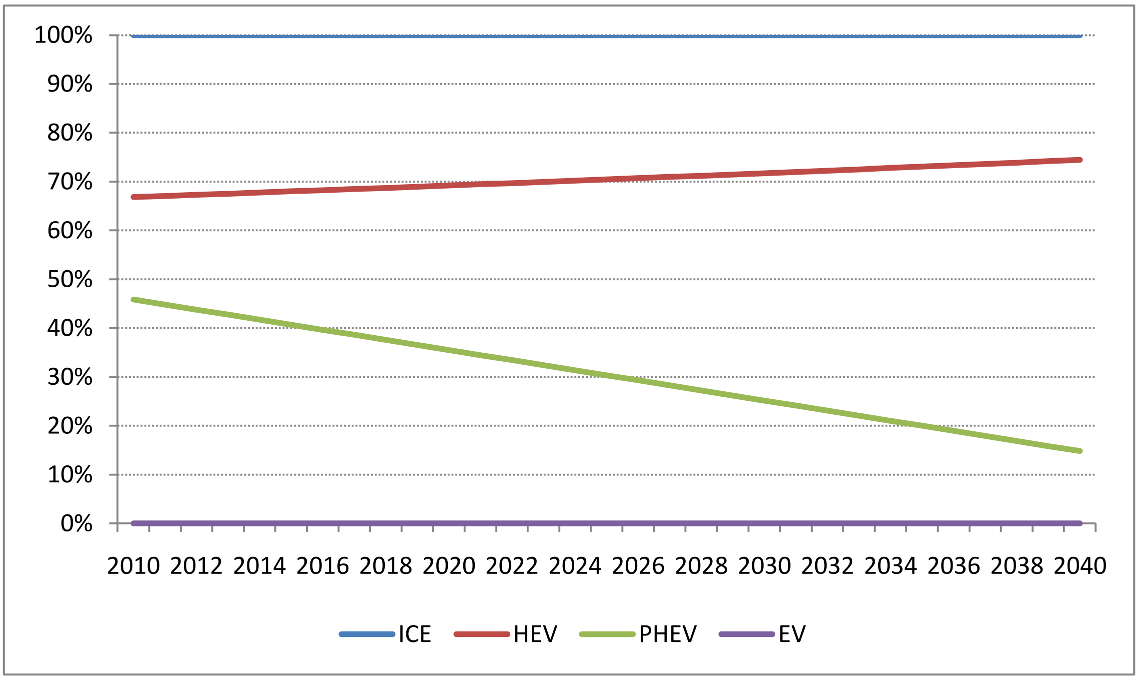
Source: AECOM

[41] A Technology and Cost-Effectiveness Assessment for Battery Electric Vehicles, Power Assist Hybrid Electric Vehicles, and Plug-In Hybrid Electric Vehicles, EPRI 2004

4.14 Emissions

The tailpipe emissions relative to an ICE vehicle influences the sales of new vehicles through the choice model. **Figure 4-18** sets out the proportion of tailpipe emissions relative to the ICE for HEVs, PHEVs and EVs. Importantly, the consumer only considers tailpipe emissions so emissions from electricity generation are ignored. The large change for PHEVs is driven by the increased proportion of electric drive time that occurs over time.

Figure 4-18: Tailpipe emissions relative to ICE vehicles – small passenger vehicle, low VKT



Source: AECOM

4.15 Infrastructure

A key factor in the vehicle choice model is the availability of vehicle charging infrastructure relative to ICE vehicles (e.g. service stations). This is linked to the different scenarios modelled. The assumptions of level of infrastructure are summarised in **Table 4-24**.

HEVs and PHEVs are assumed to have 100% charging infrastructure relative to ICE vehicles.

Under the Base Case, both PHEVs and EVs are assumed to have no charging infrastructure.

For EVs, it has been assumed that under Scenario 2, public charging points provide 50% of ICE infrastructure and under Scenario 3, 25% of service stations switch to electric vehicle service stations. Level 1 charging is not considered comparable with ICE charging infrastructure.

Table 4-24: % of charging infrastructure relative to ICE vehicles (e.g. service stations)

Category	Base	Scenario 1	Scenario 2	Scenario 3
ICE	100%	100%	100%	100%
HEV	100%	100%	100%	100%
PHEV	0%	100%	100%	100%
EV	0%	0%	50%	75%

4.16 Multi-Fuel Bonus

The vehicle choice model also takes account of the number of options to fuel vehicles. Both hybrids, the HEV and the PHEV, receive a bonus for their ability to run off two different sources of fuel. Note this is perceived ability not actual which is why the HEV (which only runs on fossil fuels) is also given a bonus.

Sensitivity analysis will be undertaken on the results to determine how sensitive the model is to the size of the multi-fuel bonus.

4.17 Non Captive Market

The vehicle choice model cannot take account of differences in VKT (see suggested further work) as there are no published data sources to calibrate a parameter. However, it is believed that distance travelled is an important market segment that will affect the take-up of EVs. As such, the data has been split into a captive and non captive market before going through the vehicle choice model based on the different levels of available infrastructure. **Table 4-25** sets out the assumptions used to determine the proportion of vehicle sales which can be PHEVs or EVs. For example, in Scenario 1 where there is only household charging it has been assumed that people who have a low average VKT would consider purchasing a PHEV or EV as household charging will meet their usage patterns. This reduces to 50% for people who have a medium average VKT and zero for people who have a high average VKT. Similarly, no one purchasing a light commercial vehicle or taxi would consider purchasing a PHEV or EV whilst there is only household charging. These proportions change over the Scenarios as more charging infrastructure becomes available. Further work is suggested to determine the relationship between distance travelled, charging infrastructure and take-up of EVs.

Table 4-25: % of market segment that may purchase an EV or PHEV under different scenarios

Category	Base	Scenario 1	Scenario 2	Scenario 3
Low VKT	0%	100%	100%	100%
Medium VKT	0%	50%	75%	100%
High VKT	0%	0%	50%	100%
Light Commercial Vehicle	0%	0%	50%	100%
Taxi	0%	0%	0%	100%

4.18 Supply Constraints

A major issue to the take-up of EVs in the short term (next 5 to 10 years) will be supply constraints. There are expected to be global supply constraints until at least 2012 and these will be exacerbated in Australia which is not seen as a key market for vehicle manufacturers. See **Section 9.2** for further discussion on supply constraints.

As such, a supply constraint has been built into the model to ensure it reflects current market conditions.

4.18.1 HEV Supply Constraint

It has been assumed that there are around 1,000,000 HEVs currently in global production and these will continue to grow by 35% per annum. Australia will receive 1% of global demand (as per sale of HEVs to date) and supply will be constrained until 2020.

4.18.2 PHEV Supply Constraint

It has been assumed that by 2012 there will be around 150,000 PHEVs in global production (see **Figure 3-2**) and 1% of these will reach Australia. Production will grow at 20% per annum and be constrained until 2020.

4.18.3 EV Supply Constraint

It has been assumed that by 2012 there will be around 500,000 EVs in global production (see **Figure 3-2**) and 1% of these will reach Australia. Production will grow at 20% per annum and be constrained until 2020.

4.19 Cost of Infrastructure

The cost of infrastructure is broken down into the cost to physically install the different levels of infrastructure as well as any costs involved with upgrading the electricity network to support the charging infrastructure.

It has been assumed that there will be no requirements to upgrade the electricity transmission and distribution network to cope with Level 1 home charging. This assumes the use of smart metering (so that households charge during the off peak period) and that any significant investments are known in advance so can be built into investment plans with little additional costs. It is possible that Level 2 charging will require 3-phase which would require upgrades to the household service and possibly the street. A 20% increase in the network access costs to electricity consumers using Level 2 charging has been assumed to represent this. However, further work on the impact on electricity networks is recommended.

The cost of the charging infrastructure will vary by the different scenarios.

4.19.1 Base Case

There will be no costs under the Base Case.

4.19.2 Scenario 1 (Household Only Charging)

The costs under Scenario 1 are minimal. Level 1 charging utilises standard electrical circuits and power outlets and all charging electronics required to support Level 1 can be carried onboard the vehicle. It has been assumed that every household that has the capacity to charge a vehicle will also have a plug available.

4.19.3 Scenario 2 (Household and Public Charging)

Household Charging

Level 2 charging requires a ―charging interface" to be wired into a building‘s electricity supply to provide protection from higher voltage/power, and these systems typically involve the use of a specialised plug and socket. Level 2 charging can therefore be performed at home, but only if the appropriate equipment has been installed by an electrician. It has been assumed that households will face an additional cost of $1,000 for an electrician to supply and fit a charging interface. The equipment cost of the level 2 interface is expected to be included as standard by the vehicle manufacturer.

A 20% increase in the network access cost component of electricity prices has been assumed to apply to electricity consumed in Level 2 household charging to represent the potential costs of an upgraded household connection to the local distribution network.

Public Charging

There are various public charging stations currently in place in the US and Europe that can provide an indication of cost. Earlier this year, the city of Amsterdam announced plans to deploy 200 EV charging stations before 2012. They have appointed California‘s Coulomb Technologies to install the charging stations at a cost of US$5,000 each (approximately A$6,200)[42]. In 2008, the City of Westminster installed 12 electric vehicle charging points using charging stations from Electromotive, a UK company, at £3,300/unit (approximately A$6,600) (Westminster Council press release[43]). The charging stations have since been rolled out across London.

In June 2009, Toyota Industries announced a new public charging station that goes on sale in Japan this summer[44]. Toyota developed this unit with Nitto Electric Works and it's designed to feed single phase electric power at 200 V and 16 A. The charging units will cost ¥450,000 or about A$5,600 at current exchange rates.

All of the above public charging stations are around A$6,000, so a price of $6000 per unit has been used in the model. Most of the charging stations discussed are Level 1 charging stations but there are not expected to be significant cost differences between Level 1 and Level 2 charging infrastructure.

4.19.4 Scenario 3 (Household Charging, Public Charging and Electric Vehicle Service Stations)

The household charging and public charging will incur the same costs as Scenario 2. The cost of an electric vehicle service station is as yet unknown. BetterPlace estimate that it will cost $500,000 to build battery swap stations.

Another company leading the way in charging stations is Evoasis which develops full service Fast-Charge, EV and PHEV Charging Station Facilities (EVSTAT) for deployment in metro areas and roadway access points in both the public and private sector. EVSTAT Stations are electrical ―Sub-Stations" in their own right, using utility power stored during off-peak generation to supply EV and PHEV battery power at peak demand hours, thereby reducing the load placed on energy utilities during these periods. EVSTAT Stations also generate on-site power from green energy sources built into the structure, with over 6,000 square feet of photovoltaic (PV) panels, further reducing station energy dependency during sunrise-to-sunset operating hours.

It has been assumed that a charging station will cost $500,000 per station to build.

4.19.5 Summary

Table 4-26 summarises the infrastructure costs under the different scenarios.

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[42] Cleantech.com, NRC Handelsblad March 2009

[43] http://www.westminster.gov.uk/councilgovernmentanddemocracy/councils/pressoffice/news/pr-4234.cfm

[44] http://www.autobloggreen.com/2009/06/08/toyota-industries-will-sell-electric-car-charging-stations-this/

Table 4-26: Infrastructure costs for each scenario

Scenario	Costs	
	Infrastructure Costs	Electricity Network costs
Scenario 1 (Base Case): No charging infrastructure	None	None
Scenario 1: Household charging only (Level 1)	None	None*
Scenario 2: Household charging (Level 1 and 2) plus public charging stations	$1,000 per household for interface unit installation (equipment cost included as standard item) $6,000 per public charging unit	None*
Scenario 3: Household charging (Level 1 and 2) plus EV service station	$1,000 per household for interface unit installation (equipment cost included as standard item) $6,000 per public charging unit $500,000 per charging station	None*
* Assuming the right incentives are in place to encourage charging in off peak periods. Further work is being undertaken in this area.		

4.20 Model Outputs

The above analysis will be used to calculate the following model outputs which will feed into the cost benefit analysis:

- Proportion of vehicle sales by market segment and engine configuration;
- Vehicle kilometres travelled (VKT) by market segment and engine configuration;
- Infrastructure Costs;
- Vehicle costs (purchase price and operating costs);
- Cost per kilometre travelled for the different market segmentations and engine configurations; and
- Externalities (quantities and values) including greenhouse gas emissions and air pollution.

4.21 Further work

Further work is suggested on refining the vehicle choice parameters.

It is preferred that revealed preference data is used to corroborate the relative shares predicted by a choice model based solely on stated preference data. However, there is no revealed preference data available on electric vehicle take up due to the fact that this is a new market. What revealed preference data is available reflects the behaviour of early adopters rather than mainstream purchasers. Research suggests that early adopters have different purchasing habits to mainstream purchasers and in particular are less price sensitive. Furthermore, the relatively low take up of non-ICE vehicles is likely to reflect the limited supply of these vehicles into the Australian marketplace rather than consumer preferences.

The stated preference data that is available on electric vehicle demand is dated and mainly from the US which does not fully reflect Australian driving conditions. For instance, TRESIS is the only known

Australian study that has estimated electric vehicle demand. However, the TRESIS model is relatively old (uses 1991 RP data) and reflects preferences based on previous generation EVs which typically had lower vehicle performance. The data was also collected at a time when fuel prices weren‘t as high and people were less concerned with environmental issues. Recent vehicle sales data suggest people‘s views on vehicles have changed substantially over the past decade with a clear shift toward smaller, more fuel efficient vehicles. This suggests that the parameters used in this study may not reflect how consumers would respond under current market conditions.

There is also little in the literature on how peoples choices are affected by the distance they drive. As a result this could not be taken account of within the vehicle choice model and separate assumptions were made to capture this impact.

A more up to date stated preference survey would allow for a more robust assessment of demand for electric vehicles under Australian driving conditions, an updated model will allow for a better assessment of the following effects:

- Availability of a broader range of fuel types (e.g. LPG and diesel) in the Australian market;
- Higher ―believability" of electric vehicles as a viable alternative to ICE vehicles;
- Greater awareness of global warming and the environmental impact of ICE vehicles;
- Potential increasing sensitivity to fuel price fluctuations; and
- The multi-fuel capacity and electric vehicle bonuses.

Accounting for the abovementioned effects using new stated preference data will allow for a more precise evaluation of electric vehicle demand and may uncover additional factors that drive vehicle choice.

Moreover, collection of new stated preference data would allow for the estimation of new vehicle choice models which better capture potential heterogeneity in consumer preferences. Compared to the average, different market segments may be more or less cost sensitive and value various aspects of vehicle performance differently, in particular early technology adopters. Other relevant market segments include:

- Different purchasing groups (e.g. private versus fleet)
- Different driving patterns (e.g. distance travelled); and
- Socio-economic groups (e.g. income, age, residential location, existing vehicle ownership).

When properly modelled, heterogeneity in preferences manifests itself in different parameter values and bonuses for different market segments and may lead to marked differences in market shares between different consumer groups (e.g. early adopters). However, accounting for heterogeneity in consumer preferences cannot be accomplished without original stated preference datasets, whether through sample segmentation or by more complex modelling techniques such as mixed logit modelling.

It is also suggested further work is undertaken on understanding the supply constraints in Australia and what drives these and how vehicle use may change in the future (this model assumes similar vehicle use).

5.0 Results of Vehicle Choice Model

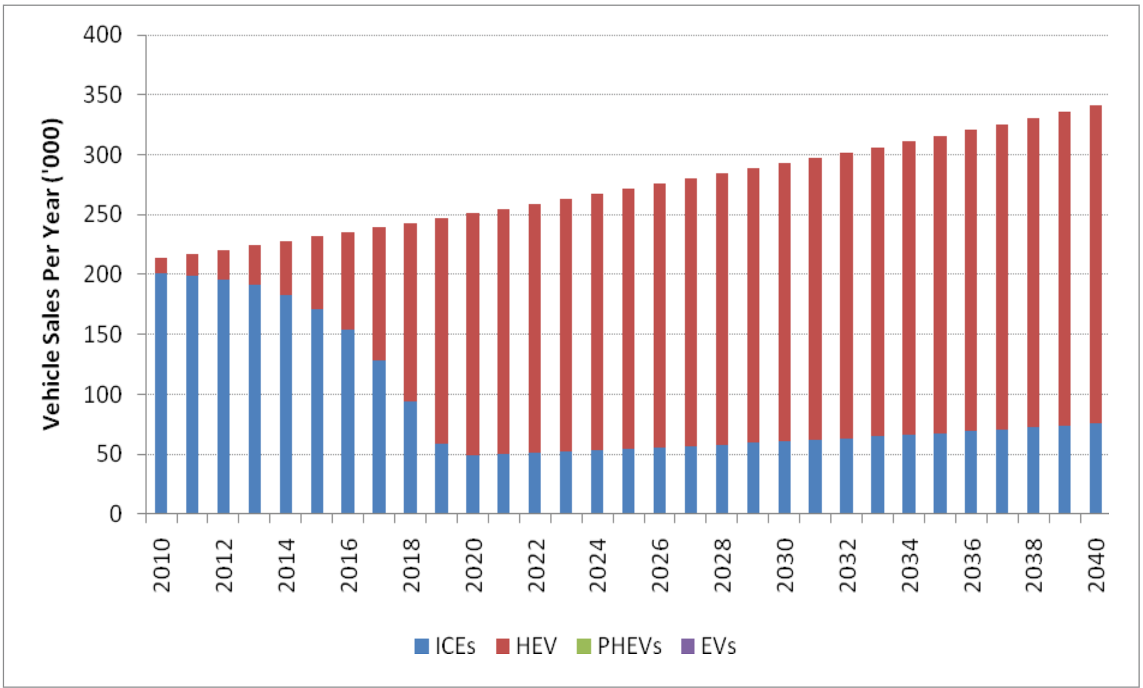
A key part of this study is the vehicle choice model which determines what proportion of new vehicle sales are for the different vehicle types.

The results presented below are based on central forecasts of oil price, electricity price and CPRS policy.

5.1 Proportion of Vehicle Sales for Different Scenarios

Figure 5-1 sets out the proportion of sales for each vehicle type for the Base Case. Under the Base Case there are no sales on PHEVs or EVs. The sale of HEVs starts to ramp up and takes over as the main vehicle type by 2020 once the price of HEVS converges to that of an ICE vehicle and there are no supply constraints. This is consistent with manufacturing expectations. Toyota, expect HEVs to be the majority of their vehicle sales by 2020 and most manufacturers expect to have an equivalent HEV for every vehicle in their range.

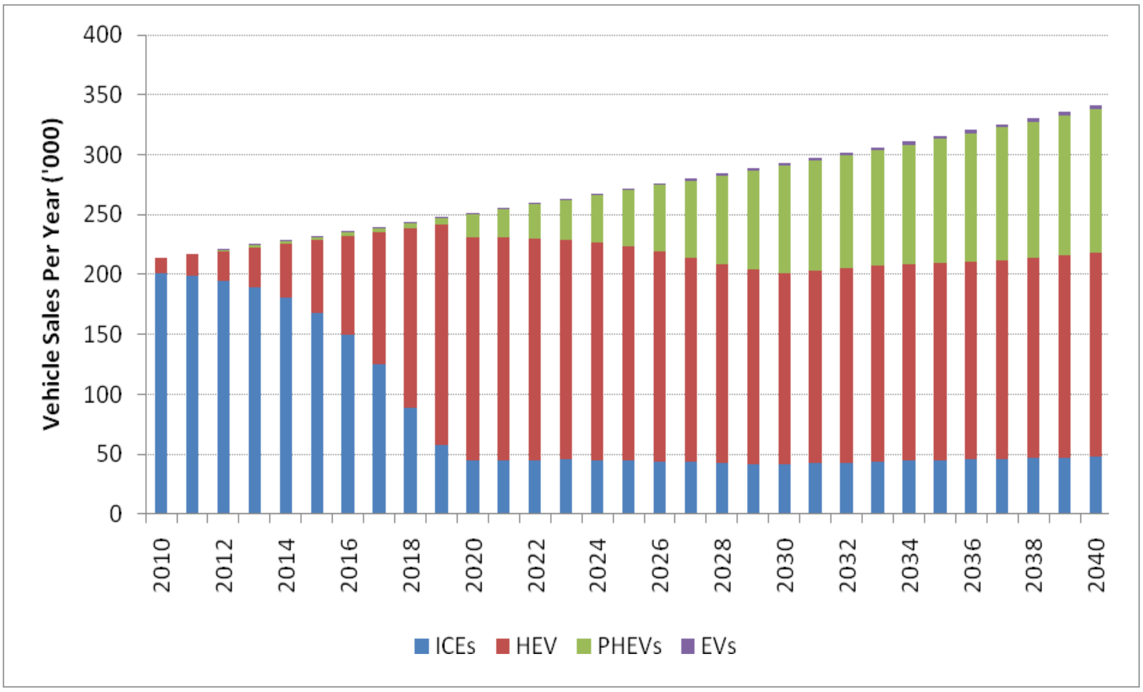
Figure 5-1: Vehicle sales in Base Case



Source: AECOM

Under Scenario 1, **Figure 5-2**, there is a small number of PHEVS and EVS in the market until 2020. After 2020, when supply is no longer constrained PHEVs become an increasing proportion of total sales. EVs remain a small proportion under this scenario.

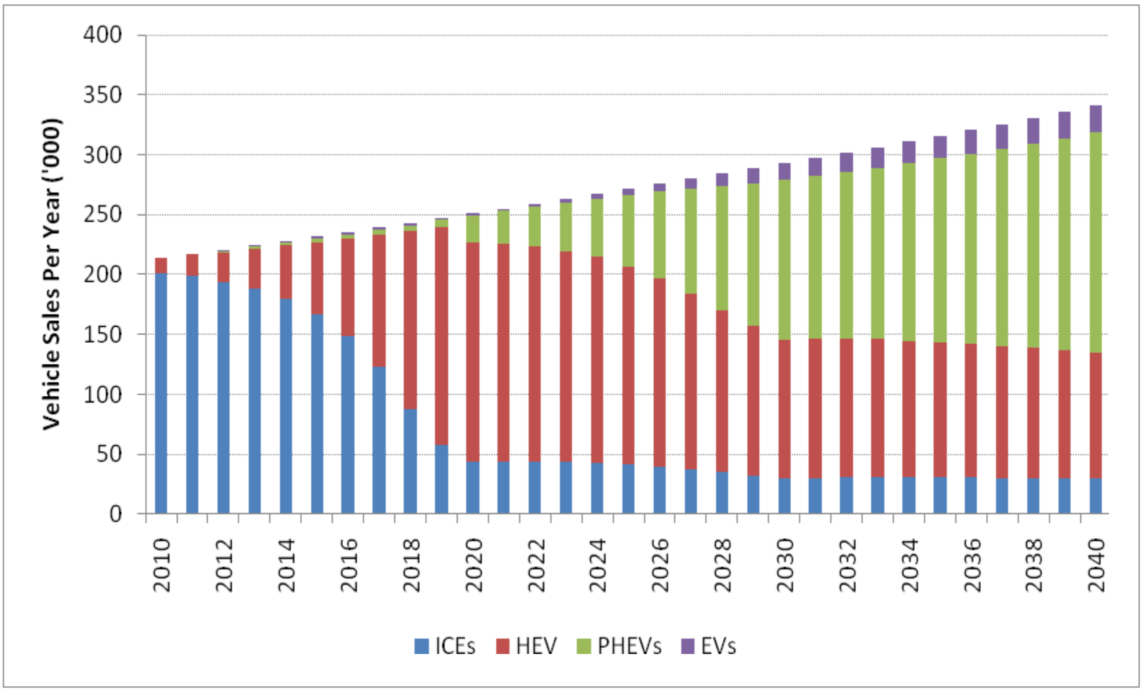
Figure 5-2: Vehicle sales in Scenario 1



Source: AECOM

Figure 5-3 sets out Scenario 2 which has similar proportions to Scenario 1, with an increasing number of EVs in the later years as prices have converged with that of an ICE vehicle.

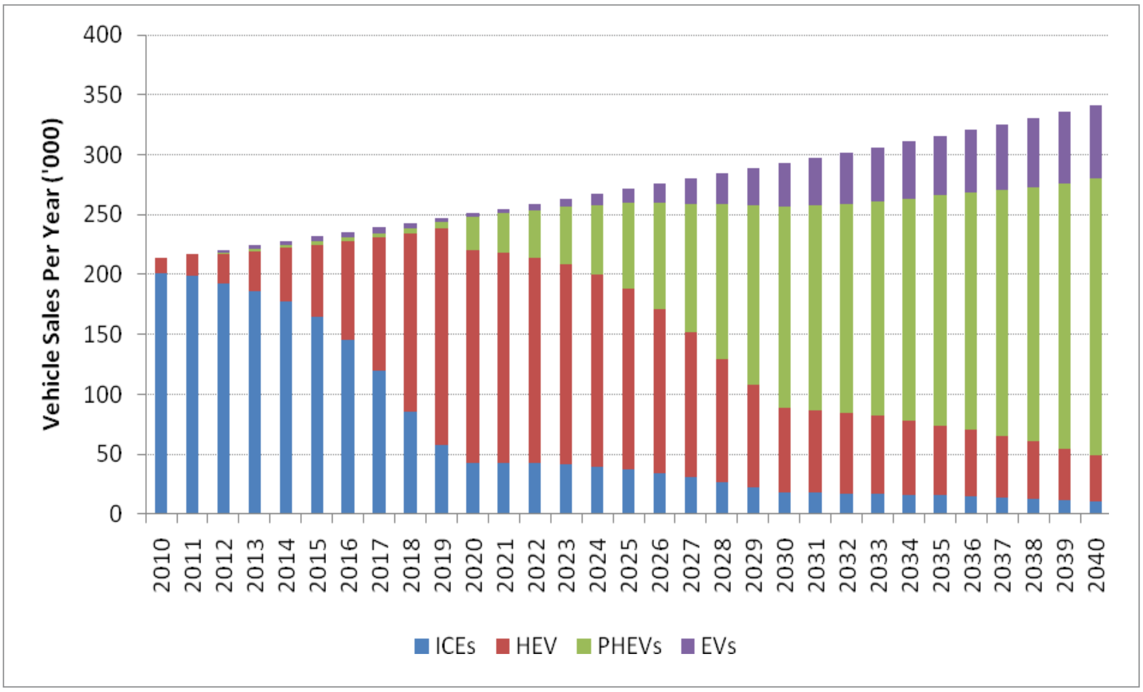
Figure 5-3: Vehicle sales in Scenario 2



Source: AECOM

Scenario 3, **Figure 5-4**, shows EVs and PHEVs taking over as the main vehicle choice from the late 2020's as prices converge with ICE vehicles. PHEVs remain the largest proportion of sales in 2040, but pure EVs are becoming an increasing proportion of sales.

Figure 5-4: Vehicle sales in Scenario 3



Source: AECOM

In summary, the take-up of PHEVs and EVs (plug-ins and pure EVs) is highly dependent on when the price converges with conventional vehicle prices and any supply constraints into the Australian market. The supply of infrastructure (as represented in the different scenarios) also has a big impact on the take-up of EVs.

The vehicle choice model takes account of:

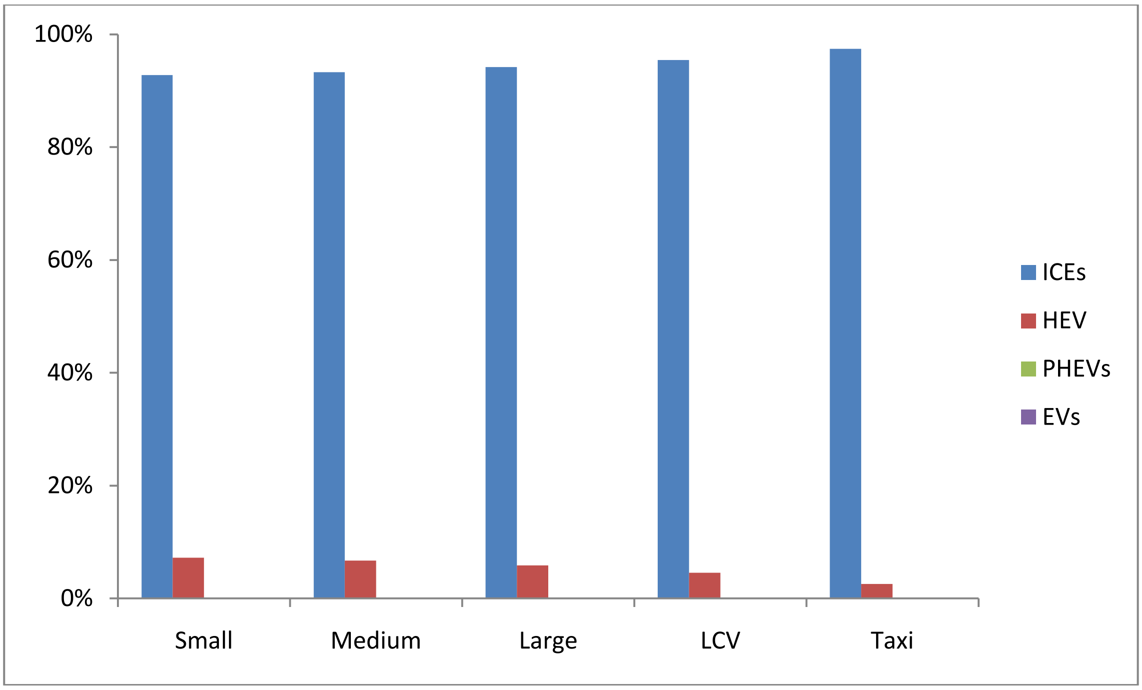
- Vehicle cost;
- Fuel cost;
- Range;
- Emissions;
- Infrastructure and
- Multi fuel bonus

The vehicle price and fuel costs have a large negative impact on the vehicle choice decision, whereas the range and infrastructure have a large positive impact. Emissions and multi fuel bonus are smaller factors in the decision making process. Over time, EVs will become cheaper and their range will increase. Provided charging infrastructure becomes readily available, there will be a shift over time towards EVs.

5.2 Proportion of Vehicle Sales for Different Market Segmentations

As set out in **Figure 5-5**, in 2010, under all Scenarios, new vehicle sales comprise mainly of ICE vehicles, with around 7% of passenger vehicles (small, medium and large) being HEVs, and only 3% of taxis being HEVs.

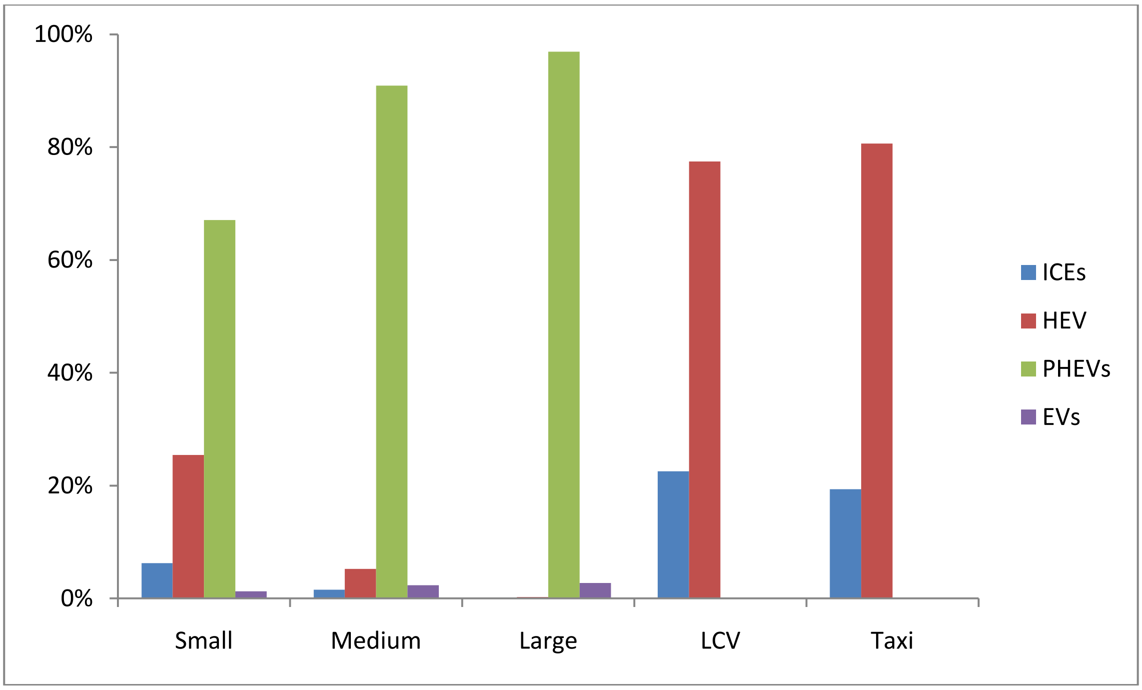
Figure 5-5: Vehicle sales in 2010 (all scenarios)



Source: AECOM

As set out in **Figure 5-6**, under Scenario 1, by 2040 a large proportion of new passenger vehicles are PHEVs with only a small number of EVs. Importantly, small vehicle sales have a higher proportion of HEVs than medium and large vehicle sales, with increasing numbers of PHEVs for larger vehicles. Light commercial vehicles and taxis are predominantly HEVs, with no PHEVs and EVs. EVs sales are very small at 1% to 3% for passenger vehicles.

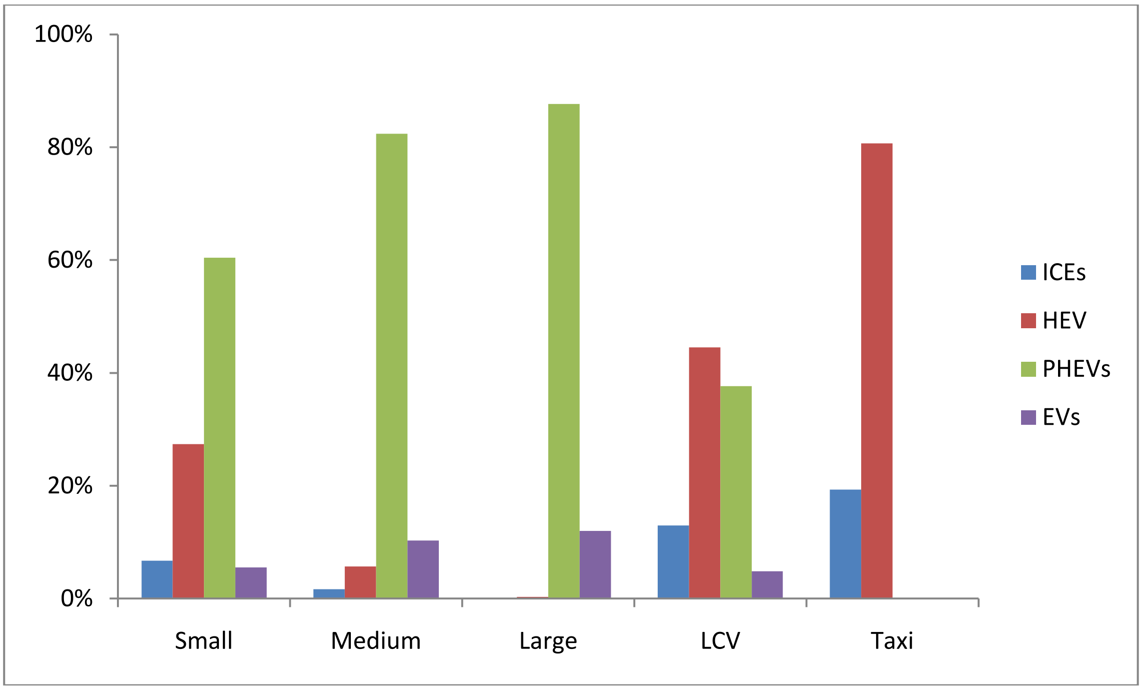
Figure 5-6: Vehicle sales in 2040 (Scenario 1)



Source: AECOM

As set out in **Figure 5-7**, under Scenario 2, by 2040 EVs have a larger proportion of passenger vehicle sales, particularly in the medium to large vehicle sales which account for around 11% to 12% of total sales.

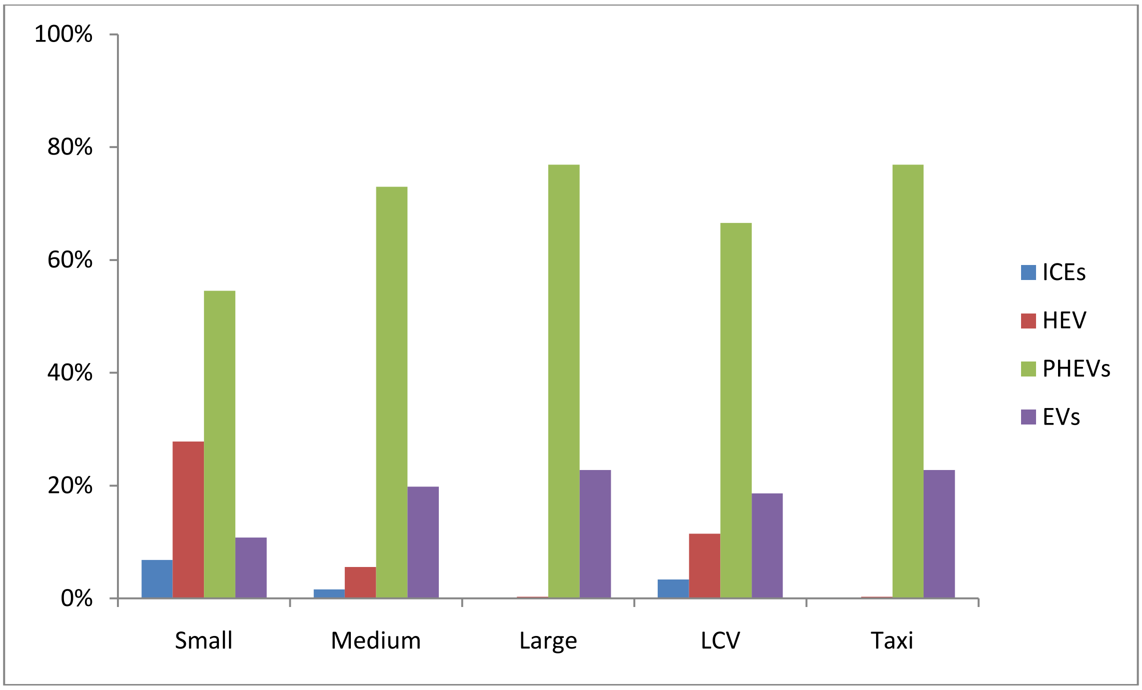
Figure 5-7: Vehicle sales in 2040 (Scenario 2)



Source: AECOM

As set out in **Figure 5-8**, under Scenario 3, with electric vehicle charging stations, electric vehicle sales increase to around 20% of sales by 2040 in most of the categories apart from small vehicles. Small vehicles retain a large proportion of HEVs whereas the other market segments have moved away from HEVs towards PHEVs and EVs. Over time, as the prices converge, the main differences are driven by operating cost savings which are less for smaller cars which typically travel less and have better fuel efficiencies.

Figure 5-8: Vehicle sales in 2040 (Scenario 3)



Source: AECOM

In summary, the vehicle choice model predicts:

- A transition to HEVs in near term (5-10 years), PHEVs over medium term (5-20 years) and EVs over longer term (20 years plus).
- Take-up of HEVs and EVs (plug-ins and pure EVs) is highly dependent on when the price converges with conventional vehicle prices and any supply constraints into the Australian market.
- The supply of infrastructure (as represented in the different scenarios) has a big impact on the take-up of EVs.
- In short term there is increased uptake of alternative engine configurations in the small vehicle category. However, as prices fall, the vehicle range increases and more charging infrastructure becomes available larger vehicles and vehicles that travel large distances tend to purchase a higher proportion of EVs. This is due to the fact that operating costs are more important for these vehicle owners and fuel efficiencies in ICE vehicles tend to be much lower in larger vehicles.

6.0 Externalities

In order to calculate the change in externalities, emission factors have to be determined. Both physical emission factors for different pollutants and the economic values of these factors need to be applied. This study has considered greenhouse gas emissions from both fossil fuels and electricity, and air pollution arising from vehicles. Air pollution from electricity generation has not been included because electricity is purchased from the National Electricity market operating across all states in eastern Australia and therefore cannot be sourced to any particular generation type or location.

6.1 Air Pollution

6.1.1 Quantity

Tailpipe emissions on a per kilometre travelled basis, have been estimated from figures published by the 2007 NSW Transport Facts[45], and are shown in **Table 6-1** and **Table 6-2**.

It has been assumed there will be no air pollution for EVs and for HEVs air pollution will only arise from the proportion of drivetime using fossil fuels.

Table 6-1: Air pollution emissions factors (g / km) – ICE passenger vehicles

Engine Type	CH_4 g / km	N_2O g / km	NO_x g / km	CO g / km	VOC g / km	PM_{10} g / km
Petrol (Euro III)	0.006	0.053	0.070	1.620	0.030	0.014
Diesel (Euro IV)	0.003	0.027	0.270	0.330	0.040	0.041
LPG (Euro IV)	0.005	0.008	0.040	0.830	0.010	0.014
Hybrid (Euro III)	0.006	0.053	0.060	1.620	0.010	0.014

Source: NSW Transport facts 2007, Apelbaum Consulting, April 2007

Table 6-2: Air pollution emissions factors (g / km) – ICE light commercial vehicles

Engine Type	CH_4 g / km	N_2O g / km	NO_x g / km	CO g / km	VOC g / km	PM_{10} g / km
Petrol (Euro IV)	0.002	0.053	0.030	0.850	0.010	0.011
Diesel (Euro IV)	0.001	0.017	0.600	0.210	0.020	0.037
LPG (Euro IV)	0.002	0.007	0.030	0.720	0.010	0.012

Source: NSW Transport facts 2007, Apelbaum Consulting, April 2007

Note: NOx, CO and VOCs are based on a vehicle having travelled 40,000 kms – see Table 5.1-2 in the Apelbaum report.

As vehicle fuel efficiencies improve over time, allowing vehicles to travel increased distance from the same amount of fuel, emissions per km are expected to decrease. It has been assumed that the per km emission factors in **Table 6-1** and **Table 6-2** are applicable to new vehicles in 2010, but will decrease in proportion with fuel efficiency gains in future years.

[45] NSW Transport facts 2007, Apelbaum Consulting, April 2007

6.1.2 Value

The Australian Transport Council guidelines[46] provide a default value for air pollution externalities of 2.45 cents per vehicle kilometre (2006 prices) for passenger vehicles in urban areas. This value has been assumed to represent emissions for a vehicle of average fuel efficiency. Emissions for each market segments have been scaled by the segment fuel efficiency relative to the average fuel efficiency in 2010, as described in **Section 4.8**.

6.1.3 Summary

Table 6-3 sets out the total air pollution savings by 2040 under each scenario. The savings increase substantially across the scenarios as take-up of EVs increases.

The results presented below are based on central forecasts of oil price, electricity price, CPRS policy and the shadow cost of carbon.

Table 6-3: Total air pollution savings by 2040

Air Pollutant	Scenario 1 (tonnes saved by 2040)	Scenario 2 (tonnes saved by 2040)	Scenario 3 (tonnes saved by 2040)
CH_4	316	779	1,343
N_2O	2,695	7,779	13,739
NO_x	4,065	11,529	20,117
CO	83,345	215,836	375,086
VOC	561	1,336	2,418
PM_{10}	822	2,284	4,002

Source: AECOM

Table 6-4 sets out the cost savings from air pollution under each of the scenarios compared to the Base Case. By 2040, Scenario 3 results in a saving of around $1.3 billion compared to the Base Case. Scenario 2 has total savings of around $710 million and Scenario 1 has savings of around $261 million.

Table 6-4: Air pollution savings ($m)

	Scenario 1 ($ saved by 2040)	Scenario 2 ($ saved by 2040)	Scenario 3 ($ saved by 2040)
Air pollution cost savings (7% discount rate)	$261m	$710m	$1,256m

Source: AECOM

Note that the model only includes vehicles purchased after 2010 so is not measuring the total vehicle stock.

6.2 Greenhouse Gas Emissions

The greenhouse gas emissions will be different for the different types of fuel used in the different engine configurations under consideration. As such, fossil fuel emissions and electricity emissions have been considered separately.

[46] National Guidelines for National Transport System Management in Australia, 2006, section 3 Appraisal of Initiatives

6.2.1 Quantity

Fossil Fuels

Estimates of emissions from the combustion of individual fuel types are made by multiplying the quantity of fuel by a fuel specific energy content factor and a fuel specific emissions factor. **Figure 6-1** sets out the guidance from the Department of Climate Change in their National Greenhouse Accounts (NGA) Factors.

Figure 6-1: Australian guidance on greenhouse gas emission calculations from fuel

The following formula can be used to estimate greenhouse gas emissions from the combustion of each type of fuel listed in Table 4 used for transport energy purposes.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

E_{ij} is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO_2-e tonnes).

Q_i is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

EC_i is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 4.

If Q_i is measured in gigajoules, then EC_i is 1.

EF_{ijoxec} is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO_2-e per gigajoule) used for transport energy purposes — see Table 4.

Source: National Greenhouse Accounts (NGA) Factors, November 2008

Table 6-5: Emission factors for fuel

Fuel	Energy Content Factor (GJ/kL)	Emission Factor (kg CO_2e/GJ)		
		CO2[47]	CH_4	N_2O
Gasoline	34.2	72	0.02	0.2
Diesel	38.6	74.5	0.01	0.6
LPG	26.2	64.9	0.3	0.3
These figures are for post 2004 vehicles that conform to Euro design standards				

Source: National Greenhouse Accounts (NGA) Factors, November 2008

It is assumed that the emission factors for fuel will not change over time. Fossil fuels may become more difficult to extract over time requiring more use of energy upstream. There is not enough information to model this so it has been assumed to remain constant.

[47] These emissions factors include Scope 1-3. See the report National Greenhouse Accounts (NGA) Factors, November 2008 for further discussion on the different scopes. http://www.climatechange.gov.au/workbook/pubs/workbook-nov2008.pdf

Electricity

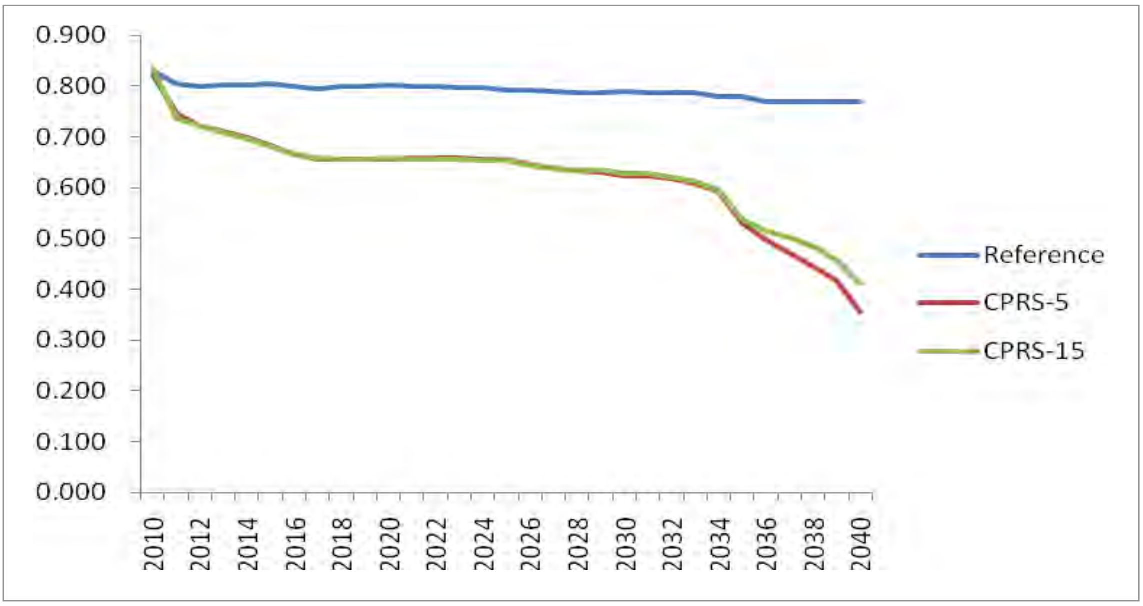
The National Greenhouse Accounts (NGA) Factors recommend a combined emissions intensity factor of 1.085 kg CO_2e/kWh for electricity generated in New South Wales and the Australian Capital Territory. However it should be noted that a National Electricity Market (NEM) operates in eastern Australia, so it is not reasonable to identify where electricity is generated. Rather, the focus should be on mix of generation in the NEM. Going forward the greenhouse gas emissions of EVs is dependent on the mix of the electricity generated and sold to power the vehicle.

The mix of electricity generation is expected to change significantly over the next 30 years. Government policies such as the National Renewable Energy Target (NRET) and the Carbon Pollution Reduction Scheme (CPRS) will provide impetus to this change. There is general consensus that whatever specific technology mix emerges, it is likely to deliver a progressive decarbonisation of electricity generation by mid-century. This is reflected in the Treasury's forecast of the electricity emissions intensity, as illustrated in **Figure 6-2**, which have been used in this study. These factors only represent Scope 2 emissions so Scope 3 emissions have been added to this, assuming they remain the same proportion of total emissions.

The carbon policy scenarios specifically modelled are:

- Reference case – no additional emission reduction measures (also excludes expanded national renewable energy target);
- CPRS-5 – 5% reduction from 2000 emission levels by 2020 and 60% reduction by 2050 (includes NRET); and
- CPRS-15 – 15% reduction from 2000 emission levels by 2020 and 60% reduction by 2050 (includes NRET).

Figure 6-2: Electricity emissions intensity

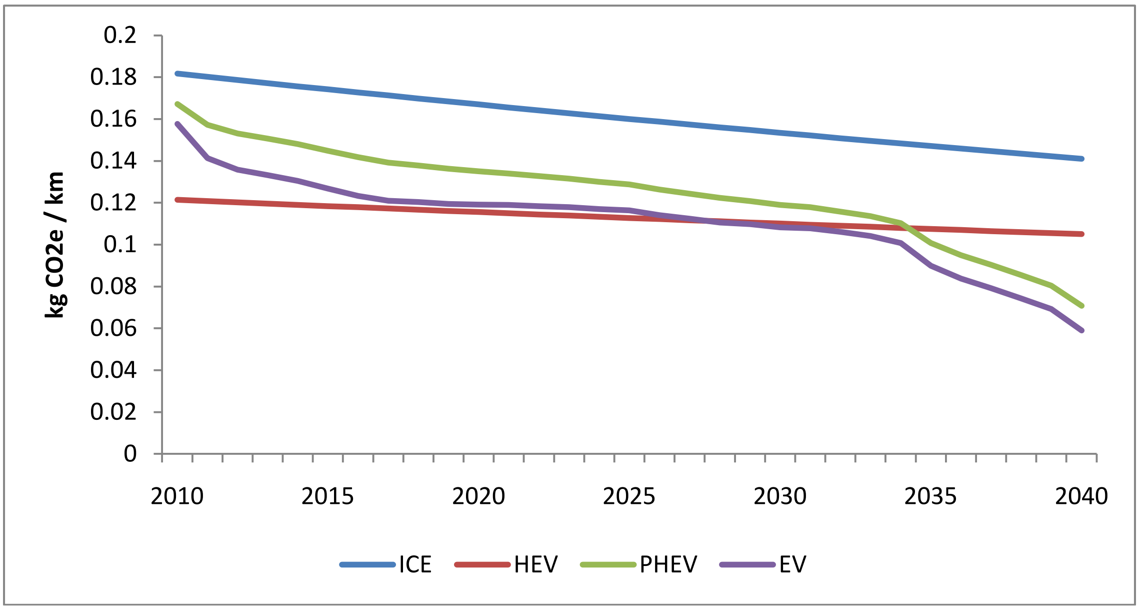


Source: Australia's Low Pollution Future, The Economics of Climate Change Mitigation, 2008

Greenhouse Gas Intensities of Different Engine Configurations

Figure 6-3 illustrates the greenhouse gas intensities per kilometre travelled for the different engine configurations for a small passenger vehicle. The intensity is dependent on the fuel efficiency and how this changes over time, as well as the greenhouse gas intensity of the different fuel (fossil fuel or electricity). ICE vehicles are the most greenhouse gas intensive per kilometre travelled. HEVs are the least greenhouse gas intensive per kilometre travelled until the late 2020's, when the emissions intensity of electricity falls due to increased renewable energy generation. Around 2027 EVs take over as the least greenhouse gas intensive vehicle. PHEVs track the performance of EVs but are slightly behind due to the proportion of ICE drivetrain.

Figure 6-3: Greenhouse gas intensities per kilometre travelled – small passenger vehicle, low VKT[48]



Source: AECOM

6.2.2 Value

As discussed in **Section 4.10.1**, the Treasury modelling forecasts of the CPRS permit price have been used in this study to ensure consistency with other CPRS forecasts. These have been adjusted to reflect recently announced policy changes including delaying the implementation of the scheme by a year and a $10 fixed price in the first year.

Although the proposed Carbon Pollution Reduction Scheme (CPRS) is expected to price greenhouse gas emissions that result from petrol/diesel or electricity, we feel further assessment is warranted. The CPRS will be a market price reflecting the value of traded carbon emissions rights given the constraints on supply imposed by the scheme. This, in practice, is often less than the social cost of carbon which seeks to encapsulate the full global cost today of an incremental unit of CO_2e emitted now, summing the full global cost of the damage it imposes over the whole of its time in the atmosphere.

There is a large amount of literature available on the issue of external costs of greenhouse gas emissions. The values vary significantly depending on the approach used and the country in which the analysis is undertaken. International research on the social cost of carbon suggests a figure of around A$50/tonne CO_2e. The UK Government recently adopted a value of £25.5/tonne CO_2e (2007 prices) that increases by 2% per year to reflect the damage costs of climate change caused by each additional tonne of greenhouse gas emitted (around A$65 in 2009). This has been made mandatory

[48] Fuel efficiencies as set out in **Section 4.8**

for all economic appraisals by the UK Government and was endorsed by the OECD. Recent research on the external cost of greenhouse gas emissions for the European Commission recommends a central value of €25 /t CO_2e (around A$50/t CO_2e) in 2010 rising to €40 /tCO_2e (around A$80/t CO_2e) by 2020[49].

Given there is an emerging body of international evidence suggesting the social cost of carbon is around $50/t CO_2e, the UK values have been used in this study to value the changes in greenhouse gas emissions. The central case is based on values published by the UK Department of Environment, Food and Rural Affairs, converted to Australian dollars by means of purchasing power parity exchange rates. The low and high values are ratios of the central case (plus and minus twenty per cent). Given some of the cost of greenhouse gas emissions is priced into the market through the CPRS scheme, the value used in this study will be the difference between the CPRS permit price and the recommended social cost of carbon.

6.2.3 Summary

Table 6-6 sets out the annual greenhouse gas emissions under each scenario. Compared to the Base Case, Scenario 3 saves around 31.3 million tonnes CO_2e by 2040.

Table 6-6: Total air pollution savings by 2040

	Scenario 1 (tonnes saved by 2040)	Scenario 2 (tonnes saved by 2040)	Scenario 3 (tonnes saved by 2040)
GHG emissions (tCO_2e)	5.6m	17.3m	31.3m

Source: AECOM

[49] Handbook on estimation of external costs in the transport sector, CE Delft, February 2008.

7.0 Sensitivity

This study considers a new market for vehicles powered by electricity that could develop over the next 30 years. There is much uncertainty around the future path of many of the key variables. This study has used the best available information to forecast variables and built a model that will allow extensive sensitivity testing around the key variables and be easily updated as new information becomes available.

The key areas of sensitivity testing are highlighted in **Table 7-1**.

The key factors likely to affect the outcomes of this study include:

- Vehicle price and changes over time;
- Fuel prices (fossil fuels and electricity); and
- Fuel efficiencies and changes over time.

Table 7-1: Summary of key assumptions

Variable	Current Assumption / Suggested Sensitivity
General model assumptions	
Discount rate (economic evaluation)	7% Sensitivity at 4% and 10%
Discount rate (financial evaluation)	7% Sensitivity testing at 4%, and 10%
New vehicle sales assumptions	
Demand for new passenger vehicles	Assume grows at 1% per annum Sensitivity on different growth rates
Projections of new passenger vehicle sales by vehicle type	Currently assume shift from large to medium vehicles continues. In 2008: Small – 30% of new sales Medium – 45% Large – 25% Assume that this changes by 2020 to: Small – 30% Medium – 55% Large – 15% Sensitivity different % shift and different year
Proportion of VKT ranges in each vehicle size category	It is assumed that VKT proportions by vehicle type will be unchanged in the future
Proportion of new LCV sales	Assume grows at 5% per annum, declining to 3% per annum by 2030 Sensitivity on different growth rates
Taxis	Assume no increase in licences/vehicles
Vehicle price assumptions	
Fixed vehicle price	Prices based on global survey $10,000 premium in Australia compared to US prices No growth in ICE prices HEVs reach price parity with ICEs in 2020 PHEVs and EVs reach price parity with ICEs in 2030 Sensitivity on different prices and growth rates

Variable	Current Assumption / Suggested Sensitivity
Fuel efficiency	
Fuel type	Current fossil fuel mix remains same Passenger vehicles: 88% petrol, 5% diesel and 7% LPG LCV: 57% petrol, 34% diesel and 9% LPG Taxi: 100% LPG
Growth in fuel efficiencies	ICE: 37% between 2006 to 2050 HEVs: relative to ICE See **Table 4-14** EVs: 20% increase to 2050 PHEV: EV 50% of kilometres in 2006 increasing to 80% in 2030
Fuel costs	
Oil price	• High – corresponds to EIA (Energy Information Agency) high price scenario; • Reference – corresponds to the EIA reference scenario; and • Low – equal to a 20% discount from the reference scenario.
Base prices	Diesel 100% petrol price LPG 40% of base petrol prices
Excise	The current fuel excise is $0.381 and is applied to petrol and diesel. LPG tax is scheduled to begin on 1 June 2011 (assumed to be same as petrol excise)
CPRS	Price based on forecast by Treasury modelling Assume no pass through to fuel prices for first 3 years
GST	10%
Electricity prices	
Carbon emissions policy	Prices from Treasury modelling: • Reference case – no additional emission reduction measures (also excludes expanded national renewable energy target) • CPRS-5 – 5% reduction from 2000 emission levels by 2020 and 60% reduction by 2050 (includes NRET) • CPRS-15 – 15% reduction from 2000 emission levels by 2020 and 60% reduction by 2050 (includes NRET)
Residential network charge	Equal to network charge as determined by Treasury Modelling[50]
Additional residential network charge	20% premium on residential network charge
Commercial charging station network charge	Equal to residential network charge plus a premium see **Section 4.10**
Public charging point network charge	Equal to residential network charge plus a premium see **Section 4.10**
Other vehicle costs	
Fuel cost per km	Derived from fuel efficiencies and prices for fossil fuels and electricity
Registration	Fixed registration from RTA. Assumed no growth
Insurance	Greenslip – no growth Comprehensive insurance – no growth
Maintenance	ICE – 13.45c/km HEV – assumed same as ICE (13.45c/km)

[50] Impacts of the Carbon Pollution Reduction Scheme on Australia's Electricity Markets, Report to Federal Treasury 11 December 2008, McLennan Magasanik Associates (MMA)

Variable	Current Assumption / Suggested Sensitivity
	PHEV – assumed 125% more than ICE (16.81c/km) EV – assumed 50% less than ICE (6.73c/km)
Other assumptions	
Range	ICE and HEV – 500km for small passenger; 550km for all other categories EV – range from 120km to 300km depending on vehicle category. See **Table 4-23** PHEV – range maximum of EV or ICE All grow over time in line with increased fuel efficiencies EVs also grow from 5% per annum increase in battery storage
Emissions	Derived from fuel efficiency, fuel emissions factor and vehicle segment
Infrastructure	Availability relative to ICE vehicles: ICE and HEV – 100% availability for all scenarios PHEV and EV – availability depends on scenario. See **Table 4-24**
Multi-fuel bonus	HEVs and PHEVs receive bonus Sensitivity undertaken with and without multi fuel bonus
Non-captive market	Proportion of market that may purchase EV or PHEV dependent on VKT and scenario See **Table 4-25**
Supply constraints	There are expected to be global supply constraints until at least 2012 and as such, a supply constraint has been built into the model to ensure it reflects current market conditions **HEV supply constraint** - 1,000,000 HEVs currently in global production, will grow by 35% per annum. Australia will receive 1% of global demand. Supply will be constrained until 2020 **PHEV supply constraint** - By 2012 there will be around 150,000 PHEVs in global production and 1% of these will reach Australia. Production will grow at 20% per annum and be constrained until 2020 **EV supply constraint** - By 2012 there will be around 500,000 EVs in global production and 1% of these will reach Australia. Production will grow at 20% per annum and be constrained until 2020
Cost of infrastructure	Base – no costs Scenario 1 – no costs Scenario 2 • $1000 per household for interface unit • $6000 per public charging unit Scenario 3 • $1000 per household for interface unit • $6000 per public charging unit • $500,000 per charging station Different costs

8.0 Economic and Financial Results

This section brings the model results together to assess the economic and financial viability of an electric vehicle market.

The results presented below are based on central forecasts of oil price, electricity price, CPRS policy and the shadow cost of carbon.

8.1 Net Present Value

Table 8-1 sets out the present value of the benefits associated with introducing EVs into the NSW market compared to the Base Case. The model shows that under all scenarios the EV market is both economically and financially viable over the long run. The net present benefit becomes positive after 2030 under all scenarios.

This is largely driven by the high vehicle purchase costs of alternative engine configuration vehicles decreasing over time and the operating cost savings increasing over time. In addition, there are large savings in greenhouse gas and air pollution emissions. Greenhouse gas emission savings total $33m under Scenario 1, $91m under Scenario 2 and $165 million under Scenario 3. Air pollution savings total $261m under Scenario 1, $710m under Scenario 2 and $1,256 million under Scenario 3.

The net benefits increase with the level of charging infrastructure because this increases the take-up of EVs. Higher levels of charging infrastructure also bring forward the break-even year.

Table 8-1: Present Value of Benefits incremental to the Base Case*

Benefits	Scenario 1			Scenario 2			Scenario 3		
	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)
Vehicle Purchase ($m)	-$272	-$1,230	-$1,230	-$415	-$2,010	-$2,313	-$625	-$2,766	-$3,192
Vehicle Operation ($m)	$71	$461	$1,447	$133	$1,020	$4,008	$242	$1,694	$6,756
Charging Infrastructure ($m)**				-$1	-$15	-$37	-$3	-$26	-$65
Financial Benefits ($m)	-$201	-$769	$217	-$283	-$1,005	$1,658	-$386	-$1,098	$3,499
GHG Emissions ($m)	$3	$11	$33	$4	$21	$91	$7	$36	$165
Air Pollution ($m)	$11	$82	$261	$21	$182	$710	$40	$319	$1,256
Economic Benefits ($m)	-$187	-$676	$511	-$258	-$802	$2,459	-$339	-$743	$4,920
Breakeven year	2035			2032			2031		

*Based on central forecasts of oil price, electricity price and CPRS policy. A 7% discount rate has been used for all present value calculations.

** Net charging infrastructure is capital cost of charging infrastructure minus premium customers pay to cover cost of infrastructure.

Source: AECOM electric vehicle model

8.2 Sensitivity Analysis

As set out in **Section 7.0**, there is much uncertainty around the future path of many of the key variables. Whilst the model has been designed to allow extensive sensitivity analysis, this report will focus on the key factors likely to affect the outcomes of this study, including:

- Vehicle price and changes over time;
- Fuel prices (fossil fuels and electricity); and
- Discount rates.

Table 8-2 and **Table 8-3** set out the present value of the economic and financial costs under various sensitivity scenarios. In summary:

- Results are very sensitive to the year in which EVs reach price parity with ICE vehicles. Bringing price parity forward/delaying it by five years has a significant impact on the results;
- Changing the initial price does affect the results but this is not as sensitive as the year in which prices converge;

- If the price convergence is delayed and the price increases the viability of Scenario 1 (and Scenario 2 in the financial results) starts to be affected;
- Results are sensitive to increasing oil prices but less so to electricity and CPRS prices;
- Combination of high oil prices with low electricity prices has a large positive impact on the results;
- The multi fuel bonus increases the take-up of HEVs and PHEVS compared to EVs, resulting in less benefits in terms of cost and externality savings;
- The supply constraint makes the overall results better. This is because it delays the purchasing of vehicles that are more expensive in the early years. By constraining supply you prevent people purchasing more expensive vehicles. Increased vehicle purchase costs in early years are more significant than operating cost savings in later years due to the high level of discounting. The loss in consumer welfare from people not being able to purchase their preferred vehicle is not captured in the model.
- Results are sensitive to the discount rate used, when a 10% discount rate is used Scenario 1 becomes financially not viable; and
- The results of all the sensitivity tests are intensified moving from Scenario 1 to Scenario 3.

Table 8-2: Present Value of economic benefits under various sensitivity scenarios (compared to the Base Case)

Economic Benefits	Scenario 1			Scenario 2			Scenario 3		
	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)
Vehicle Prices (7% discount rate)									
Price parity with ICEs in 2015 (instead of 2020) for HEVs and 2025 for PHEVs and EVs (instead of 2030)	-$163 m	$19 m	$1,420 m	-$239 m	$505 m	$4,604 m	-$319 m	$1,367 m	$8,502 m
Price parity with ICEs in 2025 (instead of 2020) for HEVs and 2035 for PHEVs and EVs (instead of 2030)	-$217 m	-$923 m	-$265 m	-$277 m	-$1,084 m	$794 m	-$348 m	-$1,146 m	$2,236 m
10% increase in vehicle prices for HEVs, PHEVs and EVs	-$233 m	-$782 m	$358 m	-$293 m	-$951 m	$2,170 m	-$366 m	-$993 m	$4,426 m
10% decrease in vehicle prices for HEVs, PHEVs and EVs	-$135 m	-$530 m	$711 m	-$214 m	-$572 m	$2,856 m	-$287 m	-$338 m	$5,623 m
Price parity with ICEs in 2015 for HEVs and 2025 for PHEVs and EVs **plus** 10% decrease in vehicle prices	-$122 m	$146 m	$1,574 m	-$200 m	$738 m	$4,925 m	-$262 m	$1,797 m	$9,099 m
Price parity with ICEs in 2025 for HEVs and 2035 for PHEVs and EVs **plus** 10% increase in vehicle prices	-$246 m	-$994 m	-$448 m	-$293 m	-$1,156 m	$462 m	-$352 m	-$1,270 m	$1,683 m
Fuel Prices (7% discount rate)									
Low oil price	-$190 m	-$681 m	$393 m	-$256 m	-$839 m	$2,067 m	-$333 m	-$842 m	$4,177 m
High oil price	-$180 m	-$664 m	$767 m	-$262 m	-$703 m	$3,337 m	-$348 m	-$476 m	$6,611 m
Low electricity price	-$186 m	-$676 m	$542 m	-$259 m	-$794 m	$2,559 m	-$341 m	-$720 m	$5,108 m
High electricity price	-$187 m	-$676 m	$481 m	-$258 m	-$811 m	$2,358 m	-$338 m	-$767 m	$4,735 m
No CPRS	-$186 m	-$683 m	$479 m	-$258 m	-$813 m	$2,359 m	-$339 m	-$758 m	$4,736 m
High CPRS	-$186 m	-$680 m	$536 m	-$260 m	-$800 m	$2,553 m	-$343 m	-$725 m	$5,110 m
Low oil price, high electricity price and central CPRS price	-$190 m	-$681 m	$364 m	-$256 m	-$845 m	$1,973 m	-$332 m	-$860 m	$4,004 m
High oil price, low electricity price, central CPRS price	-$180 m	-$663 m	$801 m	-$263 m	-$690 m	$3,451 m	-$350 m	-$441 m	$6,826 m
Without multi fuel bonus	-$199 m	-$628 m	$566 m	-$266 m	-$655 m	$2,903 m	-$349 m	-$459 m	$6,105 m
No supply constraint	-$931 m	-$1,327 m	-$108 m	-$1,097 m	-$1,409 m	$1,932 m	-$1,265 m	-$1,376 m	$4,390 m
Discount Rates									
4% discount rate	-$222 m	-$934 m	$1,552 m	-$305 m	-$1,073 m	$5,792 m	-$396 m	-$907 m	$11,014 m
10% discount rate	-$158 m	-$499 m	$84 m	-$221 m	-$608 m	$983 m	-$293 m	-$604 m	$2,159 m

Source: AECOM electric vehicle model

Table 8-3: Present Value of financial benefits under various sensitivity scenarios (compared to the Base Case)

Financial Benefits	Scenario 1			Scenario 2			Scenario 3		
	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)	NPV (to 2020)	NPV (to 2030)	NPV (to 2040)
Vehicle Prices (7% discount rate)									
Price parity with ICEs in 2015 (instead of 2020) for HEVs and 2025 for PHEVs and EVs (instead of 2030)	-$176 m	-$109 m	$1,056 m	-$265 m	$192 m	$3,575 m	-$373 m	$787 m	$6,640 m
Price parity with ICEs in 2025 (instead of 2020) for HEVs and 2035 for PHEVs and EVs (instead of 2030)	-$230 m	-$1,001 m	-$508 m	-$299 m	-$1,234 m	$213 m	-$387 m	-$1,402 m	$1,221 m
10% increase in vehicle prices for HEVs, PHEVs and EVs	-$245 m	-$862 m	$85 m	-$311 m	-$1,106 m	$1,461 m	-$397 m	-$1,258 m	$3,176 m
10% decrease in vehicle prices for HEVs, PHEVs and EVs	-$152 m	-$639 m	$392 m	-$246 m	-$802 m	$2,022 m	-$352 m	-$757 m	$4,127 m
Price parity with ICEs in 2015 for HEVs and 2025 for PHEVs and EVs **plus** 10% decrease in vehicle prices	-$138 m	$5 m	$1,192 m	-$237 m	$385 m	$3,843 m	-$340 m	$1,132 m	$7,123 m
Price parity with ICEs in 2025 for HEVs and 2035 for PHEVs and EVs **plus** 10% increase in vehicle prices	-$256 m	-$1,055 m	-$661 m	-$308 m	-$1,273 m	-$50 m	-$379 m	-$1,467 m	$793 m
Fuel Prices (7% discount rate)									
Low oil price	-$203 m	-$770 m	$108 m	-$278 m	-$1,015 m	$1,333 m	-$373 m	-$1,147 m	$2,881 m
High oil price	-$196 m	-$765 m	$453 m	-$289 m	-$914 m	$2,508 m	-$400 m	-$856 m	$5,124 m
Low electricity price	-$201 m	-$770 m	$246 m	-$284 m	-$984 m	$1,788 m	-$386 m	-$1,054 m	$3,738 m
High electricity price	-$201 m	-$768 m	$189 m	-$282 m	-$995 m	$1,602 m	-$382 m	-$1,090 m	$3,394 m
No CPRS	-$203 m	-$779 m	$186 m	-$284 m	-$1,001 m	$1,596 m	-$386 m	-$1,088 m	$3,370 m
High CPRS	-$200 m	-$769 m	$263 m	-$283 m	-$981 m	$1,848 m	-$386 m	-$1,044 m	$3,858 m
Low oil price, high electricity price and central CPRS price	-$204 m	-$769 m	$82 m	-$278 m	-$1,019 m	$1,247 m	-$371 m	-$1,161 m	$2,723 m
High oil price, low electricity price, central CPRS price	-$195 m	-$765 m	$485 m	-$290 m	-$904 m	$2,614 m	-$402 m	-$828 m	$5,324 m
Without multi fuel bonus	-$209 m	-$707 m	$288 m	-$287 m	-$840 m	$2,113 m	-$391 m	-$813 m	$4,623 m
No supply constraint	-$957 m	-$1,445 m	-$432 m	-$1,146 m	-$1,657 m	$1,094 m	-$1,344 m	-$1,791 m	$2,929 m
Discount Rates									
4% discount rate	-$240 m	-$1,078 m	$986 m	-$335 m	-$1,368 m	$4,285 m	-$451 m	-$1,425 m	$8,336 m
10% discount rate	-$170 m	-$560 m	-$76 m	-$240 m	-$730 m	$580 m	-$329 m	-$818 m	$1,444 m

Source: AECOM electric vehicle model

8.3 Externalities

Table 8-4 summarises the total greenhouse gas and air pollution (CH_4, N_2O, NO_x, Co, BOC and PM_{10}) emission savings compared to the base case under each scenario.

Table 8-4: Greenhouse gas and air pollution emission savings compared to the base case

tonnes	Scenario 1			Scenario 2			Scenario 3		
	To 2020	To 2030	To 2040	To 2020	To 2030	To 2040	To 2020	To 2030	To 2040
Greenhouse Gas Emissions	169,763	908,201	5,621,115	224,888	1,929,891	17,255,754	361,435	3,462,002	31,307,014
CH_4	4	62	316	9	139	779	18	243	1,343
N_2O	23	500	2,695	61	1,254	7,779	133	2,228	13,739
NO_x	228	1,185	4,065	313	2,314	11,529	466	3,784	20,117
CO	897	15,802	83,345	2,101	37,068	215,836	4,358	65,242	375,086
VOC	45	167	561	57	271	1,336	91	473	2,418
PM_{10}	22	186	822	36	410	2,284	61	701	4,002

Source: AECOM electric vehicle model

8.4 Cost per Kilometre

Table 8-5 sets out the expected lifetime cost per kilometre for the different engine configurations in 2010 and 2040. The total cost of ownership includes the vehicle price, annual fuel[51] and maintenance costs (based on average annual distance travelled as set out in **Table 4-5**) and insurance. Future costs have been discounted at 7%.

Table 8-5: Lifetime cost per kilometre for each engine configuration in 2010 and 2040[52]

Engine Type	Small Passenger		Medium Passenger		Large Passenger		Light Commercial		Taxi	
	2010	2040	2010	2040	2010	2040	2010	2040	2010	2040
ICE	$0.263	$0.264	$0.286	$0.287	$0.352	$0.355	$0.277	$0.279	$0.271	$0.275
HEV	$0.299	$0.245	$0.318	$0.272	$0.380	$0.341	$0.299	$0.264	$0.321	$0.264
PHEV	$0.297	$0.217	$0.313	$0.227	$0.469	$0.274	$0.365	$0.214	$0.466	$0.234
EV	$0.260	$0.191	$0.270	$0.199	$0.416	$0.243	$0.318	$0.185	$0.438	$0.220

Source: AECOM

Figure 8-1 sets out how the cost per kilometre changes from 2010 to 2040 for a small vehicle. Significantly, despite the high vehicle price EVs are around the same cost per kilometre as ICE vehicles in 2010 due to large fuel cost savings over the life of the vehicle. The cost per kilometre falls steadily until 2030 when the price of an EV reaches price parity with an ICE vehicle. After 2030, the cost per kilometre of EVs is around 72% of the cost per kilometre for ICE vehicles. HEVs and PHEVS, which do not have the full fuel savings of an EV, take longer to reach a favourable cost per kilometre with an ICE vehicle but both remain significantly below ICE vehicles once vehicle price parity has been

[51] Fuel prices are forecast out to 2040 and have been assumed to be constant after this time.
[52] The cost per kilometre is non-scenario specific as vehicle and operating costs do not change significantly across the scenarios.

reached, at 82% for PHEVs and 93% for HEVs. The cost per kilometre of medium vehicles is similar to small vehicles.

Figure 8-1: Lifetime cost per kilometre - small

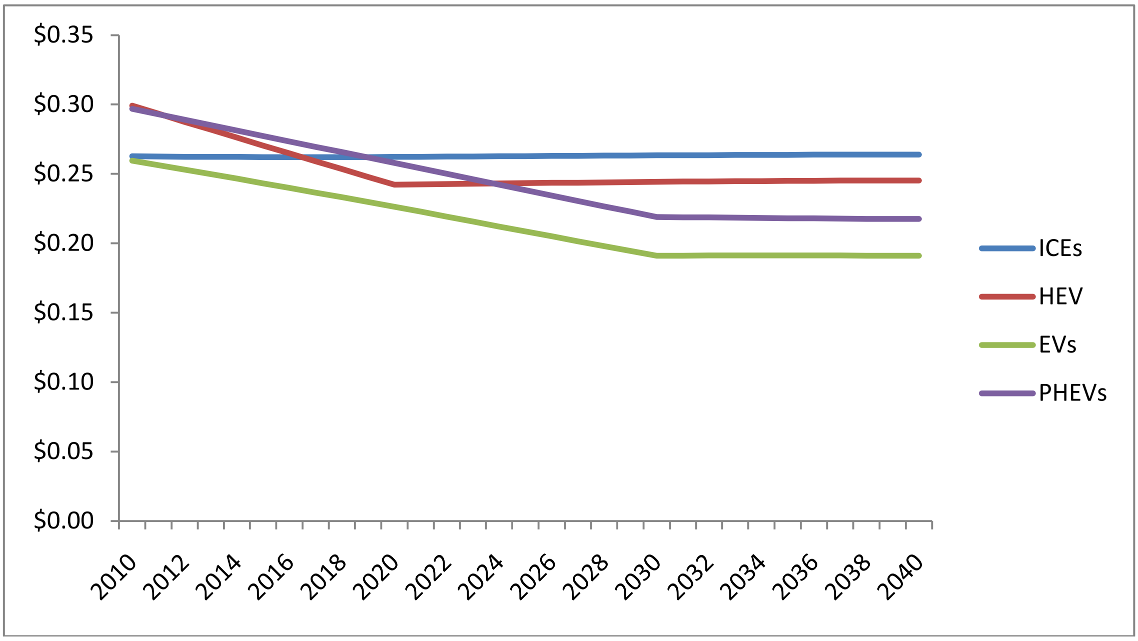


Figure 8-2 sets out how the cost per kilometre changes from 2010 to 2040 for a large vehicle. As highlighted in the review of current or planned EVs (**Table 3-1**) the vehicle price for large EVs is currently high, outweighing the operating cost savings until around 2017. However, once vehicle prices reach price parity with ICE vehicles there are significant cost savings for large vehicles, which tend to travel larger distances. By 2040, the cost per kilometre for a large EV is 68% of the ICE cost, compared to 72% for a small EV. The cost per kilometre for Light Commercial Vehicles is similar to large passenger vehicles, although stabilises at 52% of the ICE cost per kilometre due to the larger distances travelled.

Figure 8-2: Lifetime cost per kilometre – large

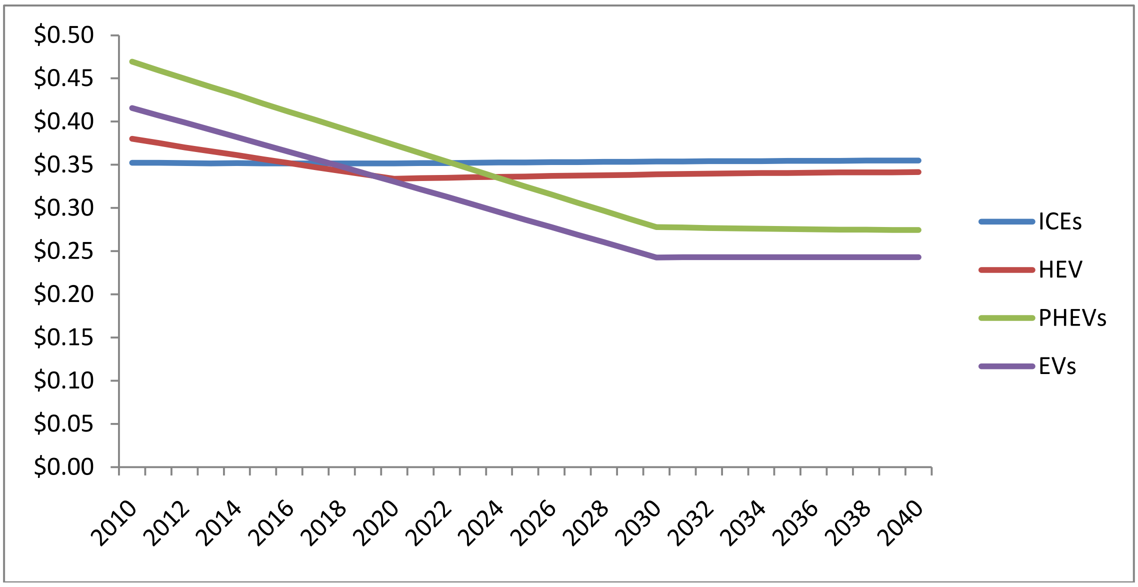
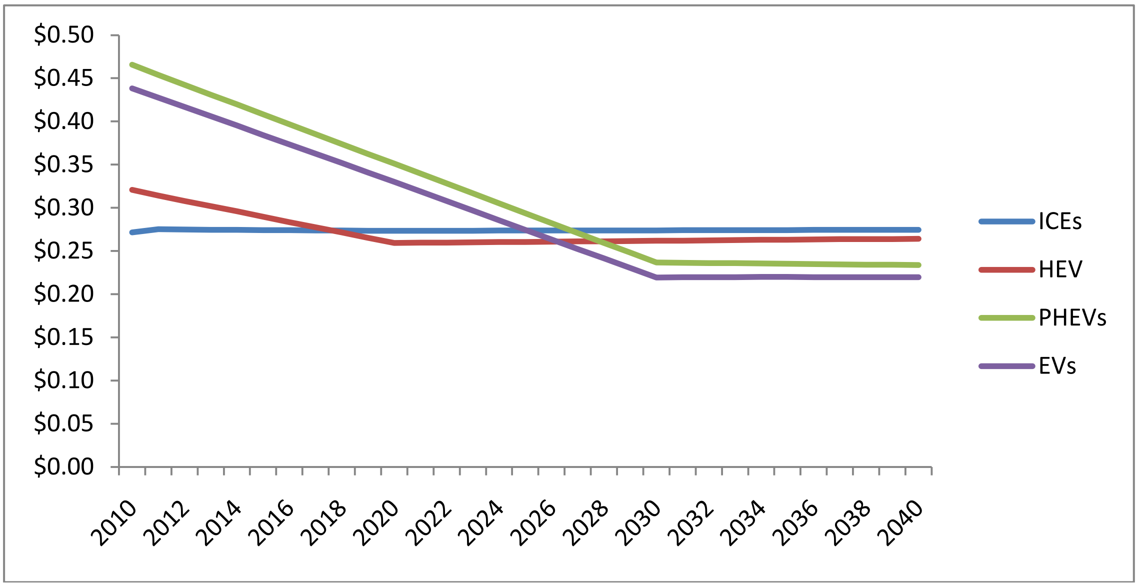


Figure 8-3 sets out the cost per kilometre changes from 2010 to 2040 for taxis. As with large passenger vehicles and light commercial vehicles the high vehicle cost of EVs, PHEVs and HEVs outweighs the cost savings from fuel in the early years. The fuel savings are not as high as for other vehicles due to the high use of LPG in taxis which is less than half the price of petrol and diesel. Taxis also have a much shorter vehicle life than other vehicles (Taxis are not allowed to be older than 6.5 years) which reduces the time available to recoup the fuel savings.

Figure 8-3: Lifetime cost per kilometre – Taxis



In summary, the cost per kilometre for smaller EVs is already cost competitive with ICE vehicles due to the fuel cost savings outweighing the high up-front vehicle cost. As PHEVs and HEVs only achieve a proportion of the fuel cost savings, it takes longer to offset the higher vehicle cost. Conversely, large passenger vehicles and LCVs take longer to reach cost per kilometre parity with ICEs due to the high upfront price premium for large EVs, PHEVs and HEVs. However once they reach parity there are larger savings compared to an ICE due to the larger distances travelled. Taxis take longer to reach a cost per kilometre comparable to ICE vehicles and even with vehicle price parity, the fuel savings are not as high as for other vehicles. This is due to the high use of LPG in taxis and the much shorter vehicle life.

It is important to note that the cost per kilometre measure is complementary to the results set out above. The cost per kilometre uses the same inputs as the vehicle choice model (vehicle price, fuel costs, and maintenance costs) but is not a result of the vehicle choice model and should not be compared with the results.

The cost per kilometre allows a theoretical comparison of the lifetime costs of different engine configurations. However, people make their decisions based on a number of factors including available infrastructure, vehicle range and preference for ―greener vehicles". They also tend to make decisions based on an average ownership of four to five years. The vehicle choice model tries to include these factors into the analysis.

8.5 Model Conclusions

The model shows that the plug-in electric vehicle market in NSW is both economically and financially viable. However, the economic and financial returns accrue over the longer term. The move towards a plug-in electric vehicle market also generates large savings in greenhouse gas and air pollution emissions.

The vehicle choice model predicts a transition to HEVs in the short term (5-10 years), PHEVs over the medium term (5-20 years) and EVs over the longer term (20 years plus). In the short term there is increased uptake of alternative engine configurations in the small vehicle category. Significantly, despite the high vehicle price, small EVs are around the same lifetime cost per kilometre as ICE vehicles in 2010 due to large fuel cost savings over the life of the vehicle. As vehicle prices fall, the vehicle range increases and more charging infrastructure becomes available, owners of larger vehicles and vehicles that travel large distances tend to purchase a higher proportion of EVs. This is due to the fact that operating costs are more important for these vehicle owners.

Higher levels of charging infrastructure (as represented in the different scenarios) significantly increase the take-up of plug-in electric vehicles and hence increase the viability of the market. Other key factors affecting both take-up and viability include the vehicle cost and rate at which it converges with ICE vehicles (this is largely driven by battery costs), fuel prices (particularly higher oil prices), vehicle range and the existence of local supply constraints.

Vehicle costs and vehicle range are expected to converge over time as technology improves and production increases, therefore the removal of supply constraints and the provision of charging infrastructure are the key areas that warrant further attention if the take-up of EVS is to be encouraged.

9.0 Issues for Consideration

In undertaking this study, several issues arose that were not able to be incorporated into the model, but are important in understanding the electric vehicle market and how it may evolve over time. These are discussed below.

9.1 Battery Issues

- **Evolution toward standardisation of technology**: As discussed in **Section 2.3**, the prospects for improvement in plug-in vehicle batteries are quite promising. Today's batteries have been deemed ―sufficient" for the commencement of mass-market commercialisation, and as the battery supply industry matures, there will be increasing emphasis to develop standard battery architectures. Standards could define voltages, currents, hardware, software, interconnects, cell and pack form factors, diagnostic systems, etc. Developing standards will be further motivated by increased emphasis on battery compliance regulations for safety, servicing and interchangeability.
- **Cost of batteries**: The cost of batteries will be a critical factor affecting the market uptake of plug-in electric vehicles. **Section 2.2.4** discussed industry expectations are for a reduction of battery costs through economies of scale as production volumes increase and industry learning curves. Without significant increases in production, these cost reductions may not materialise.
- **Environmental issues around batteries (production and disposal)**: While lithium-ion batteries can theoretically be produced and disposed of in an environmentally-sustainable manner, the industry is yet to fully adopt responsible practices as it expands its facilities for manufacturing and recycling.
- **Battery life expectancy and uncertainty**: While the latest expectations for lithium-ion battery life are quite promising and battery technology continuously improving, there is still the possibility that manufacturers will bring EV/PHEV products to market before battery lifetime issues are fully understood and resolved. This is largely a practical issue relating to limited on-road experience with latest-generation lithium battery vehicles and the significant time and resources needed for exhaustive testing. The provision of manufacturer warranties and replacement guarantees will clearly be an important factor in this regard.
- **Value of batteries:** An important consideration will be the residual value of used automotive batteries and the development of secondary markets (e.g. telecoms, backup power). A high aftermarket price for vehicle batteries would make battery leasing more attractive, shifting some of the upfront cost and risk away from the vehicle purchaser,

9.2 Supply Constraints

A major issue to the take-up of EVs in the short term (next 5 years) will be supply constraints. A recent study on the electric vehicle market predicted limited global supply until at least 2012[53]. It is expected that, with the exception of some niche manufacturers like G-Wiz, Tesla, and a few others, only Mitsubishi will have a market ready model available in 2011. Most manufacturers including Nissan, BMW and Renault are currently in the testing phase of their vehicles and are at least 3 years away from mass roll out.

Despite a global slowdown in vehicle sales, the launch of the new Toyota Prius in May 2009 has been hugely successful with early indicators that demand will be much greater than current production plans. Toyota have a sales goal of 400,000 worldwide for the year with half of this in the US. In Japan alone, Toyota received 80,000 orders (20% of total expected global sales) for the car before it went on sale. They sold 110,000 Prius' in Japan in May and there is a waiting list of several months. Indications are that the launch of the Prius in the US will face a similar response with some dealers reporting to have been accumulating waiting lists for more than a year. Toyota has three Prius

[53] Concerted Government Support Critical for Powering the Electric Vehicle Market, Frost & Sullivan, May 2009

manufacturing lines in Japan, which at full capacity are able to make about 50,000 Prius cars a month or 600,000 cars per annum.

Local sales of HEVs suggests global supply constraints are exacerbated in Australia. Toyota has sold more than 1.27 million Prius‘ worldwide since its debut in 1997. In Australia, almost 12,000 Toyota Prius‘ (just under 1% of global sales) have been sold since its product launch here in 2001.

Australia has a relatively small vehicle market and is not a key market for vehicle manufacturers. As highlighted by the recent launch of the Toyota Prius, vehicle manufacturers cannot meet demand in key markets such as the US and Japan. Australia is likely to continue to face exacerbated supply problems until vehicle production increases significantly to meet demand globally.

9.3 Market Structure / Business Model

9.3.1 Current Market Structure for Vehicle Travel

The current market for vehicle travel is characterised by the following:

- **Car manufacturers**: The car manufacturing market is highly competitive with a large number of market players. Car manufacturers produce cars and undertake R&D.
- **Petrol stations**: Oil companies refine oil to produce petrol. They also franchise petrol stations. The market for petrol is dominated by a small number of large players but there are also some independent petrol stations. Importantly, supermarkets and convenience stores have also entered the petrol station market.
- **Independence between car make and petrol station**: At this stage, any car can be filled up at any petrol station. There is no link between the car manufacturer and the petrol station that can be used. However, there are arrangements between fleet operators and petrol stations that bind drivers of fleet cars to use one brand of petrol station only.

The current market structure of vehicle travel is therefore characterised by vertical separation.

9.3.2 Market Structure for Electric Vehicles

In theory the market structure for EVs does not have to differ substantially from the market structure of the current vehicle market. A vertically separated market structure would imply:

- **EVs** would be produced by car manufacturers which are independent from other market participants; and
- **Charging stations** are provided by companies that are independent from car manufacturers.

However, there are a number of business models proposed by private companies that suggest a different market structure from the existing market, and in particular a more vertically integrated market for electric vehicle travel. For example, BetterPlace is proposing a business model that integrates:

- Provision of the vehicle;
- Charging stations as well as charging at home; and
- Battery swapping.

The model is similar to those used for mobile phone contracts. The customer buys a vehicle via BetterPlace and subsequently signs up to a contract for a certain number of kilometres of travel. The customer can recharge at a BetterPlace charging or battery swapping station. This level of vertical integration implies that customer‘s decision-making on whether to drive an electric vehicle is simplified.

The business models chosen by providers of electric vehicle infrastructure can have a strong influence on customer decision-making. While this should not change the fundamental cost and benefits of electric vehicle travel, it could change the perception of relative costs and benefits by customers and hence affect their choice of vehicle.

9.3.3 Implications of Competition Policy

According to the Competition Principles Agreement (1995, updated in 2007):

" […] the Commonwealth will put forward legislation to establish a regime for third party access to services provided by means of significant infrastructure facilities where:

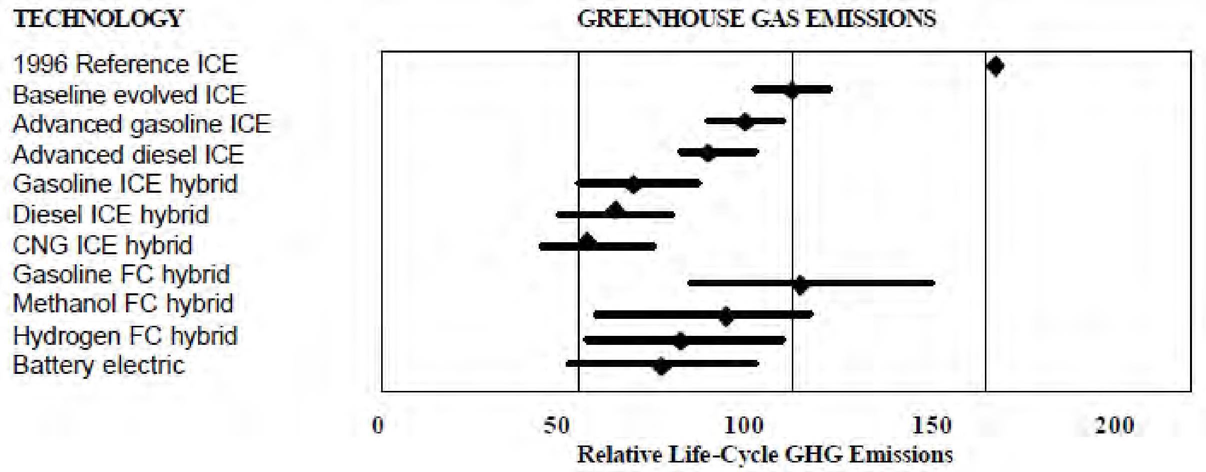
- *a) it would not be economically feasible to duplicate the facility;*
- *b) access to the service is necessary in order to permit effective competition in a downstream or upstream market;*
- *c) the facility is of national significance having regard to the size of the facility, its importance to constitutional trade or commerce or its importance to the national economy; and*
- *d) the safe use of the facility by the person seeking access can be ensured at an economically feasible cost and, if there is a safety requirement, appropriate regulatory arrangements exist."*

Considering infrastructure for re-charging and battery swapping, it is not clear-cut whether it is economically feasible to duplicate facilities. In general, there is sufficient land available for infrastructure charging points to be developed by more than one company. However, if one company establishes charging facilities without any competition at the time, the question of third party access arises. If it is determined that electric vehicle charging infrastructure cannot easily be duplicated, owning such infrastructure leads to significant market power and third party access would need to be regulated in order to prevent any company from charging monopoly rents.

9.4 Lifecycle Considerations

The lifecycle of batteries and associated electric-drive components will clearly be a determining factor for the overall sustainability of the plug-in vehicle industry. Early efforts to characterise the lifecycle of electric-drive vehicles are revealing some positive indications. For example, Toyota has conducted studies using empirical data for their HEV products and some comprehensive, predictive studies have been performed by MIT, EPRI and others. In most cases, electric-drive vehicles have been shown to result in reduced lifecycle emissions of greenhouse gases and other pollutants, as well as potential for reductions in total lifecycle costs. However, given Australia's current reliance on fossil fuels, the ongoing use of these fuels for manufacturing process energies and electric power generation will be a critical factor, and further lifecycle assessment will be required based on Australia's unique local context.

Figure 9-1: Life-Cycle Comparisons of Technologies for New Mid-Sized Passenger Cars



Reference: Malcolm A. Weiss, John B. Heywood, Elisabeth M. Drake, Andreas Schafer, and Felix F. AuYeung (2000) –ON THE ROAD IN 2020: A life-cycle analysis of new automobile technologies”, MIT Energy Laboratory Report # MIT EL 00-003, Massachusetts Institute of Technology, Cambridge MA.

9.5 Electricity Issues

The most significant electricity issue arises in respect of how electric vehicle charging infrastructure is priced and how consumers respond. If consumers charge their EVs during peak periods, then there will be an increase in cost of supply due to increase in peak generation and congestion on transmission and distribution infrastructure. If electricity wholesale and network prices rise for all users, the incentive may be too weak to encourage consumers to change their charging behaviour. However prices could be structured to encourage charging outside peak periods with charging infrastructure that does not require major upgrades to networks. Clearly there is interplay between cost of charging and convenience, which will affect the take-up of EVs.

There has been some discussion about the potential for batteries in EVs to act as a distributed storage system — charging during off-peak periods when prices are low and discharging back into the network during peak periods when prices are high. The connection agreements and pricing arrangements for such distributed storage would be challenging to negotiate, based on experience with distributed generation systems such as solar photovoltaics. The impact of such discharges on battery life is also unclear. It is likely to be many years before distributed storage is implemented.

The use of EVs will add to overall electricity consumption and may require investment in additional generation capacity to meet this consumption. This could potentially become an issue should there be large scale shifts from conventional fossil fuel powered vehicles to EVs. Under the higher EV take up of Scenario 3, annual electricity consumption for EVs and PHEVs in 2039-40 (8.2TWh) represents an increase of around 10% of 2007-08 total NSW electricity consumption (78.3TWh[54]). However, general growth in electricity consumption between 2008 and 2040 will reduce the significance of EV electricity consumption as a proportion of total consumption.

9.6 Government Policies

Governments all around the world have developed policies to encourage the take-up of EVs. Some policies are designed to support industry (infrastructure, development of technology) whilst other policies are to encourage increased demand through subsidising the purchase and operating costs for consumers. **Table 9-1** summarises government policies around the world. Most countries have a combination of supply side policies and demand stimulus policies. In summary policies are aimed at:

[54] ABARE *Energy in Australia 2009* (Department of Resources, Energy and Tourism) 2009.

- Supporting the development of the technology (particularly batteries);
- Supporting the electricity network to adjust to the additional demand from EVs;
- Providing charging infrastructure; and
- Making EVs more attractive to consumers (through subsidising the vehicle and reducing operating costs – free parking, free charging).

Table 9-1: Summary of government policies to support EVs

Country	Policies
US	**Supply side support** *Support to manufacturing industry* In March 2009, US announced the launch of two programmes aimed to support the electric vehicle industry, worth around US$2.4 billion, including: • $1.5 billion in grants to U.S. based manufacturers to produce highly efficient batteries and their components; • Up to $500 million in grants to U.S. based manufacturers to produce other components needed for EVs, such as electric motors and other components; and • Up to $400 million transportation electrification demonstration and deployment projects. *Support to electricity industry* The American Clean Energy and Security Act (ACES), which passed the Energy and Commerce Committee on May 21, 2009, has extensive provisions for electric cars. The bill calls for all electric utilities to, ―develop a plan to support the use of plug-in electric drive vehicles, including heavy-duty hybrid electric vehicles". The bill also provides for ―smart grid integration," allowing for more efficient, effective delivery of electricity to accommodate the additional demands of plug-in EVs. Finally, the bill allows for the Department of Energy to fund projects that support the development of electric vehicle and smart grid technology and infrastructure. *Support for infrastructure providers* In California, the mayors of San Francisco, San Jose, and Oakland have announced a nine-step policy plan to encourage the use of EVs in the Bay Area. The mayors will advance policies to expedite permits for installing charging outlets, create incentives for employers to install charging outlets, secure suitable 110-volt outlets in every government building for charging EVs, develop a plan for installing 220-volt charging outlets throughout each city, and harmonize local regulations and standards to achieve regulatory consistency for electric vehicle companies. The mayors will also establish programs for buying large numbers of EVs at discount rates for government and private fleets. **Demand side support** From 1 January 2009, electric vehicle buyers can receive tax credits varying from $2500 to $7500 depending on the vehicle's battery capacity.
European Union	**Demand side support** The European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE) 55 has a table summarizing the taxation and incentives for EVs in the different European countries. Assistance is mainly on the demand side relating to:

[55] http://www.avere.org/state_subsidies.pdf

Country	Policies
	• Direct subsidies (e.g. Sweden subsidizes 40% of difference between EV and conventional vehicle; Netherlands subsidizes up to 4,000 Euro per vehicle) • Reduction in VAT and other taxes (e.g. Austria has 50% reduction in VAT, Norway has no VAT) • Reduction in parking and other charges (tolls, highways) (e.g. many countries have free parking and many offer free public charging)
Portugal	**Supply side support** The Government has committed to investing in setting up electric charging stations across the country and in raising awareness of the vehicle's benefits.]
UK	In October 2008 the UK pledged £100 million to support electric, hybrid and other more environmentally friendly car projects over a five-year period to help make Britain "the European capital for electric cars". The funding will be used to support a number of measures, as set out below. **Supply side support** The UK has committed up to £20m, through the ―Alternative Fuel Infrastructure Grant Program" to support the installation of electric vehicle charging points. The UK Government also has a number of program to support research, development and demonstration of low carbon vehicles. **Demand side support** In April 2009, the UK Government announced financial assistance in the region of £2,000 to £5,000 to purchase EVs and PHEVS when they arrive at the showrooms. There are a range of other national incentives , including: • Vehicle Excise Duty exemption; • Enhanced Capital Allowance; and • Lowest rate of Benefit in Kind /company car tax. There are also a variety of local measures, including Congestion Charge exemption in London and free/reduced price parking in the City of Westminster
Denmark	Denmark is planning to introduce a greater number of battery driven electric cars on the streets - charged on renewable energy from the country's many windmills. Whilst Denmark does not offer direct purchase subsidies the government does offer consumers the incentive of waiving the 180% tax on vehicle purchase for an EV.
China	China's Ministry of Industry and Information Technology (MITI) has offered subsidies of up to around A$12,000 for taxi fleets and agencies for the purchase of an electric car.
Japan	Subsidies will cut 75% of the price premium between an electric vehicle and a conventional vehicle.

It is important to consider the applicability of government policies in Australia. It is worth noting that the limited supply in Australia over the next few years may limit the effectiveness of demand side initiatives. On the other hand, given the current global supply issues, the lack of consumer incentives in Australia may act as a disincentive for manufacturers to bring plug-in products here compared to other markets. It will be important for government to consider these issues if they decide to look further into the role they could play in the electric vehicle market.

9.7 Other Issues

This study is a partial equilibrium model and as such there are a range of other effects that may occur as a result of changes in the vehicle market that have not been considered in this study. These include:

- **Commodity prices:** The large scale use of EVs is likely to affect commodity supplies and prices particularly oil, copper, lithium and other metals prevalent in EVs and batteries.
- **Employment and skills:** The move from conventional vehicles to EVs may impact employment in the petrol vehicle industry (service stations, mechanics) in terms of number of jobs and skills required. The results of this study indicate that the stock of vehicles using petrol does not fall below current levels until after 2030. The long time frame means that capital and labour employed in petrol vehicle industries could relatively easily move across to electric vehicle industries with little industry restructuring costs. For example, service stations could become recharge stations and mechanics could progressively re-skill to service EVs. Local refining of petrol is unlikely to cease, as any reduction in petrol sales after 2030 would mean less refined petrol imports. Currently at least 15% of petrol used in NSW is imported as refined petrol.

10.0 Review of Market Failures

This section highlights market failures that may occur in the electric vehicle market. Importantly, some market failures may be present in the early stage of the electric vehicle market that hinder the development of the market and others may arise once the market is more established. By understanding these market failures Government will be better placed to ensure that they do not hinder the growth and development of the electric vehicle market.

10.1 Impediments to the Development of a Market in Australia

There are a variety of potential barriers and market failures that may hinder the development of the electric vehicle market, including:

- **First mover uncertainty:** The lack of standardisation and regulation in the battery industry may hinder the development of charging infrastructure. On the other hand, the first movers could find themselves in a position of significant market power to dictate the standards to industry.
- **Supply constraints:** The size of the Australian market, relative to other countries, is relatively small, resulting in exacerbated supply problems in the Australian market. Automotive companies seem reluctant to commit to increased production until there is more certainty about the future of the industry.
- **Short time horizon/short-termism:** The literature of vehicle choice decisions suggests that consumers make the decision largely based on the purchase price rather than the life of the vehicle. Given, at the moment EVs have higher purchase price but reduced operating costs there is likely to be distortion away from choosing EVs. This is likely to continue until electric vehicle prices converge with conventional vehicles.

10.2 Market Failures that may arise in the Electric Vehicle Market

There is a variety of potential market failures that may become more serious as the electric vehicle market grows, including:

- **Lack of competition:** The current market structures being suggested by industry may result in increased vertical integration of the industry, with less choice and higher prices for consumers.
- **Barriers to entry:** Setting up electric vehicle service stations is likely to be expensive. Once there is a network set up it may act as a barrier to entry, resulting in a lack of competition (discussed above).
- **Public goods nature of new technologies[56]:** One of the biggest market failures that affects the EVs market is the positive benefits that arise from reductions in greenhouse gas emissions, air pollution and noise emissions. These benefits are largely unpriced in the market at the moment, although CPRS is intended to price some of the greenhouse gas externalities.
- **Information asymmetry:** There may be a certain amount of ambiguity among consumers about the performance and safety of EVs compared to conventional vehicles. For each person to commit resources to researching and assessing the performance of electric vehicles may be too time consuming and costly.

[56] As defined in the IPART review of NSW climate change mitigation measures, May 2009

APPENDIX 2

2. Lincoln-Rocklin Report on incorporating NEVs in CBD traffic

City of Lincoln and City of Rocklin
Joint Report to the California State Legislature

as required by

Assembly Bill 2963
(Chapter 422, Section 1. Chapter 7

Neighborhood Electric Vehicle
Transportation Plan Evaluation

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Justin Nartker, Public Works Operations Supervisor, City of Rocklin

Date: January 1, 2011

NEV Transportation Plan Evaluation

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EXECUTIVE SUMMARY

In August 2006, Lincoln’s City Council formally adopted a resolution to approve its Neighborhood Electric Vehicle (NEV) Transportation Plan (EXHIBIT A) that implements the City’s vision to provide safe and efficient access for NEVs to downtown and other commercial areas. Prior to 2005, federal law only permitted NEVs to operate on streets with a posted speed limit of 35 mph or less, but California state law, **Assembly Bill (AB) 2353**, established special provisions to define the use of NEVs on city streets. The legislation allowed NEVs to operate on streets with posted speed limits above 35 mph where designated NEV lanes are available.

On January 1, 2008 the City of Lincoln submitted a Report to the California State Legislature that evaluated the NEV Transportation Plan in the City of Lincoln with regard to traffic and safety impacts on higher speed facilities permitted by **AB2353** (EXHIBIT B). The report also evaluated the design and implementation of NEV-specific signage and pavement makings as part of the plan.

On July 22, 2008, **AB 2963** was enacted to extend the January 1, 2009, termination date applicable to these NEV provisions to January 1, 2012. It also extended the reporting requirements for both cities (Lincoln and Rocklin), to the extent they implement a NEV transportation plan, to report to the Legislature by January 1, 2011, relative to whether the NEV transportation provisions should be terminated, continued, or expanded statewide.

In accordance with AB 2963, Section 1, 1963.7 (b), this report shall include all of the following:

(1) A description of all NEV transportation plans and their elements that have been authorized up to that time.
(2) An evaluation of the effectiveness of the NEV transportation plans, including their impact on traffic flows and safety.
(3) A recommendation as to whether this chapter should be terminated with respect to the City of Rocklin in the County of Placer or expanded statewide.

Based on these findings, it is recommended that the provisions in **AB2963** should be expanded statewide.

CITY OF LINCOLN NEV TRANSPORTATION PLAN IMPLEMENTATION

Improvements identified on APPENDIX G of EXHIBIT B, NEV Transportation Plan Map, have not been fully implemented for various reasons, such as the following:

- Construction of roadway enhancements have not been completed due to global economic conditions that have stalled development.
- Reduction of workforce available to construct signing and striping improvements to existing roads.
- Existing roadway cross section is not sufficient to allow designation of NEV Route in accordance with the design standards set forth in the NEV Transportation Plan.

Status of signing and striping improvements for each roadway identified on the NEV Transportation Plan Map as being “DESIGNATED NEV LANES” are shown on Table 1.

CHALLENGES TO IMPLEMENTATION – PHYSICAL

Physical challenges to implementation of the plan include insufficient cross sections of older roadways, roadways that have only been partially built in a phased approach to development, roadways that have not been constructed at all due to a slowdown of development, and roadways that connect to roadways outside of City jurisdiction with posted speed limits that are greater than 35 mph.

Many older roadways lack sufficient roadway cross sections to include Class II bicycle lanes, let alone shared NEV / Bicycle Class II lanes. However, these types of roadways are generally located in areas that are not fully developed. As future development proceeds, it is anticipated that these roadways will be improved to include widths sufficient to accommodate shared NEV / Bicycle Class II lanes as part of a “Complete Streets” approach to Roadway Development.

Portions of Ferrari Ranch Road and East Joiner Parkway were constructed in a phased approach. As development proceeds, these roadways will be further developed with roadway cross sections that are consistent with the provisions of the NEV Transportation Plan for designation as NEV routes.

Several portions of roadway extend to City Limit boundaries, where they connect to County roads with posted speed limits greater than 35 mph. Until such time that the State expands the provisions of **AB2353 / AB2963** Statewide, and the County implements necessary improvements to provide for NEV facilities on these roadways, the City will continue to terminate designated NEV routes at the nearest logical termini within Lincoln City limits.

CHALLENGES TO IMPLEMENTATION – ROADWAY USERS

One of the primary challenges experienced by the City of Lincoln during the early stages of implementation of the NEV Transportation Plan was educating the public about the physical, legal and functional differences between NEVs and golf carts.

The area of the City where the majority of NEV users are located in is Sun City Lincoln Hills. The first phase of Lincoln Hills opened ten years ago as an age-restricted golf cart community. Lincoln Hills now includes 6,800 single family units and a population of approximately 11,000 residents. Amenities include two championship golf courses, and as a result there are a large number of golf cart owners in Lincoln Hills.

Golf cart users may still occasionally utilize the roadways outside the golf cart transportation plan (Ref: California Vehicle Code 21115 – the legal radius is one mile from any golf course area). The need for additional signage, and educating golf cart users on legality, may continue to be challenging to some extent.

SIGNING AND STRIPING ANALYSIS

As the City began installing signing and striping improvements throughout the City, many golf cart owners mistakenly believed that they were entitled to operate their golf carts throughout the City. In response to this misconception, the City's Public Works Department, Police Department and NEV user groups initiated informational campaigns to educate golf cart users about the functional and legal differences between golf carts and NEVs. According to front line City staff who fielded most of the phone calls and office visits by golf cart owners regarding the use of golf carts vs. NEVs in the City, public information requests went from almost daily occurrences to the point where no requests have come in within the past nine months. The Lincoln Police Department has also reported a significant decline in the number of infractions cited for golf carts operating outside the confines of the golf cart community on NEV lanes. **Therefore, existing signage and striping has shown to be appropriate.**

In addition, it has also been reported that golf cart purchases by Lincoln Residents have virtually stopped, as the residents are more frequently opting for NEVs as an alternative, which are allowed on the Lincoln Hills golf courses.

CONFLICTS BETWEEN ROADWAY USERS

The conflicts between NEVs, bicycles and motor vehicles appear to have decreased since the 2008 Report to the Legislature. This decrease in conflicts can be partially attributed to roadway users becoming increasingly familiar with NEVs and how they operate. It can also be attributed to further implementation of the NEV Transportation Plan, which has provided substantially more designated facilities on the roadways, which lessen conflicts between NEVs and motor vehicles.

NEVs AND BICYCLES

There have been a few minor conflicts between NEVs and bicyclists that have been reported. These conflicts are in the form of complaints by bicyclists due to the NEVs operating at slightly higher speeds than bicycles and the quiet operation of NEVs. Bicyclists may become startled by an NEV that suddenly appears along side, without much warning.

These conflicts can be reduced by NEV users extending courtesy to bicyclists when passing. These courtesies include providing sufficient room when passing, and providing an auditory signal in advance of passing the bicyclist. This solution is similar to what should be done when a bicyclist is passing another bicyclist.

NEVs AND MOTORISTS

Since the inception of the NEV Transportation Plan there has only been one reported collision involving an NEV. The collision involved an NEV rear ending a motor vehicle that had temporarily stopped in a Class II golf cart / NEV lane within Lincoln Hills. The driver of the NEV was found to be at fault, and arrested for driving under the influence of alcohol. Neither of the drivers of the NEV or the motor vehicle were injured, and property damage to both vehicles was minor.

Had the impaired NEV driver been operating a typical motor vehicle, it is likely that a similar collision would have resulted in more significant damage to both vehicles, and an increased likelihood that injuries would have resulted. This would have been a result of the driver most likely traveling at a higher rate of speed than an NEV, and the increased vehicle weight would have transmitted significantly greater momentum into the collision. Therefore it could be reasoned that the presence of a low-speed and lighter weight vehicle reduced the potential for damage and injuries, and ultimately increased safety for other roadway users. However, the City of Lincoln does not recommend that the operation of an NEV be considered as a mitigating factor for cases of driving under the influence of alcohol or drugs, or any other forms of unsafe driving behavior.

NEV LEFT-TURN MOVEMENT CONFLICTS

The City of Lincoln has not received any significant complaints, issues or concerns regarding NEV use of left turn pockets.

NEVs tend to move over to the left turn lane, much like bicycles are able to do. The general feelings of safety for turning and maneuvering an NEV are subjective. Driving skills, experience, and familiarity with the driver's surroundings area all key factors. However, as a general rule of thumb, if a bicycle has sufficient speed, site distance, and capability to move from a bike lane to a left turn lane, then an NEV would certainly have similar capability, since NEVs are generally faster and more visible than a standard bicycle.

CITY OF ROCKLIN

In November of 2007, Rocklin's City Council formally adopted a resolution approving a NEV Transportation Plan that meets the City's vision to allow NEV to operate on city streets with speed limits over 35 MPH. This is in keeping with California State Law, Assembly Bill (AB) 2353, which defines the use of NEVs on high speed (over 35 MPH) streets as applicable to the City of Rocklin and the City of Lincoln.

Although the City has posted NEV Route signs on some roadways with a speed limit of 35 or less due to economic conditions funding was not available to implement the resolution described above. Currently the City of Rocklin is on track to receive funding from the Congestion Mitigation and Air Quality Improvement Program (CMAQ) in the City's 2010-2011 fiscal year which will allow the City to further implement its NEV Transportation Plan.

The overall goal is to complete a comprehensive NEV circulation system that provides an alternative mode of transportation for existing residents and new developments planned for Whitney Ranch and the downtown area.

CONCLUSSION

The NEV Transportation Plan has generally been successful for the City of Lincoln, and early results show promise for the City of Rocklin.

It is apparent that the installed infrastructure (pavement markings, signage, and striping) has been effective, and has enhanced the safety of NEV users on roadways with speed limits of 35 mph and above.

Challenges with educating the public regarding NEV uses, signs and capabilities have tended to work themselves out over time. Motorist from outside of the City of Lincoln would require similar education to reduce the confusion surrounding NEVs and NEV facilities.

Conflicts related to implementation of roadway improvements are generally found to be a result of roadways that were constructed without consideration for NEVs. Construction of new roadways can be designed to accommodate NEVs with minimal modification of development plans and at an incremental cost relative to construction of the remainder of the roadway.

Modification of existing roadways to accommodate NEV facilities can be more challenging if roadway widening is necessary. Public agencies may lack sufficient land tenure to widen roadways, and the costs for widening roadways are most certainly to be a major consideration. However, routes can be mapped in such a way as to avoid high-speed arterials (over 35 mph), thus eliminating the need for roadway widening and a shared NEV / Bicycle Class II lane.

NEV users tend to be constrained to remain within their own city's boundaries, or even within particular neighborhoods, as adequate facilities do not extend to all parts of the city, and into adjacent cities or county regions. Development of statewide standards will facilitate regional planning.

Expansion of the provisions of AB2963 statewide could yield the following benefits:

- The familiarity of NEVs and NEV facilities would likely increase outside of the Cities of Lincoln and Rocklin.
- Benefits may include: reduction of gasoline consumption for short trips; improved air quality; calmer streets; and alternative to older drivers who have aged out of driving conventional vehicles; additional shared lanes provide capacity of bicyclists' use.
- NEV facilities would likely become components of "Complete Streets" designs for new developments.
- Increased public buy in towards the idea of utilizing public funds for renovating existing roadways to include NEV facilities.
- Improved connectivity, and ability for NEV users to travel between city and county boundaries as more agencies install NEV facilities.

Table 1

Roadway	From	To	Status
Del Webb Blvd	E. Joiner Pkwy	E. Joiner Pkwy	Complete - [1, 3]
Spring Valley Pkwy	Del Webb Blvd	Stoneridge Blvd	Complete - [1, 3]
Stoneridge Blvd	Del Webb Blvd	Twelve Bridges Dr	Complete - [1, 3]
Sun City Blvd	Del Webb Blvd	Coachman Ln	Complete - [1, 3]
Sun City Blvd	Coachman Ln	Ferrari Ranch Rd	Incomplete - [2, 4]
Ingram Pkwy	Del Webb Blvd	Lariat Ln	Complete - [1, 3]
Ingram Pkwy	Lariat Ln	Ferrari Ranch Rd	Incomplete - [2, 4]
E. Joiner Pkwy	Del Webb Blvd (north)	Twelve Bridges Dr	Incomplete - [3, 4]
E. Joiner Pkwy	Twelve Bridges Dr	Rocklin City Limit	Incomplete- [3, 6]
E. Joiner Pkwy	Del Webb Blvd (north)	Sterling Pkwy	Complete - [3]
Twelve Bridges Dr	Industrial Ave	Colonnade Dr	Incomplete - [2, 5]
Twelve Bridges Dr	Colonnade Dr	Stoneridge Blvd	Complete - [2]
Twelve Bridges Dr	Stoneridge Dr	Camino Verdera	Incomplete - [2, 4]
Twelve Bridges Dr	Camino Verdera	Sierra College Blvd	Incomplete - [2, 5]
Bella Breeze Dr (south)	E. Joiner Pkwy	Dresden Dr	Complete - [1, 3]
Bella Breeze Dr. (north)	E. Joiner Pkwy	Dresden Dr	Incomplete - [3]
Sterling Pkwy	E. Joiner Pkwy	SR 65	Incomplete - [3, 4]
Joiner Pkwy	Sterling Pkwy	Nicolaus Rd	Complete - [2]
Joiner Pkwy	Nicolaus Rd	Lakeside Dr	Incomplete - [3, 4]
First St	Fuller Ln	Joiner Pkwy	Incomplete - [3, 4]
First St	Joiner Pkwy	SR 65	Complete - [3]
First St	SR 65	Ina Way	Incomplete - [3, 4]
Third St	Joiner Pkwy	SR 65	Complete - [3]
Fifth St	Joiner Pkwy	SR 65	Complete - [3]
McBean Park Dr	Ferrari Ranch Rd	East Ave	Incomplete - [3, 9]
East Ave	McBean Park Dr	Twelfth St	Incomplete - [3, 4]
Twelfth St	East Ave	McCourtney Rd	Incomplete - [3, 4]
McCourtney Rd	Twelfth St	Placer County limits	Incomplete - [3, 4]
Gladding Pkwy	East Ave	Nicolaus Rd	Incomplete - [3, 7]
Nicolaus Rd	Gladding Pkwy	O St	Incomplete - [3, 6]
Nicolaus Rd	O St	Joiner Pkwy	Incomplete - [3, 4]
Nicolaus Rd	Joiner Pkwy	Teal Hollow Dr	Incomplete - [2, 4]
Nicolaus Rd	Teal Hollow Dr	Aviation Blvd	Incomplete - [2, 6]
Nicolaus Rd	Aviation Blvd	Airport Rd	Incomplete - [2, 5, 6]
Aviation Blvd	Nicolaus Rd	end	Incomplete - [2, 4]

Roadway	From	To	Status
Venture Dr	Aviation Blvd	McClain Dr	Incomplete - [2, 4]
Venture Dr	McClain Dr	Lakeside Dr	Incomplete - [3, 4]
Ferrari Ranch Rd	SR 193	Ingram Pkwy	Incomplete - [3, 5]
Ferrari Ranch Rd	Ingram Pkwy	Caledon Cir (west)	Incomplete - [3, 4]
Ferrari Ranch Rd	Caledon Cir (west)	Fiddyment Rd	Incomplete - [3, 7]

1. Roadway within existing Golf Cart Community with individual Class II lanes for Golf Carts / NEVs and Bicycles.
2. Roadways with posted speed limit over 35 mph, signed and striped with a shared NEV / Bicycle Class II lane.
3. Roadway with a posted speed limit of 35 mph or less, signed as NEV route. Shared NEV / Bicycle Class II lane provided when appropriate.
4. Lack of personnel available to implement signing and striping improvements.
5. Roadway does not have logical termini to destination of other roadway that permits use by NEVs
6. Current cross section of roadway is insufficient to permit signing and striping of roadway as a designated “NEV Route” in accordance with the design standards in the NEV Transportation Plan.
7. Construction of roadway has not occurred due to global economic conditions and downturn of development.
8. East Joiner Parkway formerly known as East Lincoln Parkway. Name changed on September 26, 2006 by Resolution 2006-196.
9. Currently State Highway. Modifications to be made after relinquishment to City by State.

EXHIBIT A

City of Lincoln NEV Transportation Plan

Date: August 2006

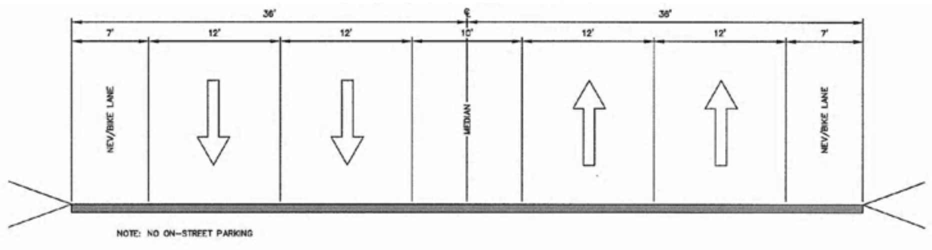
NEV Transportation Plan

Prepared by MHM Engineers & Surveyors

FINAL - August 2006

M·H·M ENGINEERS & SURVEYORS SINCE 1892

Four Lane Arterial with Class II NEV/Bike Lanes



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NEIGHBORHOOD ELECTRIC VEHICLES (NEV) TRANSPORTATION PLAN

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Chapter I - Project Overview

A. Program Description

The City of Lincoln has requested city-wide NEV routes that would "enable any resident to travel from their home to Downtown Lincoln" reports Councilmember Tom Cosgrove.

The City of Lincoln NEV project is an effort to accommodate the City's changing urban lifestyle by encouraging the use of Neighborhood Electric Vehicles, or NEVs for short. This effort will result in air quality improvements, community cohesion, energy savings, reduced travel costs, increased mobility, independence for aging drivers, and greater use of public transit. NEVs are small, electric powered personal vehicles. They have a limited range and can travel up to speeds of 25 mph. They are an ideal transportation alternative for short, (up to 30 miles) local trips. While they may look like a golf-cart to the casual observer, they are actually a motor vehicle requiring a driver's license, registration, and insurance. NEVs such as the Chrysler GEM are specifically designed to meet federal safety standards for low-speed vehicles as defined in Section 571.500, Title 49 Code of Federal Regulations.

NEVs are a desirable new form of transportation for many reasons:

- NEVs have a great safety record.
- NEVs are zero emission electric vehicles.
- NEVs improve air quality.
- The energy consumption of an NEV is less than 1/5 that of a conventional automobile.
- NEVs provide freedom and continued mobility for aging or impaired drivers.
- NEVs are affordable.
- NEVs support the local economy by encouraging residents to shop locally.
- NEVs encourage use of existing public transportation.

California's first major citywide NEV transportation project is well underway in the City of Lincoln. Lincoln plans relatively minor modifications to accommodate NEVs. The city will implement signing and striping improvements, create special parking spaces, and build an NEV crossing at the Auburn Ravine, a stream that divides this fast-growing city. Businesses have already begun to accommodate and encourage NEV transportation by providing special parking for their NEV customers.

The City of Lincoln is in a very favorable position to accommodate the beneficial use of NEVs. NEVs are already circulating in the *Sun City Lincoln Hills* development and special parking areas are provided in the adjacent Safeway and Raley's shopping center. The City believes that with the advent of a comprehensive NEV circulation system, the number of NEVs users will dramatically increase.

To accommodate use of NEVs, the City of Lincoln must become "NEV Ready". An NEV ready city can be defined as having the necessary infrastructure, including charging facilities, striping, signage, parking, and education to safely accommodate NEV travel. The City intends to implement these changes in stages. This plan will allow limited NEV use in the near future, culminating in a comprehensive NEV travel plan throughout the City.

In accordance with Assembly Bill (AB 2353), the City of Lincoln plan envisions three levels of NEV routes:

<u>Class I NEV Route:</u>
Class I NEV routes provide a completely separate right-of-way for the exclusive use of NEVs, pedestrians and bikes with cross-flow minimized. The minimum paved width for a Class I NEV route is 14-feet (for two way travel) with a minimum 2-foot wide graded area provided adjacent to the pavement. The proposed bridge over Auburn Ravine connecting Sun City Lincoln Hills area to E Street is an example of a Class I NEV route. It is the intent to design all Class I NEV routes to allow combined NEV/bicycle use.

<u>Class II NEV Route:</u>
Class II NEV routes are designated as a separate striped lane adjacent to traffic. There is one striped lane for each travel direction. The desirable minimum width for a Class II NEV route is 7-feet. Del Webb Blvd. is an example of a Class II NEV lane. It is the intent to design all Class II NEV routes to allow combined NEV/bicycle use.

<u>Class III NEV Route:</u>
Class III NEV routes provide for shared use with automobile traffic on streets with a posted speed limit of 35 mph or less. All residential streets within Sun City Lincoln Hills are Class III NEV routes. The City will provide signage to direct NEVs to preferred streets. Some streets within the City that are posted 35 mph may be designated as not appropriate for NEV use.

(NEV Route plans are shown in Appendix A.)

B. Impact and Benefits

1. General

Many other entities in the region will benefit from the City of Lincoln's experience in implementing an NEV transportation plan. When the plan is complete, the process will be made available to other entities to help facilitate their own NEV transportation plan. Here are a few of the benefits of the Lincoln NEV Project:

- The emergence of an NEV friendly Lincoln has allowed home builders in Lincoln to customize new development to accommodate NEVs.
- Lincoln plans to include NEV routes in their General Plan update.
- NEV routes can double as bicycle routes with proper design, thus the miles of bike trails will increase within the City.
- Accommodating NEVs is more effective and less costly than dial-a-ride programs for unmet transit needs.
- Air Quality improvements result from the use of small electric motors that emit no pollutants in the local atmosphere. Over half of the otherwise short cold-start automobile trips in cities the size of Lincoln are within the range of NEVs.
- NEVs can achieve the energy equivalent of over 150 mpg for a standard gasoline powered vehicle.
- NEV use provides for a more cohesive community due to their limited travel range.
- NEV travel encourages residents to support their local businesses.
- NEVs provide mobility for people who cannot drive an automobile, including aging drivers.
- NEVs are affordable and can reduce personal travel cost.
- The NEV industry is seeing an increase in the use of these vehicles for use beyond the golf course.

2. **NEVs Promote Safety and Provide Independence for Aging Drivers**
With the State's aging population, we are confronted with the conflicting interest of providing continued mobility to aging drivers while promoting a safe driving environment for all drivers. The State has implemented a process that will result in new driver testing, which will result in the suspension of automobile driver's licenses' for some people. The City's plan includes a proposal for a separate classification of driver's license for NEVs.

The loss of a driver's license often brings lifestyle changes that make it hard to cope. Understandably, no one wants to feel isolated and dependent on others for their personal mobility. NEVs are an ideal solution to meet the States competing interest between mobility and safety. NEVs will provide personal mobility to local stops including the grocery store, bus stops and the doctor's office. An NEV commute beats the alternatives of risking a high-speed accident in a conventional automobile or sitting at home waiting for a ride from a friend or relative.

3. **Taking the Lead**
The City of Lincoln, the fastest growing city in the west, has fostered the use of NEVs within Sun City Lincoln Hills, but that is not enough. The City envisions a plan to promote NEV travel throughout the City. With the City's growing retirement population, the opportunity to accommodate NEV travel is at hand. City engineers have already signed and striped some City streets for NEV use. Merchants are providing special parking and charging stations. The City is planning for a pathway and bridge across the Auburn Ravine to accommodate NEV travel on both sides of town. While the City of Lincoln appears to be ahead of the rest of the state, the City is not ahead of their people. More NEVs are on City streets every day. There are NEVs in Rocklin, Roseville, Auburn, and Folsom today and their presence is expanding.

C. Project Status

The following steps having been taken by the City in order to implement the NEV transportation plan:

- Placer County Air Pollution Control District (PCAPCD) approved $10,000.00 on August 14, 2003 towards Lincoln's NEV transportation plan.
- The City has reviewed the Draft Twelve Bridges Golf Cart Transportation Plan (Fehr & Peers) in order to coordinate that plan within the proposed NEV transportation plan.
- SACOG funding guidelines have been altered to include NEVs per the City's request. Prior to the City's input, SACOG's funding guidelines did not mention NEVs.
- The City has coordinated with PCAPCD to include NEV questions to be included in PCAPCD semi-annual transportation survey.
- The City has coordinated with Assemblyman Tim Leslie's office regarding AB 2353.
- The City has submitted NEV funding requests to SACOG through PCTPA, and to date has received funding approval for over $270,000 from SACOG.
- AB 2353 signed into Law on January 1, 2005.
- Public Workshop held on August 30, 2005
- MUTCD approved experimental signage and striping.
- Developed NEV Standards.
- NEV Standards shared with the City of Rocklin
- Putnam Award for Excellence recipient 2006.

D. Reporting Requirements of Assembly Bill No. 2353

City of Lincoln and Rocklin shall jointly submit a report to the Legislature on or before January 1, 2008, in consultation with the Department of Transportation, the Department of the California Highway Patrol, and local law enforcement agencies.

The report shall include the following:

- A description of all NEV transportation plans and their elements that have been authorized up to that time.
- An evaluation of the effectiveness of the NEV transportation plans, including their impact on traffic flows and safety.
- A recommendation as to whether Chapter 7 should be terminated, continued in existence applicable solely to the City of Lincoln and the City of Rocklin in the County of Placer, or expanded statewide.

Chapter 7 shall remain in effect only until January 1, 2009, and as of that date is repealed, unless a later enacted statue, that in enacted before January 1, 2009, deletes or extends that date.

E. Reporting Requirements of CTCDC for experimental signage and striping

Reporting requirements for the CTCDC are similar to the requirements of AB 2353, as stated above. It is recommended the report be submitted to both agencies at the same time.

Chapter II - Legal Constraints / Opportunities

This section will outline the current federal, state, and local laws and ordinances relative to implementing a comprehensive NEV transportation plan as well as define the terms necessary to describe such a program. While the existing regulatory framework (AB 2353) allows for NEV travel within the City of Lincoln and Rocklin, an expansion of AB 2353 statewide would facilitate and promote the use of NEVs throughout the State.

A. Definitions

1. **"Low Speed Vehicle" or "LSV"** is defined as a motor vehicle, other than a motor truck, having four wheels on the ground and an unladen weight of 1,800 pounds or less, that is capable of propelling itself at a minimum speed of 20 miles per hour and a maximum speed of 25 miles per hour, on a paved level surface. A 'low speed vehicle' is not considered a golf cart, except when operated pursuant to Section 21115 or 21115.1 of the California Vehicle Code (CVC) pertaining to operations within a golf course facility/community. (CVC Section 385.5)

   Low-speed vehicle is a relatively new motor vehicle classification created by the National Highway Traffic Safety Administration (NHTSA) in 1998 to permit the manufacture and circulation of small, four-wheeled motor vehicles with top speeds of 20-25 miles per hour. This new classification is codified as Section 571.500 Title 49 code of Federal Regulations and California Vehicle Code Section 385.5. LSVs are required to have California license plates in order to utilize public roads.

2. **"Neighborhood Electric Vehicle" (NEV)** is an electrically powered LSV. They are manufactured by car companies and meet federal safety standards for low speed vehicles. Examples include the Daimler Chrysler "GEM" car. While "low-speed vehicle" is technically the correct term, NEV is the more popularly used and recognized term. NEVs are required to have a California license plate in order to utilize public roads.

3. **"Conventional Golf Cart"** is a motor vehicle having not less than three wheels in contact with the ground, weighs less than 1,300 pounds, is designed to be operated at no more than 15 miles per hour, is designed to carry golf equipment and not more than two persons, including the driver. CVC Section 345. A conventional-golf cart is not a low-speed vehicle.

4. **"Speed-modified Golf Cart"** means a golf cart that is modified to meet the safety requirements of Section 571.500 of Title 49 of the code of Federal Requirements and designed to travel at not more than 20 miles per hour. A modified golf-cart must be inspected and approved as meeting all the safety requirements for a low-speed vehicle and is required to have a California license plate in order to utilize public roads.

5. **"City"** means the City of Lincoln.

6. **"Study Area"** means the City of Lincoln's sphere of influence.

7. **"NEV Lanes"** means all publicly owned facilities that provide for NEV travel including roadways designated by signs or permanent marking which are shared with pedestrian, bicyclists, and other motorists in the plan area.

B. Summary of AB 2353 Introduced by Assemblyman Leslie

1. "It is the intent of the Legislature, in enacting this chapter, to authorize the City of Lincoln and the City of Rocklin in the County of Placer to establish a neighborhood electric vehicle (NEV) transportation plan for a plan area in the city. It is the further intent of the Legislature that this transportation plan be designed and developed to best serve the functional travel needs of the plan area, to have a physical safety of the NEV driver's person and property as a major planning component, and to have the capacity to accommodate NEV drivers of every legal age and range of skills. It is the intent of the Legislature, in enacting this chapter, to encourage discussions between the Legislature, the Department of Motor Vehicles, and the California Highway Patrol regarding the adoption of a new classification for licensing motorists who use neighborhood electric vehicles." – 1963, Chapter 7, AB 2353

2. For the cities of Lincoln and Rocklin, AB 2353 brings California Law up to date with the new Federal Regulations governing Low Speed Vehicles including Neighborhood Electric Vehicles. AB 2353 provides a formal process for Lincoln and Rocklin to obtain agency approvals to bridge the legal gaps that currently exist for extensive use of Neighborhood Electric Vehicles. In doing this, AB 2353 provides a tool for planning, design, and implementation of a comprehensive NEV transportation program.

3. The current Street and Highways Code Section 1951, which applies to golf carts, was enacted prior to federal legislation designating a low-speed motor vehicle category and prior to the popular emergence of NEVs. NEVs are a safer mode of transportation than golf-carts as they have stricter safety requirements. Further, unlike golf-carts, NEVs are motor vehicles subject to same rules and regulations governing motor vehicles.

4. A key aspect of AB 2353 is it provides local jurisdictions with choice. Federal Law allows NEVs on all streets posted 35 mph or less. AB 2353 allows Lincoln and Rocklin to determine which streets posted 35mph and under are appropriate for NEVs. The City of Lincoln is supporting NEV use, but has some streets posted 35 mph that are deemed unsafe for NEVs.

5. Until now NEVs were prohibited from streets posted above 35 mph. AB 2353 allows NEVs on streets posted above 35 mph where designated NEV lanes are available. Similar to bicycle laws, the bill describes three classes of NEV lanes.

6. AB 2353 allows NEVs to use and cross State highways where deemed safe and appropriate by the City and the State Department of Transportation

7. According to a recent survey of NEV owners, NEV users in the City of Lincoln drive an average of 1000 miles per year per NEV. That is 1000 miles of otherwise short cold start automobile trips. AB 2353 lets the cities of Lincoln and Rocklin accommodate the expanding popularity of low cost Neighborhood Electric Vehicles, and reap the transportation and air quality improvement benefits.

8. NEVs are also an ideal transportation option for aging drivers. As low-speed vehicles with a top speed of 25 mph and a limited travel range, NEVs have the ability to provide continued mobility and independence to aging and disabled drivers. Through AB 2353 the DMV committed to work with Assemblyman Leslie's office and the City of Lincoln to explore the feasibility of offering separate category of driver's license to NEV drivers.

9. AB 2353 was signed by the governor and became law January 1, 2005.

C. Existing Regulations for NEVs

1. NEVs must comply with all the rules and regulations for a motor vehicle as set for in the California Vehicle Code. Vehicle Code §21251 provides in relevant part that:

"…a low-speed vehicle is subject to all the provisions applicable to a motor vehicle, and the driver of a low-speed vehicle is subject to all the provisions applicable to the driver of a motor vehicle or other vehicle, when applicable, by this code or any other code, with the exception of those provisions which, by their very nature, can have no application."

2. NEVs must be registered with the State Department of Motor Vehicles and the driver must hold a valid California driver's license and be insured.

3. NEVs may travel on any street with a posted speed limit of 35 miles per hour or less. However, the City, by local ordinance or resolution, may restrict or prohibit the use of NEVs. CVC §21266(a). The City plans to designate approved NEV travel routes to direct NEV traffic to the safest available route.

4. NEVs may cross state-highways at controlled intersections only. Crossing at uncontrolled intersections is permitted with the approval of the agency with primary responsibility for that intersection. CVC §21260(2).

D. Safety Standards

NEVs must meet all safety standards for low-speed vehicles as defined by NTHSA. All vehicles sold as NEVs, such as the GEM, already meet these safety standards. Modified golf carts must include these safety modifications to comply with federal safety mandates. All NEVs must be equipped with:

- Seat belts (lap only, or lap and shoulder)
- Brake lights
- Rear lights
- Headlights
- Mirrors, one of the following selection; (1) left side and right side mirrors, (2) left-side and rear-view mirrors, or (3) multi-directional cross bar window.
- Windshield
- Horn
- Front and rear turn signal indicators
- Rear red-reflectors
- Parking brake
- Covered passenger compartment.

E. NEVs in Golf Cart Lanes

Current Law in Lincoln and Rocklin per AB 2353 allows dual use; however, outside of Lincoln and Rocklin, a conflict still exists.

F. NEV/Bicycle Lane Compatibility

NEV travel is permitted by AB 2353 on roads with speed limits in excess of 35 mph where there is a designated Class II NEV lane on the right shoulder. Bicycles are permitted to travel in these designated NEV lanes.

Chapter III - Energy/Cost Considerations

A. Energy Consumption

1. **Standard Car** (27.5 mpg)
2. **NEV** (Equivalent to 150mpg, 0.223 kwh/mile)

B. Operational Costs (For standard fleet car and NEV)

Table 1 – Annual Operating Costs

Annual Operating Costs *					
Vehicle Type	**Insurance**	**Registration**	**Fuel Costs**	**Maintenance**	**Total**
NEV	$200	$50	$16.90	$293.00	$559.90
Gas Auto	$1,200	$600	$292.40	$1,428.00	$3,520.40

Table 2 – Operating Costs per Mile

* Based on Data from the Luke AFB 9/14/2000 Report (1998 figures)								
Vehicle Type	**Cost New**	**Annual Operating Costs**	**Yrs**	**Salvage Value**	**10-YEAR COST**	**10-Year Total Miles**	**Average Operating Cost per Mile**	**Vehicle Cost per Mile**
NEV	$7,560	$560	10	$1,500	$11,659	13,000	$0.043	$0.90
Gas Auto	$18,500	$3,520	10	$1,850	$51,854	34,000	$0.104	$1.53

C. Potential Energy Sources

1. Photovoltaic Cells/Batteries
2. Fuel Cells
3. Utility/Batteries

D. Energy Benefits

The cost to operate an NEV is less than 1/5 that required for a conventional automobile. In accordance with the July 1, 2002 report to CEC (p600-02-020F) demonstration of NEVs, NEVs achieve an equivalent mpg of 150. The actual measured energy use is 0.223 kwh/mile. The average auto mpg is 27.5 as of 2002, and less in urban traffic.

E. Incentives/Subsidies

1. Federal: 2.5% of purchase price tax credit
2. Local: designated parking spaces and lanes, free charging stations.

Chapter IV - Air Quality Benefits

A. Air Quality Setting

The city of Lincoln is located within the Sacramento Federal Non-attainment Area (SFNA), a region federally designated as "severe non-attainment" of federal air quality standards for ozone air pollution. Only the Los Angeles basin in California is designated as "extreme" with worse air quality. Under federal law, the SFNA must demonstrate attainment by 2005, then maintain healthy air thereafter. NEVs will provide real, quantifiable emission benefits for local and regional air attainment strategies.

NEV trips made possible by the development of this project will produce a variety of air emission benefits to Lincoln and its citizens, and to the five-county air basin. Ozone air pollution is formed by "tailpipe" oxides of nitrogen (NOx) and reactive organic gases (ROG) mixing in the presence of sunlight. The great majority of local ozone air pollution comes from "mobile sources", with the largest portion resulting from light-duty on-road vehicle use. Some air pollution also comes from evaporative (fuel) emissions that escape from the vehicle during fueling and operation. In winter, carbon monoxide (CO), a product of incomplete combustion that increases as temperatures drop, can be a problem near heavily traveled intersections and in lower lying areas that tend to trap air pollutants in stagnant weather conditions.

Vehicle exhaust also contains toxic air contaminants, such as benzene and formaldehyde. Emission control systems take time to come up to operating temperature, especially in winter. A recent report to the California Energy Commission (TIAX, LLC) stated:

> "It is well documented that cold-start emissions have significant impact on air quality. Due to cold-start fuel enrichment, subsequent quenching of hydrocarbons in a cold engine, and the delayed attainment of proper operating temperatures of the catalytic converter, between 60 and 80% of the toxic air emissions from automobiles occur during the cold-start period."

The good news is that NEVs eliminate the issue of cold starts, with their high rates of toxic and criteria pollutant emissions.

B. NEV Emission Benefits to Lincoln and the Air Basin

NEVs eliminate NOx, CO, ROG and toxics emissions that otherwise result from internal combustion-powered vehicle. NEVs operating in Lincoln will displace gasoline vehicle trips. To demonstrate the emission benefits of a successful NEV program, the following assumptions were used to model the most important emission benefits with the URBEMIS2002 mobile source emissions estimation program:

- 5000 NEVs at program buildout
- 2008 is the modeling year
- Each NEV will travel 1000 miles/year
- NOx is primary target; emission reductions annualized from summer conditions
- Only vehicle emissions were calculated with URBEMIS2002 (no area or construction emissions)
- Trip characteristics derived as 2.78 miles/each for 1000 mile/year
- Trips calculated as home to work
- 95% light duty passenger car and 5% light duty truck ratio assumed

Table 3 – Lbs/Day Emissions Reduced with 5000 /NEVs

ROG lbs/day	NOx lbs/day	CO lbs/day	SO2 lbs/day	PM10 lbs/day
86.80	**15.35**	**286.90**	**.14**	**20.87**

Table 4 – Tons/Year Emissions Reduced with 5000 NEVs

ROG tons/year	NOx tons/year	CO tons/year	SO2 tons/year	PM10 tons/year
15.84	**2.8**	**52.36**	**.026**	**3.8**

C. Cost-Effectiveness of NEV Air Emission Benefits for Lincoln

The cost of reducing air pollution is often calculated in units of dollars spent per unit of emission reduction received. In simple terms, when the local Placer Air Pollution Control District calculates the value of funding it provides "mobile source" (vehicle) emission reduction projects, including NEVs, it divides the tons of emissions reduced by what it spent to achieve them.

The NEV project does NOT require large investments by air agencies, in spite of the considerable emission reductions that will occur. This is because NEVs will take advantage of existing roadway improvements and infrastructure. Since NEVs have a much lower cost to operate, and even "green image" environmental benefits important to increasing numbers of drivers and local businesses, the "costs" for the emission reductions produced by the NEVs will be substantially underwritten by the vehicle buyer. Therefore, the cost-effectiveness of the emission benefits to Lincoln and the broader Sacramento air basin is a bargain.

Because NEVs operate at essentially zero emissions, (using grid power) vehicles with an internal combustion engine will operate with greater emissions. No grid power in the Sacramento region is generated in the local air basin, and it is reasonable to argue that because NEVs produce a wide range of emission benefits to society they should be able to claim that their grid power comes from hydroelectric or other environmentally benign sources.

D. Luke Air Force Base NEV Fleet Demonstration Program Report

The September 14, 2000 Luke Air Force Base NEV Fleet Demonstration Program report provided the following air quality benefits for each of their NEVs:

Table 5 – Air Quality Benefits

Vehicle Type	**10-Year Total Miles**	**10-Yr VOC lb**	**10-Yr CO lb**	**10-Yr NOX lb**
NEV Elect.	13,000	(52.0)	(390.0)	(67.6)
Gas Auto	34,000	136.0	1,020.0	176.8

E. Community Design Benefits

The NEV program represents "inside out transportation planning"; or planning from the user's perspective.

F. Environmental Justice

The City of Lincoln's proposed NEV transportation plan will enhance the quality of life for aging, disabled, and low-income persons within the City.

1. NEVs Will Provide Inexpensive Mobility for Low-Income Drivers

The high cost of a conventional automobile can be a barrier to independence and mobility for low or fixed income persons. The initial and operating costs of an NEV are substantially less than those of a conventional automobile.

A new NEV retails for approximately $7,560.00. Used NEVS are also available for less. The least expensive conventional automobile is at least three times the amount of a new NEV.

The operating costs of an NEV are also substantially lower than those of a conventional automobile. The average annual operating cost for an NEV including insurance, registration, fuel, and maintenance is $559.00. The same costs for a conventional automobile are $3,520.00; over six times the operating costs of an NEV.

2. NEVs Will Promote Safety and Provide Independence for Aging and Disabled Drivers

With the State's aging population, we are confronted with the conflicting interest of providing continued mobility to aging drivers while promoting a safe driving environment for all drivers. After the tragic accident in Southern California, where an elderly driver crashed into a farmers market killing several bystanders, the State's population has become acutely aware of the dangers of drivers with diminished skills often brought on by old age. After the accident, the State immediately began considering new driver's license testing, a move that will inevitably result in the loss of a driver's loss for drivers with diminished driving skills, included the elderly and disabled.

The loss of a driver's license can lead to isolation and dependence on others for mobility. The proposed NEV transportation plan will provide for a special driver's permit, issued by the local jurisdiction, which will allow aging or disabled persons to drive an NEV in designated NEV routes. Since NEVs are smaller, have a limited travel range, and a top speed of 25 miles-per-hour, they provide a safe alternative to impaired drivers when compared to a conventional high-speed automobile. The emergence of an NEV transportation plan in the City of Lincoln will provide continued mobility and independence to aging or disabled drivers, allowing them to access businesses, medical centers, and visit friends while driving an NEV.

NEVs also will reduce the need for comparatively expensive and under-funded dial-a-ride programs.

In conclusion, the City's proposed NEV transportation plan will enhance the lives of low-income, elderly, and disabled persons throughout the City by providing them with affordable transportation options. The City plans to conduct outreach to all members of the community, including the elderly, disabled, low-income, and other minority groups to determine their transportation needs when preparing the City's comprehensive NEV transportation plan.

G. Conclusion – Air Quality Benefits

Facilitating NEV operation will result in substantial air quality benefits to Lincoln, while providing extremely cost-effective pollutant reductions to assist the air basin in attaining and then maintaining federally enforced ambient air quality standards. Cost-effectiveness per ton of emission reduced will be unsurpassed, since air agencies will not be expected to provide per-vehicle subsidies. With deployment of 5000 NEVs as a result of this proposal, nearly eighteen tons per year of ozone pre-cursor emissions will be avoided based on URBEMIS estimation. Moreover, once this NEV pilot study is completed for Lincoln, results will be made available to other communities similarly interested in reducing dependence on petroleum products while simultaneously reducing vehicle-caused air pollution.

Chapter V - Community Considerations

The NEV program represents "inside out transportation planning"; or planning from the user's perspective.

A. NEVs Provide Multiple Community Benefits

NEVs are already in use in Lincoln and Rocklin areas within a limited radius of golf courses. NEV users are asking officials of both Lincoln and Rocklin "how can I legally get to a shopping area in my NEV?" The NEV project is designed to accommodate NEV use and is already successful at eliminating automobile trips.

NEVs travel at a slower speed than autos and provide opportunity to develop a more friendly cohesive community at the neighborhood level than fast autos. The slower speed also contributes to NEV safety for impaired drivers.

As discussed in Chapter II, Legal Constraints, the NEV project included legislation (AB 2353) that has a requirement for DMV to work with the California Highway Patrol and the Legislature to create a new driver's license classification for NEV operation. With an "NEV operators permit" a person who no longer felt comfortable to drive an automobile could continue to be independent. NEVs will provide individual transportation to public transit systems and satisfy some of the more costly unmet transit needs.

NEVs operate for about 20% of the cost of owning and operating automobiles. For low income families that live near their work, an NEV could replace a gross polluting auto. Part of the NEV project includes proposals to include NEVs in State incentive, grant and rebate programs.

B. Discussion of other NEV/Golf Cart Communities

The City of Lincoln's efforts to accommodate and encourage NEVs has many of its roots in other electric vehicle communities. With the advent of the active adult communities, (age 55 or older) golf carts and electric vehicles have become a common sight.

Other Sun City communities have long encouraged the use of electric vehicles. That is certainly the case in *Lincoln Hills* where the use of electric vehicles in local neighborhoods has increased over the years, since first being introduced in the spring of 1999. Rush hour in *Lincoln Hills* isn't necessarily at 8 a.m. and 5 p.m., it is more likely at 10 a.m. after the morning softball game, or 2:30 p.m. after golf as the NEVs and golf cart vehicles make their way to the neighborhood shops.

Every day in *Lincoln Hills* numerous electric vehicles make their way through neighborhood connections to get a cup of coffee from Starbuck's, or go to Safeway for groceries or do their banking at any of the four neighborhood banks. NEVs are convenient, safe, affordable, non-polluting and good for the local economy. Business owners near *Sun City Lincoln Hills* and other Sun City communities appreciate electric vehicle users patronizing their businesses and accommodate NEV and Golf Cart use with special parking spaces.

As a part of this study and proposed pilot program for the City of Lincoln, it might be helpful to review some other electric vehicle plans over the past 10 to 15 years. Electric vehicle activities have been taking place in California and Arizona Sun City communities for quite some time now. NEVs have proven to be natural, efficient alternative forms of transportation in many active adult communities.

These programs were started for ease of accessibility to neighborhood activities through use of an electric vehicle. The various community programs started with golf cart transportation plans, which still exist and now include a good amount of NEV use as well, depending on the community and access to roadways and commercial centers. It is worth a quick review and look at other Sun City/Del Webb communities.

CONCLUSION:

NEVs are an affordable, safe, non-polluting alternative to traditional modes of transportation. It is apparent that as communities make commercial and downtown business sites available and accessible, the use of NEVs increases. NEVs have proven to be natural, efficient alternative forms of transportation and will provide a multitude of benefits to the City of Lincoln.

Chapter VI - NEV Transportation Planning

A. Background

Existing law (Chapter 6, Streets and Highways Code, Section 1950 – 1965) authorizes a city or county to establish a golf cart transportation plan subject to the review of the appropriate transportation planning agency and traffic law enforcement agency. Assembly Bill 2353 adds Chapter 7 (commencing with Section 1963) to Division 2.5 of the Streets and Highways Code to authorizes the City of Lincoln (until January 1, 2009) to establish a neighborhood electric vehicle (NEV) transportation plan subject to the same review process established for a golf cart transportation plan (GCTP). The bill defines "neighborhood electric vehicle (NEV)" the same as a "low speed vehicle." Within California, only electric powered LSVs can be sold. Therefore, all LSVs in the state of California are NEVs.

In enacting Chapter 7, it is the intent of the Legislature to authorize the City of Lincoln and Rocklin in the County of Placer to establish a neighborhood electric vehicle (NEV) transportation plan. It is the further intent of the Legislature that this transportation plan be designed and developed to best serve the functional travel needs of the plan area, to have the physical safety of the NEV driver's person and property as a major planning component, and to have the capacity to accommodate NEV drivers of every legal age and range of skills.

The City of Lincoln NEV project is an effort to accommodate the City's changing urban lifestyle by encouraging the use of bicycles and NEVs to travel from their home to the downtown Lincoln commercial areas. This effort will result in air quality improvements, energy savings, reduced travel costs, and increased mobility and independence for aging and impaired drivers.

Minor modifications to the existing street and circulation system are needed to accommodate NEVs. The City plans to implement signing and striping improvements consistent with this report, create special parking spaces, and develop a Class II NEV path system to facilitate access to the City of Lincoln, and to increase safety.

The City of Lincoln is well positioned to integrate the beneficial use of NEVs with their existing golf cart transportation system. NEVs are already circulating in the Sun City – Lincoln Hills development and special parking areas are provided in the adjacent Safeway shipping center. The overall goal is to complete a comprehensive NEV circulation system so that the number of users will increase commensurate with the amount of new development planned for Twelve Bridges and the City of Lincoln proper. Figure 1 shows the project study area.

B. Data Collection and Review

We reviewed the following materials in preparation of this report.

- The Revised Twelve Bridges Specific Plan EIR (August 1997)
- City of Lincoln, *NEV Transportation Plan*, CMAQ Application to SACOG, 1-15-04
- Administrative Draft – Transportation and Circulation Section 4.2 (May 2000)
- The City of Lincoln General Plan
- The Sun City – Lincoln Hills Golf Cart Transportation Plan (2001)
- City of Lincoln Parkway Pointe Offsite Improvement Plans (November 2004)

- The City of Lincoln current street design standards (2003)
- City of Palm Desert Golf Cart Transportation Plan (1999)
- 2000 Census journey-to-work data
- AB 2353 (signed into law)
- California Vehicle Code (CVC) (2003)
- Manufactures brochures and dimensions for typical golf carts and NEVs
- City of Lincoln *Neighborhood Electric Vehicle Transportation Program Draft #2 Report* prepared by MHM Engineers & Surveyors, 12-2-03.

This information provides a basis for determining the feasibility of integrating NEVs into the existing golf cart circulation system within the City of Lincoln, identifying key crossing points that allow access to planned retail, commercial, educational, and medical facilities in Twelve Bridges, and recommending street standards, crossing design, and signage to accommodate NEVs. The existing golf cart facilities and circulation routes in the City of Lincoln are summarized below along with their feasibility of accommodating NEVs.

C. Mode Share and Trip Generation Summary

Table 9 provides information from the 2000 Census on the mode shares for journey-to-work for Placer County, City of Lincoln and City of Rocklin. For the City of Lincoln (including Twelve Bridges) the automobile continues to be the primary mode of travel to work. Drive alone and carpool account for approximately 96 percent of all work trips.

Figure 1 – Project Study Area

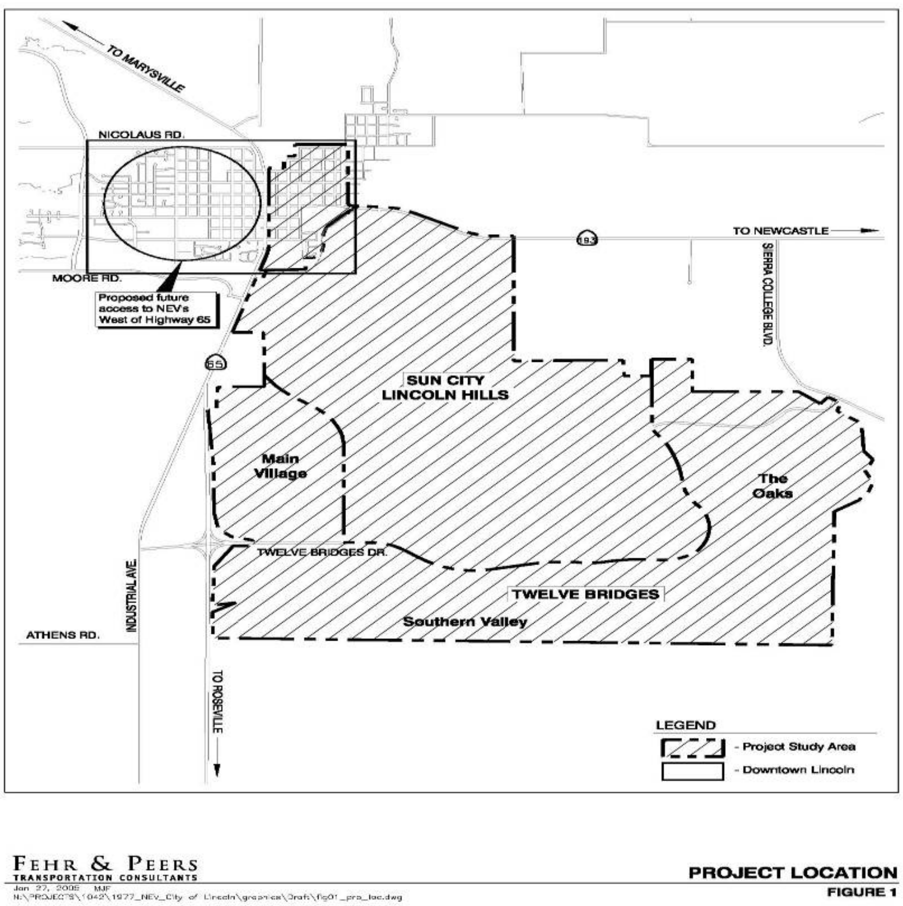


Table 6 – Mode Shares from the 2000 Census Journey to Work

City	Drive Alone	Carpool	Transit	Bicycle	Walk	Other Means	Subtotal
Lincoln CA	79.8%	16.5%	0.0%	0.4%	3.0%	0.2%	100.0%
Rocklin CA	86.9%	9.9%	0.8%	0.6%	1.5%	0.4%	100.0%
Roseville CA	86.4%	10.3%	1.4%	0.4%	1.0%	0.4%	100.0%
Lincoln CA	3,395	701	0	18	129	10	4,253
Rocklin CA	14,574	1,661	129	95	244	60	16,763
Roseville CA	29,809	3,565	485	145	332	153	34,489

Table 7 summarizes the number of dwelling units and daily person trips for Sun City – Lincoln Hills and for the remainder of Twelve Bridges. Recent data (September 2004) from the City of Lincoln shows that since 1998, there have been 3,356 building permits issued for the City of Lincoln excluding Sun City – Lincoln Hills. This represents approximately 50% of the adopted General Plan build-out The Del Webb community (Sun City – Lincoln Hills) has received 5,521 building permits during the same time frame, which represents approximately 80 percent of plan build-out.

Table 7 – Trip Generation Summary for Sun City - Lincoln Hills and Twelve Bridges

Land Use Category	Daily Trip Rate[1]	Total Daily Trips: Twelve Bridges	Total Daily Trips: Sun City - Lincoln Hills	Total
Low Density Residential	9.0/d.u.	33,525	0	33,525
High Density Residential	6.5/d.u.	6,825	0	6,825
Age-Restricted Residential	4.6/d.u.	0	31,280[1]	31,280
Commercial	525/acre	26,075	14,700	40,775
Employment Center	230/acre	18,860	0	18,860
Schools	50/acre	3,750	0	3,750
Golf Course	37.6/hole	677	1,354	2,031
Total		**89,712**	**47,334**	**137,046**

Source: City of Lincoln Traffic Model; Del Webb Specific Plan DEIR, 1993;
Revised Twelve Bridges Specific Plan EIR (1997); City of Lincoln Building Permit Section
[1] Revised consistent with recent building permit data

Feasibility: There is ample opportunity to increase non-auto mode shares within the City of Lincoln based on recent census data. Walking already shows a higher percentage of work trips than either Roseville or Rocklin. The use of golf carts and/or NEVs is captured in the "Other" category (0.2 percent). The potential for mode shifting to bike, walk or NEV travel within the City of Lincoln will depend on several factors including, a well connected on-street and off-street system, jobs-housing balance (for work related trips), adequate parking and major attractors and activity centers, and appropriate safety measures. The City of Lincoln has taken important steps to improve these elements through adoption of their bicycle master plan, development of a citywide extended golf cart transportation plan, and development of the main village and surrounding commercial, retail and employment areas. If NEV travel accounted for just one percent of the current Del Webb generated trips, there would be a potential of 400 daily trips by this efficient non-polluting mode. If the same one percent is applied to the total trips generated by Del Webb and Twelve Bridges, over 1,000 daily trips by NEV are possible.

New NEV trips resulting from the development of the circulation plan will produce a variety of air emission benefits to Lincoln and its citizens, and to the five-county air basin. The great majority of local ozone air pollution comes from "mobile sources", with the largest portion resulting from light-duty on-road vehicle use. In winter, carbon monoxide (CO) can be a problem near heavily traveled intersections and in lower lying areas that tend to trap air pollutants. The good news is that NEVs eliminate toxic emissions that otherwise result from these mobile sources.

Although trip length information is difficult to establish, a neighborhood electric vehicle program questionnaire was distributed to NEV owners in the City of Lincoln in 2003 as part of the MHM Draft NEV Report, in an attempt to refine usage and trip length information. The results from 35 responses showed the following trends:

- 77% of respondents use their NEV at least 5-days a week
- 70% of respondents drive their NEV more than 500 miles per year and 23% drive more than 1,000 miles per year
- 62% of respondents use their NEV for purposes other than recreation or golf
- 38% indicated they would drive at least 50 additional miles per week if they were allowed to drive anywhere within the City of Lincoln, and if it were safe to do so

The City of Lincoln – NEV Transportation Plan CMAQ application provided an estimate of the air quality benefits available from a mode shift to NEVs and bicycles within the downtown area based on the survey results. Table 8 provides a summary of the information. The calculation methodology is detailed in the application.

Table 8 – Air Quality Benefits of NEV and Bicycle Use

Air Quality Benefits of NEV and Bicycle Use				
Category	NEV	Bike	Combined	Notes
Annual Auto Trip Reduced	312,732	28,322	341,054	Trips/year
Annual Auto VMT Reduced	2,501,856	56,644	2,558,500	Miles/year
Ozone (ROG)	4,146	174	4,320	Lbs/year
Nitrous Oxide (NOx	3,636	114	3,750	Lbs/year
Particulates (PM10)	1,245	29	1,274	Lbs/year
Annual Emission Reduction	9,027	317	9,343	Lbs/year
Source: NEV Transportation Plan CMAQ Application to SACOG 1/04				

Feasibility: The potential for NEV and bicycle use resulting from an approved NEV circulation plan results in very positive air quality benefits for the City of Lincoln and ultimately the 5-county region.

D. Traffic Volume Data

The feasibility of using NEVs on the study area roadways considered "level of service (LOS)" and traffic volume thresholds. Table 9 provides the average daily traffic (ADT) volume LOS for various roadway types. These thresholds have been established for previous environmental analyses in the Cities of Lincoln, Rocklin and the Counties of Placer and Sacramento. LOS is measured quantitatively and reported on a scale from A to F, with A representing the best performance and F the worst in terms of congestion and delay.

Table 9 – Average Daily Traffic Volume Level of Service Thresholds

	Average Daily Traffic Volume Threshold				
Facility Type	LOS A	LOS B	LOS C	LOS D	LOS E
Two-Lane Street	9,000	10,700	12,000	13,500	15,000
Four-Lane Undivided Arterial	18,000	21,300	24,000	27,000	30,000
Four-Lane Divided Arterial	20,250	23,625	27,000	30,375	33,750
Four-Lane Restricted-Access Arterial	21,600	25,200	28,800	32,400	36,000
Six-Lane Divided Arterial	30,315	36,000	40,500	45,560	50,525
Six-Lane Restricted-Access Arterial	32,400	37,800	43,200	48,600	54,000
Two-Lane Freeway	18,800	26,400	34,000	38,000	40,000
Four-Lane Freeway	37,600	52,800	68,000	76,000	80,000
Six-Lane Freeway	56,400	79,200	102,000	114,000	120,000
Two-Lane Conventional Highway	3,100	4,800	7,900	13,500	22,900

Sources: *Sunset West Development Plan EIR* (1995), *Draft Subsequent Twelve Bridges Specific Plan EIR*, (1997), *Placer County General Plan Update DEIR* (1994), and *Sacramento County Traffic Impact Guidelines* (1997).

The City of Lincoln has adopted LOS C as their minimum criteria for urban area intersections and roadways. The feasibility of allowing NEVs to travel on area roadways were evaluated by comparing ADT to the daily volume LOS thresholds in Table 10. Figure 2 shows 2025 traffic volumes for the Main Village including Twelve Bridges Drive and East Lincoln Parkway. The future (2025) traffic forecasts are based on trip generation estimates for proposed General Plan Amendment land uses, prepared by Fehr &Peers for the Main Village.

Feasibility: The feasibility of operating NEVs on roadways within the City of Lincoln and Twelve Bridges based on speed limits and volumes is shown in Table 10.

Table 10 – Operational Feasibility of NEVs on Study Roadways

Facility (Speed Limit)	Roadway Speed Limit	2020 Traffic Volume	LOS C Threshold	Operational Feasibility
SR 193	35 mph	18,000	12,000	Limited[1]
Ferrari Ranch Road	35 mph	19,000	24,000	Yes[2]
Sterling Parkway	35 mph	17,000	24,000	Yes
E. Lincoln Parkway	35 mph	22,000	24,000	Yes
Twelve Bridges Drive*	35 mph	20,000	24,000	Yes
Street C (Main Village)	35 mph	2,100	12,000	Yes
Street B (Main Village	25 mph	6,200	12,000	Yes
Fieldstone Drive (Main Village)	25 mph	2,100	12,000	Yes
Street A (Main Village	25 mph	9,900	24,000	Yes
Street K (Main Village)	25 mph	8,200	12,000	Yes
Street J (Main Village)	25 mph	1,200	12,000	Yes
Downtown Lincoln (Residential Streets) east of Highway 65	25 mph	No recent estimates	Not expected to exceed 12,000	Yes
Source: Fehr & Peers 2004				

*The segment of Twelve Bridges Drive between State Route 65 and East Lincoln Parkway has a posted speed limit of 35 mph. Other portions of Twelve Bridges Drive are currently posted at 45 mph.

NEVs would be allowed to travel on SR 193 between Ferrari Ranch Road and A Street to access the downtown residential streets in Lincoln. NEVs will not be allowed on SR 193 east of Ferrari Ranch Road. Although NEVs are legal to operate on Ferrari Ranch Road, a separate Class II path system is proposed when the road is built out to complete width.

Figure 2 – Average Daily Traffic Volumes

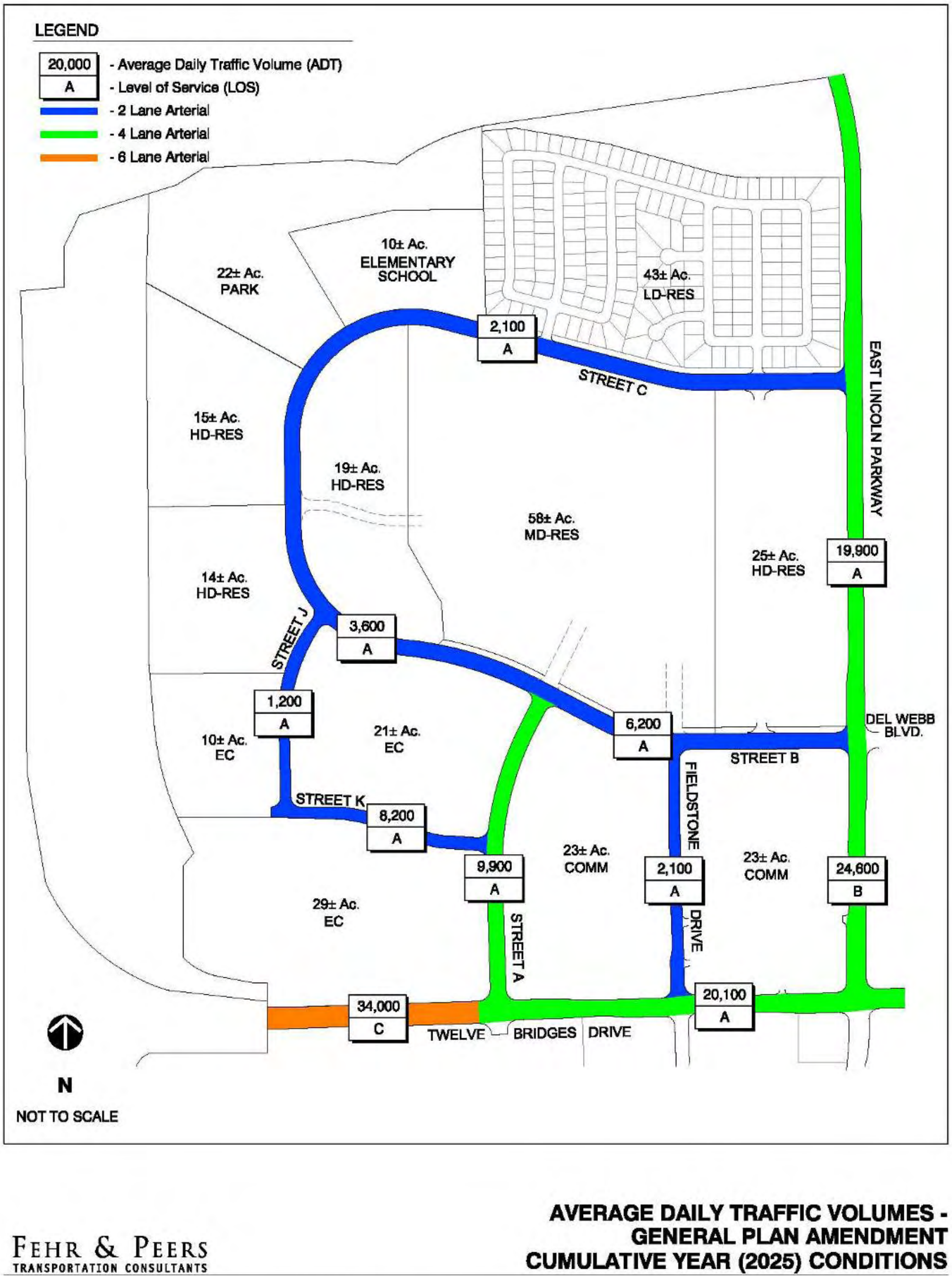


Figure 2

E. Standard NEV Signage and Street markings

The standard NEV signage and street markings are shown in Appendix B. These signs and markings are consistent with the MUTCD 2003 California Supplement, May 20, 2004 issued by the California Department of Transportation. The size and general design of signage for the NEV plan is consistent with Part 9 of the MUTCD for bicycles and with the adopted 2001 Golf Cart Transportation Plan (GTCP) for Sun City – Lincoln Hills.

The following standards and policies for NEV signing and pavement markings are recommended for use within the plan area.

1. **Combination NEV/Bike Lane Sign**. The Combination NEV/Bike Lane sign should be placed on NEV Lanes where a Class II Bike Lane is also provided. The sign should be placed at the far side of collector street intersections and at a minimum of one-half mile intervals on all continuous residential streets. (Appendix B Figure 1)

2. **NEV Pavement Marking**. The Pavement Marking should be placed on local streets, which have been designated as NEV Routes. (Appendix B Figure 2)

3. **NEV Lane Striping**. The stripe is to be placed between the traffic lane and the NEV/Bike lane. (Appendix B Figure 3)

4. **NEVs Prohibited Beyond This Point**. The NEV Prohibited Beyond This Point educational plate may be placed at entrances to public streets that will not accommodate NEV travel. This sign may be placed on the right-hand side of the roadway approximately 25 feet past the intersection so it is visible to operators before they enter that portion of the public right-of-way (Appendix B Figure 4)

5. **NEV Route**. The NEV Route sign should be placed on local streets, which have been designated as NEV Routes. The sign should be placed at the far side of collector street intersections and at a maximum of one-half mile intervals on all continuous **residential** streets. (Appendix B Figure 5)

F. NEV Standards: Lane Widths and Parking Requirements

1. Functional Classification of NEV Facilities

a. **Two-Way Paths** are defined for the purposes of this study as an off-street path with a minimum width of 14 feet plus a one foot shoulder on each side (total right-of-way width of 16 feet). This width is deemed necessary to allow NEVs to pass safely in the opposite direction considering their size and speed (See Table 13). NEV paths are designed to provide access between residential areas and commercial/retail areas, and between public streets and private property. The multi-modal design of the paths is intended for pedestrians, bicyclists, skateboarders and roller-bladders to share the facility. Note: The minimum path width may be reduced to 12-feet at the discretion of the Director of Public Works.

b. **One-Way Paths** are defined for the purposes of this study as an off-street path with a minimum width of 8 feet plus a one foot shoulder on each side (total right-of-way width of 10 feet). The 8 feet width is deemed necessary to allow pedestrians, bicyclists, skateboarders and roller-bladders to share the facility.

c. **Class II NEV/Bike Lanes:** NEV/bike lanes are portions of public roadways that are designated by signs and pavement markings for NEV/bike travel. NEV/bike lanes should be 7 feet wide and allow NEVs, bikes and golf carts (within the Golf Cart Transportation Plan) to travel adjacent to automobile traffic but within a striped separated space. Bicyclists may share NEV lanes if there is not a separate bicycle lane on the roadway. In addition, NEV/bike lanes may be reduced to 6-feet at the discretion of the Director of Public Works. NEV/bike lanes are appropriate on arterials and collector streets that meet the following design criteria:

- Road Design Speed – 45 miles per hour or less

- Automobile Traffic Volume – Streets should be capable of providing a high level of service to insure that adequate capacity exists for automobiles, bicyclists and NEVs. The City of Lincoln Public Facilities Element (PFE Policy 5-1) of the General Plan requires streets and intersections to operate at no worse than LOS "C". Based on the traffic volume thresholds shown in Table 12, a two lane collector street suggests a target vehicular threshold of 12,000 vehicles per day to maintain LOC C.

d. **Class III NEV Routes** provide for shared use by NEVs with conventional vehicle traffic on streets with a posted speed limit of 35 miles per hour or less.

2. Minimum Street Standards

The minimum street standards and typical cross-sections are shown in Appendix A. These cross-sections are based on existing City of Lincoln standards and reflect similar design widths for NEV and/or golf cart travel in Sun City – Lincoln Hills and the City of Palm Desert. Included are:

- Two lane residential collector streets with Class II NEV/Bike lanes
- Four lane arterials with Class II NEV/Bike lanes
- Residential streets (shared use)
- One-way Class 1 NEV/Golf Cart Path (off-road)
- Two-way Class 1 NEV/Golf Cart Path (off-road)

Table 11 provides a physical and operational comparison of NEVs and Golf Carts based on manufacturer specifications. The additional width and speed of the NEV requires Class I paths to be a minimum of 14-feet of pavement with at least a one foot shoulder on each side for a total right-of-way width of 16 feet. Similarly, one way Class 1 NEV/Golf Cart paths are recommended to be 8 feet of pavement with at least a one foot shoulder on each side for a total right-of-way width of 10 feet. This will allow for multi-modal travel and passing in the same direction.

Table 11 – NEV vs. Golf Cart Specifications and Comparisons

Neighborhood Electric Vehicle (NEV) vs. Standard Golf Cart Specifications and Comparisons				
CATEGORY	NEV (GEMCO)		GOLF CART (CLUB CAR)	
	2 Passenger	4 Passenger	2 Passenger	4 Passenger
Curb Weight	1,100 lbs	1,280 lbs	495 lbs	500 lbs
GVW	1,600 lbs	2,100 lbs	NA	NA
Length	98.5"	126.5"	91.5"	91.5"
Height	68"	69.75"	68.5"	68.5"

Width	55"	55"	47.25"	47.25"
Wheelbase	71.1"	101"	65.5"	65.5"
Tires	10-inch	12-inch	8.5-inch	8.5-inch
Rating	Street/Turf	Street	Street/Turf	Street
Speed	15/30 mph	30 mph	15 mph	15 mph
Source: Manufacturer specifications for GEMCO and CLUB CAR				

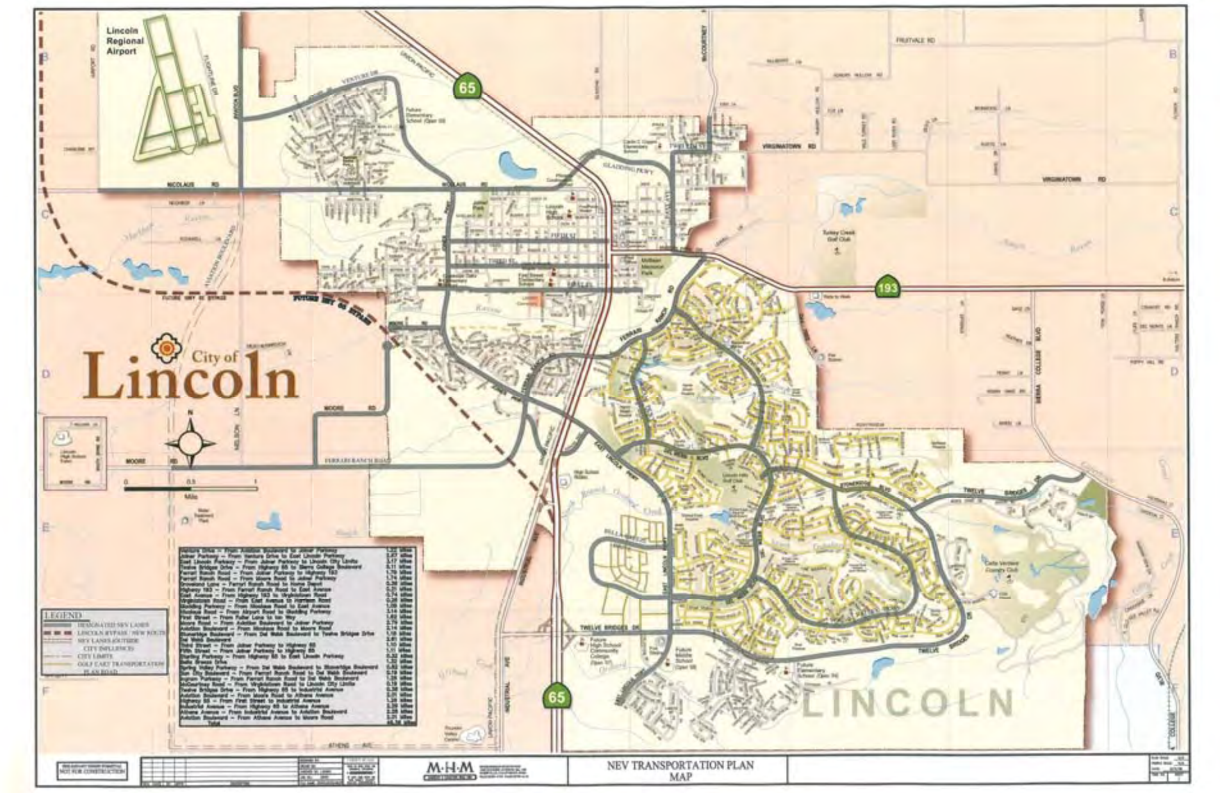
Table 12 provides a comparison of operational characteristics across various "low-speed" modes. All of these modes should be able to use the Class I NEV/Golf Cart paths within the plan area.

Table 12 – Operational Characteristics Across Low-Speed Modes

Operational Characteristics Across Low-Speed Modes				
Low Speed Mode	Speed (mph)	Width (feet)	Braking Distance (feet)	Turning Radius (feet)
Pedestrians	2.7	NA	NA	NA
Bicycles	15	3.3	15	56.3
Skates	10.5	4	20	NA
Skateboards	NA	NA	NA	NA
Scooters	5 to 8	1.2	25	NA
Wheelchairs	4 to 7	2.5	NA	2 to 4
Golf Carts	5 to 15	3.9	NA	NA
NEVs	5 to 30	4.6	NA	NA
Source: TRB Paper "What the Literature Says about Low Speed Modes," Rodier, Shaheen, and Chung, August 2003; Manufacturer specifications for GEMCO and CLUB CAR				

3. **Proposed NEV Circulation Plan**
   The proposed NEV Transportation Plan is illustrated in Figure 3.

Figure 3 – Proposed Circulation Plan



The following outlines the NEV routes included in the NEV Transportation Plan:

1. Venture Drive – From Aviation Boulevard to Joiner Parkway
2. Joiner Parkway – From Venture Drive to East Lincoln Parkway
3. East Lincoln Parkway – From Joiner Parkway to Lincoln City Limits
4. Twelve Bridges Drive – From Highway 65 to Sierra College Boulevard
5. Ferrari Ranch Road - From Joiner Parkway to Highway 193
6. Ferrari Ranch Road – From Moore Road to Joiner Parkway'
7. Groveland Lane – Ferrari Ranch Road to Home Depot
8. Highway 193 – From Ferrari Ranch Road to East Avenue
9. East Avenue – From Highway 193 to Virginiatown Road
10. Virginiatown Road – From East Avenue to Harrison Road
11. Gladding Parkway – From Nicolaus Road to East Avenue
12. Nicolaus Road – From Airport Road to Gladding Parkway
13. First Street – From Fuller Lane to Ian Way
14. Moore Road – From Aviation Boulevard to Joiner Parkway
15. Aviation Boulevard – From Nicolaus Road to Lincoln City Limits
16. Stoneridge Boulevard – From Del Webb Boulevard to Twelve Bridges Drive
17. Del Webb Boulevard
18. Third Street – From Joiner Parkway to Highway 65
19. Fifth Street – From Joiner Parkway to Highway 65
20. Sterling Parkway – From Highway 65 to East Lincoln Parkway
21. Bella Breeze Drive
22. Spring Valley Parkway – From Del Webb Boulevard to Stoneridge Boulevard

23. Sun City Boulevard – From Ferrari Ranch Road to Del Webb Boulevard
24. Ingram Parkway – From Ferrari Ranch Road to Del Webb Boulevard
25. McCourtney Road – From Virginiatown Road to Lincoln City Limits

Future routes outside of City of Lincoln limits but within the sphere of influence:

1. Twelve Bridges Drive – From Highway 65 to Industrial Avenue
2. Aviation Boulevard – From Nicolaus Road to Athens Avenue
3. Highway 65 – From First Street to Industrial Avenue
4. Industrial Avenue – From Highway 65 to Athens Avenue
5. Athens Avenue – From Industrial Avenue to Aviation Boulevard

G. NEV/Golf Cart Parking Facilities

In order to promote NEV travel, NEVs/golf carts should be given preferential parking at all common facilities, including retail centers, commercial centers, parks, medical facilities and educational facilities. Although no industry or local standards exist, we recommend the following minimum number of spaces based on our experience with other Golf Cart communities and plans, and our site review of existing parking stalls for NEVs and golf carts in the City of Lincoln:

- Retail Centers – 2 to 3 spaces (7 feet x 15 feet) per 100,000 square feet plus one additional space for each additional 30,000 square feet.
- Commercial Centers – 2 to 3 spaces (7 feet x 15 feet) per 100,000 square feet plus one additional space for each additional 30,000 square feet
- Private Neighborhood Parks – four to six spaces (7 feet x 15 feet)
- Medical Facilities – Four to six spaces (7 feet x 15 feet)
- Educational Facilities – Six to eight spaces (7 feet x 15 feet)

Note: The number of spaces suggested above, are guidelines. Larger facilities may require more parking spaces.

EXHIBIT B.

A Report to the California State Legislature

Neighborhood Electric Vehicle Transportation Plan Evaluation

Date: January 1, 2008

A Report to the California State Legislature

as required by

Assembly Bill 2353
(Chapter 422, Section 1. Chapter 7)

Neighborhood Electric Vehicle
Transportation Plan Evaluation

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EXECUTIVE SUMMARY

In August 2006, Lincoln's City Council formally adopted a resolution to approve its Neighborhood Electric Vehicle (NEV) Transportation Plan that implements the City's vision to provide safe and efficient access for NEVs to downtown and other commercial areas. Prior to 2005, federal law only permitted NEVs to operate on streets with a posted speed limit of 35 mph or less, but California state law, Assembly Bill (AB) 2353, established special provisions to define the use of NEVs on city streets. The legislation allowed NEVs to operate on streets with posted speed limits above 35 mph where designated NEV lanes are available. This report evaluates the NEV Transportation Plan in the City of Lincoln with regard to traffic and safety impacts on higher speed facilities permitted by AB2353. The report also evaluates the design and implementation of NEV-specific signage and pavement markings as part of the plan.

While a large majority of the proposed NEV Transportation Plan is pending implementation of signage and striping, this report finds that the City of Lincoln is meeting its goals of maintaining safety and acceptable levels traffic flow while increasing mobility to its residents. Continued public education efforts are necessary to inform the general public about the presence NEVs and the introduction of new signage and striping, which has helped to integrate their use on facilities with traditional automobiles and bicycles.

The City of Rocklin has completed an NEV Transportation Plan and is awaiting City Council approval as of January 2008.

Based on these findings, it is recommended that the provisions in AB2353 should be continued in the Cities of Lincoln and Rocklin. The provisions in AB2353 can be expanded statewide, provided that more comprehensive analysis is conducted once the City of Lincoln's NEV Transportation Plan has been completely implemented. A more comprehensive analysis would help to better evaluate the potential safety concerns that may exist on higher speed facilities. At this time, only a fraction of total lane miles in the NEV Transportation Plan are located on higher-speed facilities, and there have been some safety concerns by NEV users on facilities shared with traditional automobiles and by bicyclists on facilities shared by NEVs.

BACKGROUND

Neighborhood Electric Vehicles (NEVs) are electric-powered low -speed vehicles (LSVs) that typically weigh less than 1,800 pounds and can travel up to 25 miles per hour (AASHTO, 2000). While they may look like golf carts to the casual observer, NEVs are not golf carts and must meet greater safety standards set forth by the National Highway Traffic Safety Administration (NHTSA, 1998); NEVs must be equipped with basic safety equipment including: headlights, rear lights, brake lights, turn signals, rearview mirrors, reflex reflectors, parking brake, windshields, seatbelts, and vehicle identification numbers (VINs). Additionally, drivers of NEVs must possess a valid driver's license, vehicle registration and insurance.

NEVs are designed as zero-emissions vehicles to accommodate short trips in neighborhoods and urban areas. NEVs are a federally-recognized sub-class of low-speed vehicle and are limited to 25 miles per hour (mph), and may be driven on streets with speed zones of 35 mph or less. Popularity for these energy-efficient vehicles is rapidly increasing, especially within the retirement community. Yet, very few cities have modified their infrastructure to accommodate this growing mode of transportation. With the rise in active adult communities, the need for electric vehicle plans has been growing (NHTSA, 2004). Slowly, small, efficient, low speed vehicles have migrated outside these communities for local trips. Still, little infrastructure has been modified. NEV signage and striping on preferred routes need to be posted on NEV facilities, and these facilities need to be integrated into city plans.

Assembly Bill 2353

In January 2005, The California State Legislature signed Assembly Bill (AB) 2353 into law, which enabled the cities of Lincoln and Rocklin, in Placer County, to create their own NEV transportation plans. It permitted each city to go beyond the federal regulation, which only allows NEVs on all streets with a posted speed limit of 35 mph or less, to allow NEVs on streets with a posted speed limit above 35 mph if designated NEV lanes are provided. Also, the bill states that NEVs may use and cross state highways where it is determined to be safe by the City and the State Department of Transportation. Prior to AB2353, California law lacked any formal process to create a city transportation plan involving the extensive use of low speed vehicles, and while the concept of these efficient low speed vehicles has been around for some time, little has been done to integrate them into our communities (Stein et al, 1996). The City of Lincoln represents the first major citywide NEV transportation project in the State of California (MHM, 2006).

Proposed experimental traffic control standards were presented by the City of Lincoln and approved by the California Traffic Control Devices Committee (CTCDC) in July 2005. In August 2005, the City conducted a public workshop with Caltrans in attendance to participate in consensus-building process and discuss NEV issues, such as signage, striping, lane spacing, and NEV lane designation priorities.

Evaluation Goals

While AB2353 allowed the City of Lincoln to create an NEV transportation plan, it also requires that a report be submitted to the Legislature by January 1, 2008. This report serves to meet the reporting requirements for both the State Legislature for AB2353 and the California Traffic Control Devices Committee (CTCDC) for experimental signage and striping. This report contains the following:

1. A description of all NEV transportation plans and their elements that have been authorized up to that time.
2. An evaluation of the effectiveness of the NEV transportation plan elements, including their impact on traffic flows and safety.
3. A recommendation as to whether the provisions in AB2353 should be terminated, continued in existence applicable solely to the City of Lincoln and the City of Rocklin in the County of Placer, or expanded statewide.

NEV TRANSPORTATION PLAN DESCRIPTIONS

Lincoln

On August 8, 2006 the Lincoln City Council unanimously approved the NEV Transportation Plan in accordance with AB2353 which incorporated the CTCDC approved standards. Lincoln's goal was to become "NEV ready" by having the "necessary infrastructure, including charging facilities, striping, signage, parking, and education to safely accommodate NEV travel" (MHM, 2006). This plan is still being implemented in stages, ultimately extending the transportation network throughout the City. The plan aims to reduce the use of traditional automobiles for short trips along with creating a more cohesive community, reducing travel and energy costs, increasing mobility and independence for aging drivers, and increasing the use of public transit.

A major design goal of the plan was to provide infrastructure improvements to allow for the safe, smooth flow of NEVs with pedestrians, bicycles, and other motor vehicles and to allow NEV users access to every part of the city (MHM, 2006). A circulation plan (shown in Figure 1) was approved that includes three different classes of NEV routes:

- Class I routes are designed for the exclusive use of NEVs and bicycles.
- Class II routes designate a separate striped lane adjacent to traffic for the use of both NEVs and bicycles.
- Class III routes allow NEVs to share lanes with automobiles on streets with a posted speed limit of 35 mph or less.

NEV facilities within the NEV Transportation Plan area are listed in Table 1.

Figure 1. City of Lincoln NEV Transportation Plan Map

Table 1. Facilities Authorized by Lincoln NEV Transportation Plan (2006)

Street	Between	Distance
Venture Drive	Aviation Boulevard to Joiner Parkway	1.22
Joiner Parkway	Venture Drive to East Lincoln Parkway	2.67
East Lincoln Parkway	Joiner Parkway to Lincoln City Limits	3.17
Twelve Bridges Drive	Highway 65 to Sierra College Boulevard	5.11
Ferrari Ranch Road	Joiner Parkway to Highway 193	1.79
Ferrari Ranch Road	Moore Road to Joiner Parkway	1.74
Groveland Lane	Ferrari Ranch Road to Home Depot	0.36
Highway 193	Ferrari Ranch Road to East Avenue	0.21
East Avenue	Highway 193 to Virginiatown Road	0.74
Virginiatown Road	East Avenue to Harrison Road	0.26
Gladding Parkway	Nicolaus Road to East Avenue	1.09
Nicolaus Road	Airport Road to Gladding Parkway	3.14
First Street	Fuller Lane to Ian Way	1.62
Moore Road	Aviation Boulevard to Joiner Parkway	2.79
Aviation Boulevard	Nicolaus Road to Moore Road	2.14
Stoneridge Boulevard	Del Webb Boulevard to Twelve Bridges Drive	1.18
Del Webb Boulevard	(all)	2.61
Third Street	Joiner Parkway to Highway 65	1.10
Fifth Street	Joiner Parkway to Highway 65	1.11
Sterling Parkway	Highway 65 to East Lincoln Parkway	0.32
Bella Breeze Drive	(all)	1.32
Spring Valley Parkway	Del Webb Boulevard to Stoneridge Boulevard	0.82
Sun City Boulevard	Ferrari Ranch Road to Del Webb Boulevard	0.19
Ingram Parkway	Ferrari Ranch Road to Del Webb Boulevard	1.26
McCourtney Road	Virginiatown Road to Lincoln City Limits	0.19
Twelve Bridges Drive	Highway 65 to Industrial Avenue	0.38
Aviation Boulevard	Nicolaus Road to Athens Avenue	2.01
Highway 65	First Street to Industrial Avenue	1.26
Industrial Avenue	Highway 65 to Athens Avenue	2.29
Athens Avenue	Industrial Avenue to Aviation Boulevard	2.28
Aviation Boulevard	Athens Avenue to Moore Road	2.01
	TOTAL	48.38

The signage and pavement markings identified in the NEV Transportation Plan are consistent with Part 9 of the 2003 California Supplement of the Manual on Uniform Traffic Control Devices (MUTCD) issued by the California Department of Transportation (Caltrans) for bicycles and with the adopted 2001 Golf Cart Transportation Plan (GTCP) for Sun City Lincoln Hills (Fehr & Peers, 2006). The following NEV signs and pavement markings (shown in Appendix A) have been authorized for use within the plan area:

- NEV Route sign is designed to be placed on local streets, which have been designated as NEV Routes. The sign should be placed at the far side of collector street intersections and at a maximum of one-half mile intervals on all continuous residential streets. [Shown in Figure 2 on East Lincoln Parkway.]

- Combination NEV/Bike Lane Sign is designed to be placed on NEV lanes where a Class II bike lane is also provided. The sign should be placed at the far side of collector street intersections and at a minimum of one-half mile intervals on all continuous residential streets. [Shown in Figure 3 on East Lincoln Parkway.]

- Combination NEV/Bike Lane Pavement Marking is designed to be placed on NEV lanes where a Class II bike lane is also provided. [Shown in Figure 3 on East Lincoln Parkway.]

- NEV Pavement Marking is designed to be placed on local streets, which have been designated as NEV Routes.

- NEV Lane Striping is designed to be placed between the traffic lane and the NEV/Bike lane.

Figure 2. Combination NEV/Bike Lane Sign and NEV Route Sign

Figure 3. Combination NEV/Bike Lane Pavement Marking and Striping

Rocklin

The City of Rocklin has completed their NEV Transportation Plan and is awaiting City Council approval in January 2008 (Foster et al, undated). The City of Rocklin proposed to implement signage and striping in phases. The first phase includes identifying preferred Class III NEV routes and striping Class II routes where necessary to link to Class III routes. The first phase could begin as early as Spring 2008 and involve installing proper signage on all designated NEV routes where the speed limit is 35 miles per hour or less. The second phase includes striping Class II routes in preferred arterial roads. NEV facilities within the proposed Rocklin NEV Transportation Plan are shown in Figure 4.

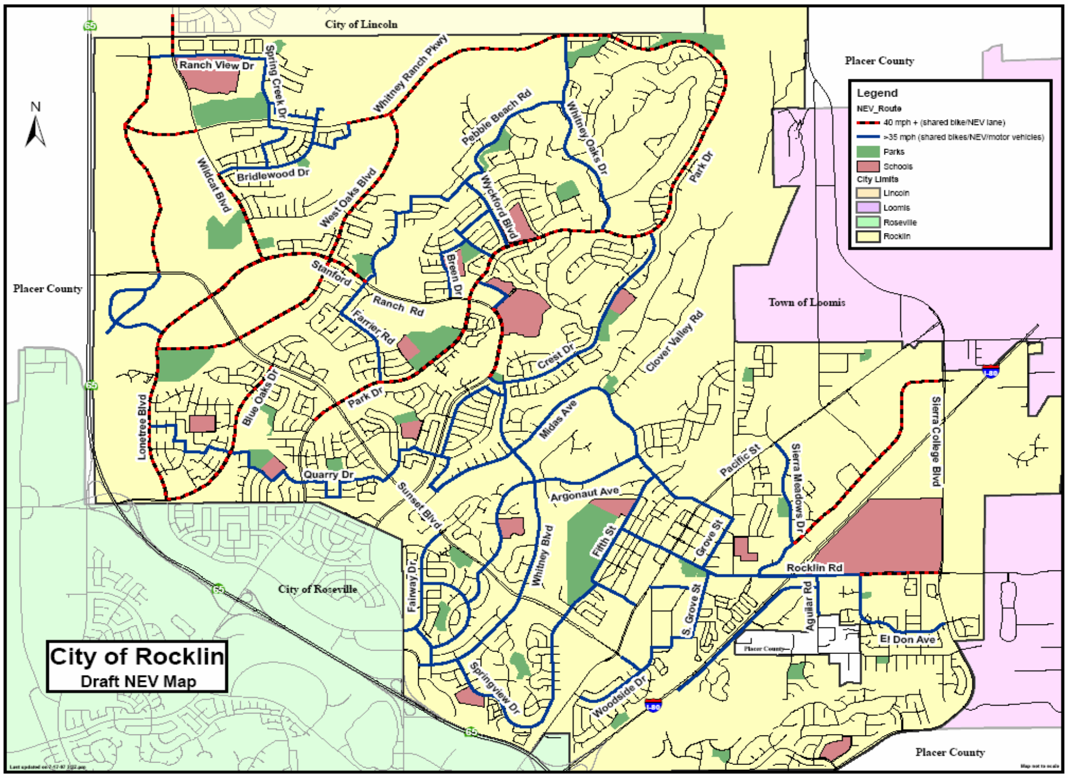

Figure 4. City of Rocklin Proposed NEV Transportation Plan Map

EFFECTIVENESS OF NEV TRANSPORTATION PLAN ELEMENTS

This report evaluates the effectiveness of the NEV Transportation Plan for the City of Lincoln, focusing on its impact on traffic flows and safety. We contacted the Lincoln Police Department and California Highway Patrol (CHP) to gather any reported information involving crashes or collisions involving NEVs in the City, and a public survey was administered regarding any non-reported incidents. The survey also included questions regarding the general perceived safety of NEVs by NEV users and the general public as well as questions about signage, striping, travel costs, community cohesion, mobility and independence for aging drivers, and the use of public transit. Finally, we gathered traffic speed data to compare the speeds before and after the NEV Transportation Plan was implemented to evaluate the effect of NEVs on traffic operations.

DATA COLLECTION AND ANALYSIS

This section reviews the three sets of data that were collected to evaluate the NEV Transportation Plan, paying particular focus on traffic conditions on higher speed facilities permitted by AB2353 as well as traffic signage and striping permitted by the CTCDC. The three sources of data used in this study included: crash/collision incident databases and traffic violation data, traffic speed and compliance data, and user surveys. Each data source is explained in greater detail below.

Traffic Incident and Violation Databases

Collision crash data were requested from both the Lincoln Police Department and California Highway Patrol to determine if a common theme existed among incidents involving NEVs, or if common themes existed among moving traffic violations. Formal inquiry requests were made for collision/crash data involving NEVs in the City to the Lincoln Police Department and the California Highway Patrol (CHP) Statewide Integrated Traffic Records System (SWITRS). Safety records did not provide any issues with conflicts between bicycles, NEVs, and automobiles.

Traffic Engineering Studies

Speed Studies and Level of Service Analysis

Speed studies were conducted before and after NEV lanes were installed to determine if NEVs impacted traffic speed along travel corridors. During May and June 2005, engineering consulting firm TY Lin Inc. conducted speed surveys along twenty roadways (41 segments) throughout the City of Lincoln as required by the California Vehicle Code, Manual of Uniform Traffic Control Devices (MUTCD), and the 2003 California Supplement to the MUTCD to determine speed limits on the roadways. A random sample of the speed data were collected using machine counters during the mid-morning and mid-afternoon hours of the weekday was made based on the selection criteria that these be at least seven seconds apart. The random sample, at least 100 per direction, was used to calculate the mean, median, and 85th percentile speed (that speed at which 85% of the traffic is traveling at or below) for each direction. The same methodology was followed to collect and sample data at the same location during the same time of day in August 2007, and used as a basis of comparison to the 2005 data.

The location chosen for the study was East Lincoln Parkway between Del Webb Boulevard and Sterling Parkway, shown in Figure 5. The same location on East Lincoln Parkway was used to collect traffic volume data for a “level of service” (LOS) analysis, which was compared to similar analysis completed by Fehr & Peers in 2006. East Lincoln Parkway is a north/south two-lane collector with NEV lanes with approximately 12,800 vehicles per day with the planned medical and commercial development in place (Fehr & Peers, 2006).

Figure 5. Location of Traffic Engineering Data Collection

It should be noted here that the City plans to provide NEV facilities on several streets identified in the NEV Transportation Plan and shown in Figure 1, but only two facilities both 1) currently provide NEV facilities with speeds at or above 35 mph and 2) had data from 2005 to use for comparison, as shown in Table 2. These two facilities are East Lincoln Parkway and Joiner Parkway. On Joiner Parkway, however, the locations where TY Lin collected data in 2005 were within close proximity of traffic control devices (i.e., stop signs) in 2007. The introduction of these stop control devices would affect vehicle speeds, so data at those locations along Joiner Parkway were not used for this evaluation.

Table 2. Facilities Surveyed by TY Lin (2005)

Street	Between	Within NEV Plan?	Speed Limit
Aviation Rd	Nicolaus Rd and Venture Blvd	Yes	40 mph
D Street	First Street and SR 193 (McBean Park Dr)	No	25 mph
East Ave	Seventh and 12th St	Yes	30 mph
East Ave	SR 193 and Seventh St	Yes	30 mph
East Lincoln Pkwy	SR 65 and Del Webb Blvd	Yes	35 mph
East 12th Street	East Ave and McCourtney Rd	Yes	35 mph
Ferrari Ranch Rd	Joiner Pkwy & Kensington/Danbury	Yes	35 mph
Ferrari Ranch Rd	SR 65 and Ingram Pkwy	Yes	35 mph
Ferrari Ranch Rd	Sun City Blvd and SR 193	Yes	35 mph
Fifth Street	O Street and SR 65	Yes	25 mph
Fifth Street	Joiner Pkwy and Chambers Dr	No	25 mph
Fifth Street	O Street and Joiner Pkwy	Yes	25 mph
First Street	SR 65 and O Street	Yes	25 mph
Ingram Pkwy	Ferrari Ranch Rd and Northfield Ln	Yes	35 mph
Ingram Pkwy	Northfield Ln & Del Webb Blvd	Yes	30 mph
Joiner Pkwy	Ferrari Ranch Rd and SR 65	Yes	40 mph
Joiner Pkwy	Nicolaus Rd and Third Street	Yes	40 mph
Joiner Pkwy	Moore Rd and Nicolaus Rd (Third?)	Yes	40 mph
Lakeside Dr	Venture Dr and Moraga Rd	No	35 mph
Lakeside Dr	Nicolaus Rd and Moraga Dr	No	35 mph
Nicolaus Rd	Aviation and Waverly	Yes	40 mph
Nicolaus Rd	Waverly and Joiner Pkwy	Yes	40 mph
Nicolaus Rd / 9th St	O Street and SR 65	Yes	40 mph
O Street	First St and Fourth St	No	25 mph
O Street	Fourth St and Nicolaus Rd	No	25 mph
Seventh Street	SR 65 and East Ave	No	30 mph
Southcreek St	Twelve Bridges and Oak Valley Dr	No	25 mph
Southcreek St	Oak Valley Dr & Eastridge	Yes	25 mph
Stoneridge Blvd	E Spring Valley Blvd and Twelve Bridges	Yes	35 mph
Stoneridge Blvd	Del Webb and E Spring Valley Pkwy	Yes	35 mph
Sun City Blvd	Ferrari Ranch Rd and Hawthorne Ln	Yes	30 mph
Third Street	O Street and Joiner Parkway	Yes	25 mph
Third Street	O Street and SR 65	Yes	25 mph
Twelve Bridges Dr	Sierra College and Stoneridge Blvd	Yes	40 mph
Twelve Bridges Dr	Stonebridge Blvd and Rossi Ln	Yes	40 mph
Twelve Bridges Dr	Eastridge Dr and Rossi Ln	Yes	40 mph
Twelve Bridges Dr	Lincoln Pkwy and Eastridge Dr	Yes	40 mph
Twelve Bridges Dr	SR 65 and E Lincoln Pkwy	Yes	40 mph

Surveys

The effectiveness of authorized traffic devices and the perceived safety of NEVs, were evaluated through the administration of a transportation survey. The survey was administered on-line between June and August of 2007 and made available to NEV users, bicyclists, and the general public (traditional motorists, users of public transit, etc). The survey contained questions for all road users regarding the perceived safety of NEVs and their perceived affect on traffic flow. Traditional motorists and bicyclists were questioned about their opinions regarding safety issues and potential conflicts in shared use lanes with NEVs. NEV users were asked to express their opinion about many different aspects of their NEV usage including but not limited to: 1) implemented signage, striping, and pavement markings, 2) safety concerns with motorists, such as at intersection or in left turning lanes, and 3) safety concerns with bicyclists and shared NEV/bicycle lanes. It also contained questions about NEV signage and striping as well as questions about goals identified in the NEV Transportation Plan. The complete survey and its results are provided in Appendices C and D, respectively.

The survey website was sent out to NEV users and bicyclists through their local clubs. A presentation was given to the Lincoln Hills Low-Speed Vehicle (LSV) Users Group in June 2007, and a link to the survey was e-mailed to members of the Lincoln Bicycle Club. The survey was also made available to the general public through a link on the City of Lincoln's website. Hard copies were made available by telephone or e-mail request, and some surveys were completed for individuals who telephoned the number available on the survey.

In an attempt to capture more traditional motorists and users of other modes, intercept surveys were conducted outside of the Safeway Market on SR 65 in Lincoln in August 2007, which resulted in a very limited sampling of users. To obtain a more representative sample of Lincoln residents, additional sampling in the downtown core or at other mixed-use areas of the City should be considered.

EVALUATION RESULTS

In this section, we review results from all three data sources.

Incident and Traffic Violation Databases

Neither inquiry to LPD or CHP yielded any results about NEV incidents/crashes or traffic violations. According to CHP, there have not been any documented incidents involving NEVs in the Statewide Integrated Traffic Records System (SWITRS). A conversation with an officer in the Lincoln Police Department indicated that NEVs were perceived to be safe in areas where the transportation plan has been implemented.

Traffic Engineering Studies

Speed Studies

Histograms of the observed speeds by the general vehicle traffic, excluding NEVs, for northbound and southbound East Lincoln Parkway are shown in Figure 6 and Figure 7, respectively. Histograms of only NEV traffic on northbound and southbound East Lincoln Parkway are shown in Figure 8 and Figure 9, respectively. Data for general vehicle traffic were collected separately from NEVs so that general vehicle traffic could be compared between 2005 and 2007 without the influence of NEVs.

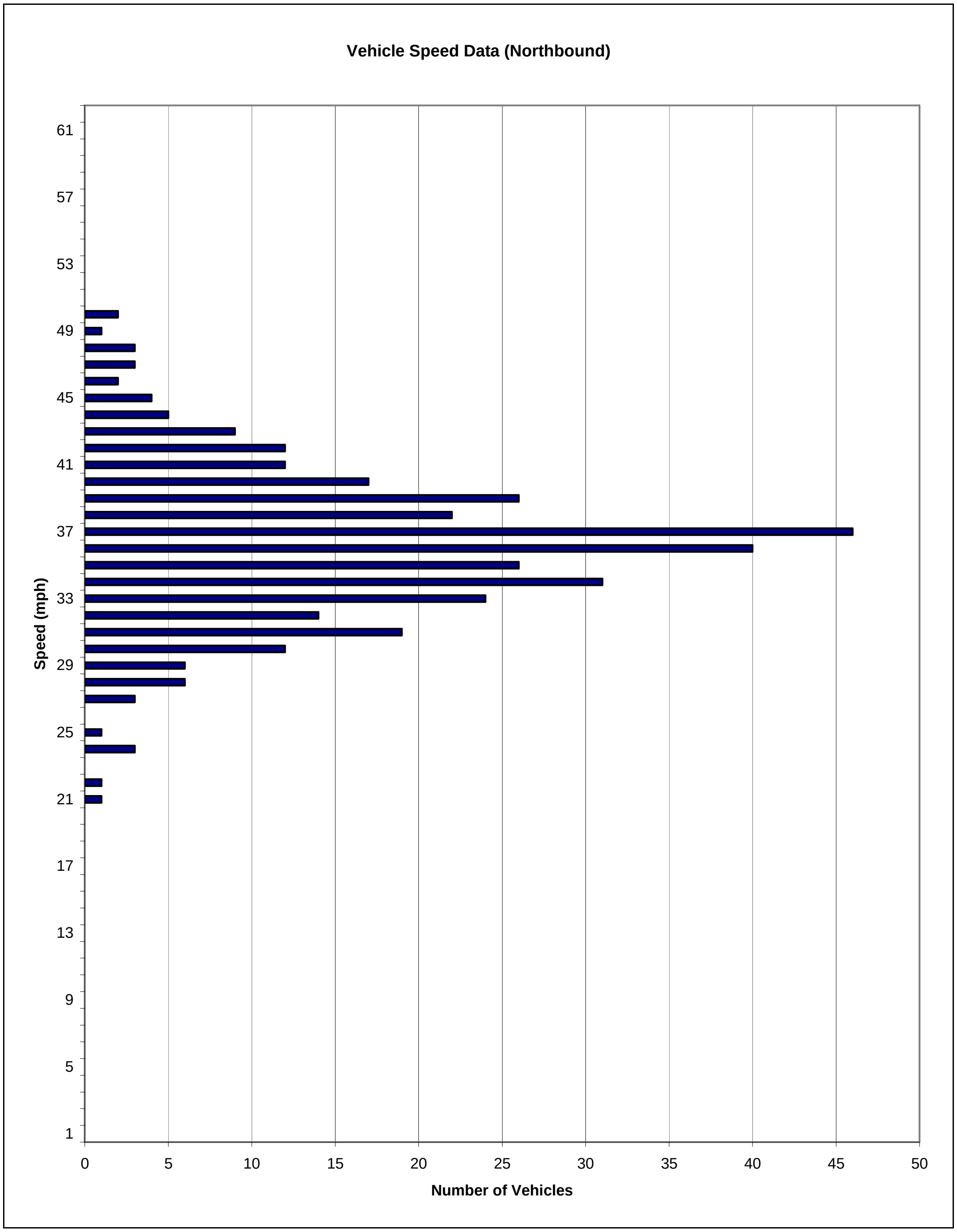

Figure 6. Vehicle Speeds on Northbound East Lincoln Parkway

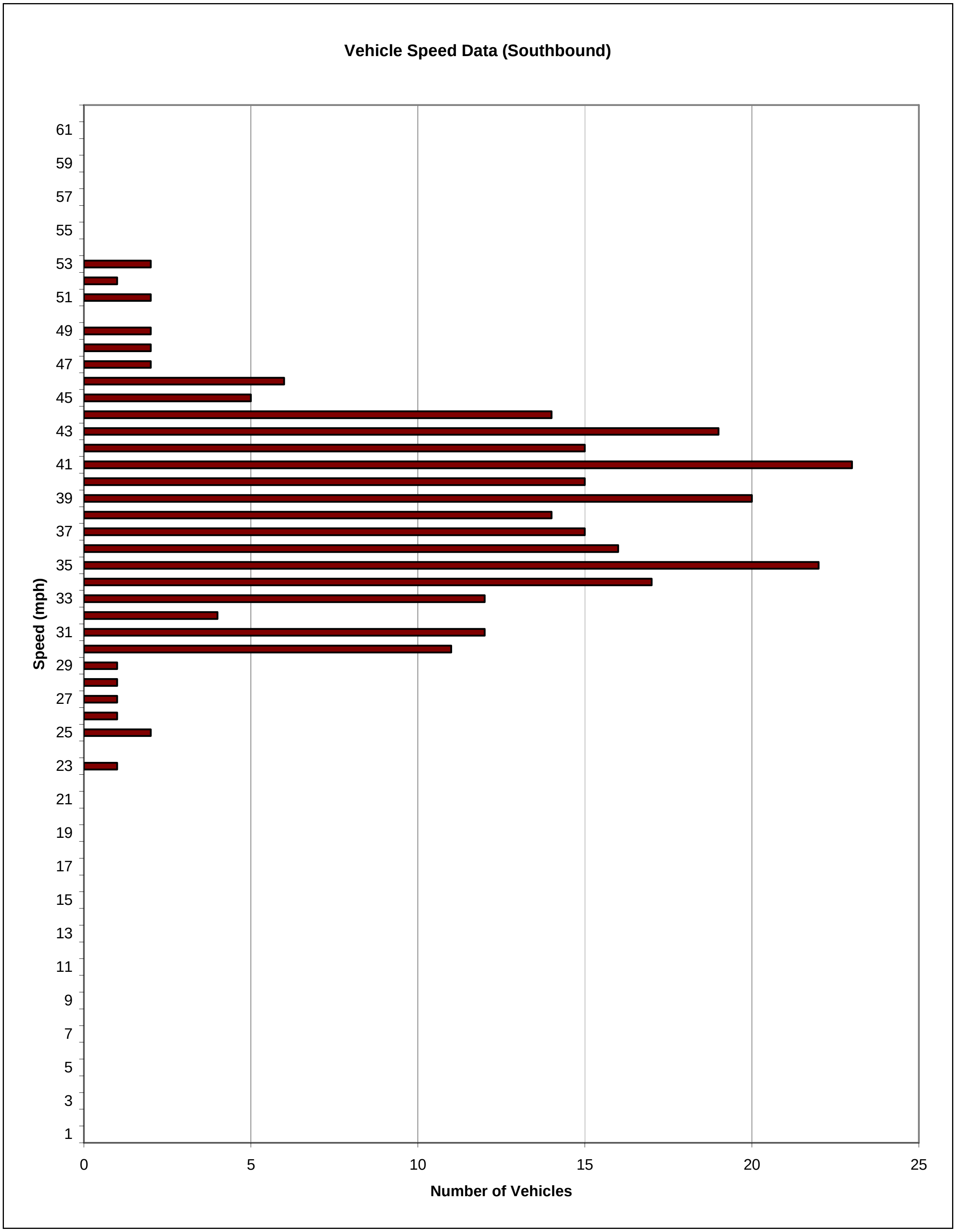

Figure 7. Vehicle Speeds on Southbound East Lincoln Parkway

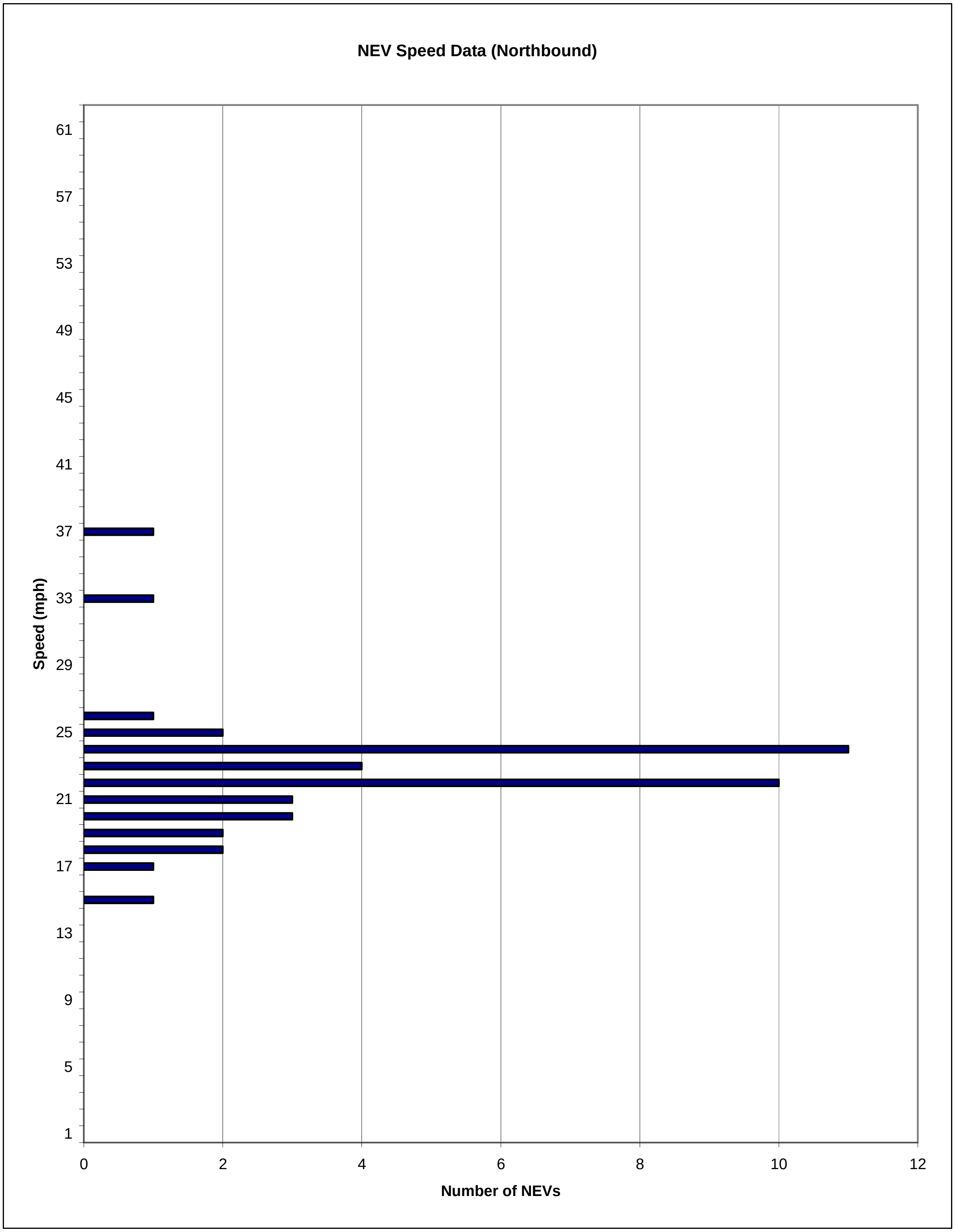

Figure 8. NEV Speeds on Northbound East Lincoln Parkway

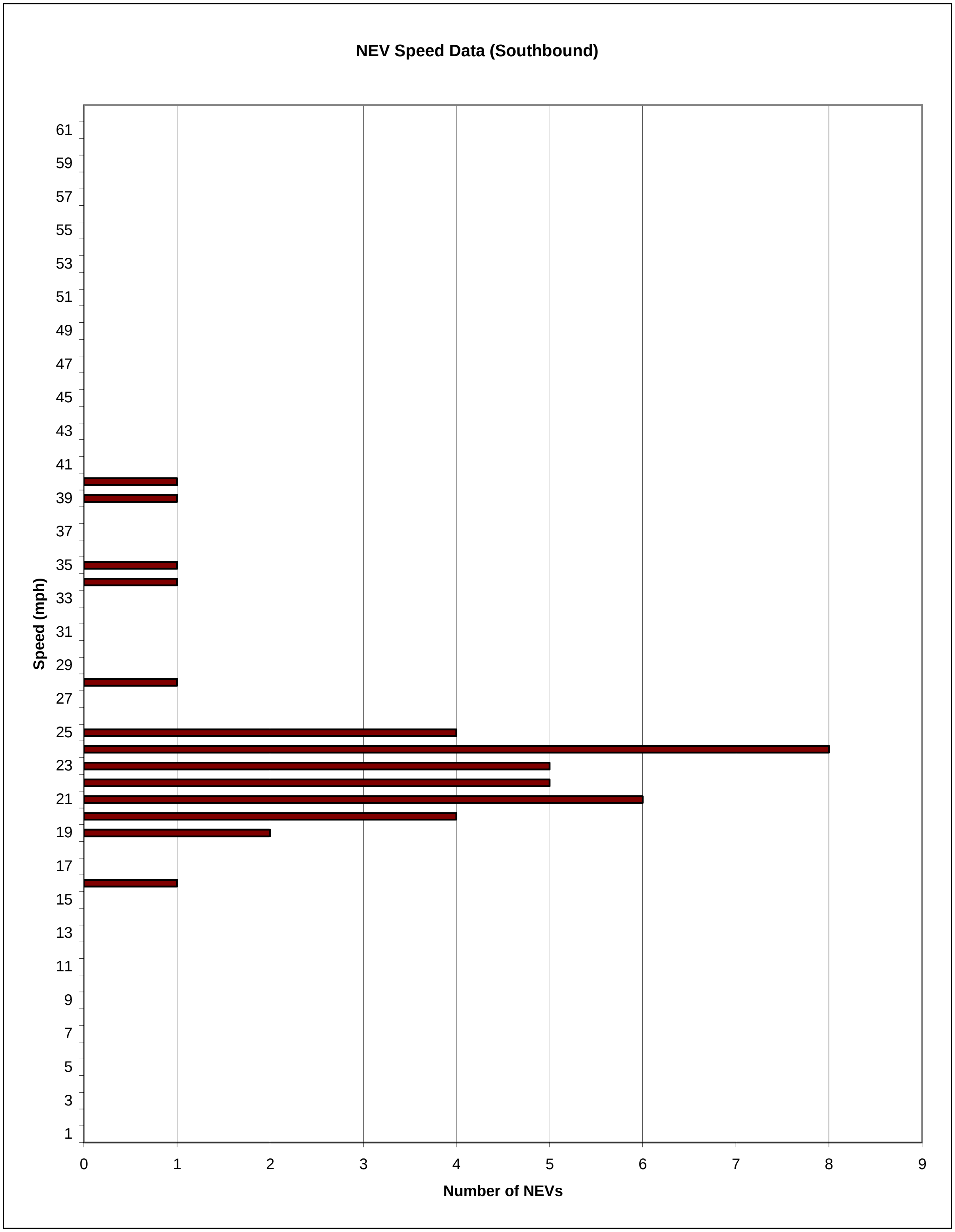

Figure 9. NEV Speeds on Southbound East Lincoln Parkway

The summary of results from both 2005 and 2007 traffic engineering studies is shown in Table 3 below. The results indicate that the average (mean) and median speeds in both directions decreased slightly from 2005 to 2007. The 85th percentile speed decreased by three miles per hour in the northbound direction and remained the same in the southbound direction. A statistical analysis indicates that the decrease in speed from 2005 to 2007 was statistically significant at the 95% confidence level. (This analysis is detailed in the appendix). In both 2005 and 2007, however, the average, median, and 85th percentile speeds were still above the posted speed limit of 35 miles per hour. As we might expect, this table also indicates that NEVs travel at a much lower speed, on average, than traditional automobiles. From this analysis, we can conclude that the introduction of NEVs has had little effect on traffic flow. In fact, it is possible that the introduction of NEVs may have a calming effect on vehicle speeds.

Table 3. Speed Data Analysis on East Lincoln Parkway

		Automobiles			**NEVs**
	Parameter	**2005 (Before NEV Plan)**	**2007 (After NEV Plan)**	**Difference**	**2007**
Northbound	Average Speed	39 mph	36 mph	-3 mph*	23 mph
	Median Speed	38 mph	36 mph	-2 mph	22 mph
	85th Percentile Speed	44 mph	41 mph	-3 mph	24 mph
	Standard Deviation	4.6 mph	4.6 mph	-	3.7 mph
	Observations	162	351	-	42
Southbound	Average Speed	40 mph	38 mph	-2 mph *	24 mph
	Median Speed	39 mph	38 mph	-1 mph	23 mph
	85th Percentile Speed	44 mph	44 mph	0 mph	25 mph
	Standard Deviation	4.4 mph	5.2 mph	-	5.0 mph
	Observations	101	258	-	40

* Difference is statistically significant at the 95% confidence level.

At this point, it is important to note, however, that these data were collected on one street in a growing part of the City. In 2005, East Lincoln Parkway ended at Sterling Parkway. Today, East Lincoln Parkway connects to a shopping area at Sterling Parkway then crosses over SR 65 to connect to the west side of Lincoln. While these changes are significant, it was assumed that vehicle speeds on the backside of an overcrossing would probably have yielded higher speeds than observed in 2005. In other words, these findings are assumed to be more conservative with the introduction of an overcrossing than without. Because of the little data available, it is recommended that a more comprehensive study be conducted once the City has implemented the majority of the proposed in the NEV Transportation Plan.

Level of Service Analysis

Level of service (LOS) is a qualitative measure of congestion and delay on intersections and roadways that is reported on a scale from A to F, with A representing the best performance and F the worst in terms of congestion and delay. LOS is determined by comparing the measured daily volumes to LOS thresholds in Table 4 for various roadway types. These thresholds had been established for previous environmental analyses in the Cities of Lincoln and Rocklin and the Counties of Placer and Sacramento (MHM, 2006). The City of Lincoln has adopted LOS C as their minimum criteria for urban area intersections and roadways.

Table 4. Average Daily Traffic Volume Level of Service Thresholds

	Average Daily Traffic Volume Threshold				
Facility Type	**LOS A**	**LOS B**	**LOS C**	**LOS D**	**LOS E**
Two-Lane Street	9,000	10,700	12,000	13,500	15,000
Four-Lane Undivided Arterial	18,000	21,300	24,000	27,000	30,000
Four-Lane Divided Arterial	20,250	23,625	27,000	30,375	33,750

While it is not clear that a two-lane street with two additional NEV lanes (four lanes total) is necessarily equivalent to a traditional four-lane arterial, based on these criteria East Lincoln Parkway with an approximate daily traffic volume of 8,961 vehicles in both directions (less than 2% of which are NEVs) would easily maintain LOS A for a four-lane divided arterial, and remains well within the City's minimum criterion.

Surveys

Before the survey results pertaining to safety and traffic impacts of NEVs are discussed, it is useful to characterize the respondents. Of the 148 people surveyed, all drove traditional automobiles while 94 (64%) also drove NEVs and 24 (16%) also rode bicycles. Summary statistics of the average respondent are provided in Table 5 and indicates that the average respondent was a 63 year old, retired, married male without children living at home with 1.7 vehicles at home (not including an NEV), and an approximate average household income of $84,000. While this survey may provide valuable information regarding the perceived safety of the NEV Transportation Plan, it is clear that this study did not capture a representative sample of Lincoln residents and should not be used for generalizations beyond this evaluation. A representative sample would emulate the entire population of all residents in the City of Lincoln, not a subset of its residents.

Table 5. Survey Respondent Summary Statistics

Gender	63% Male / 37% Female
Average Age	63 years
Martial Status	82% Married / 14% Single
Employment Status	75% retired / 12% part-time / 10% full-time
Avg. Number of Workers in Household	0.4 persons
Avg. Annual Household Income (approx)	$84,000
Avg. Auto Ownership (not including NEVs)	1.7 vehicles

Additional analysis of the 94 NEV users who participated in the survey had an average of over 31 months (2.6 years) of NEV ownership (Q3), shown in Figure 10. They also averaged almost 15 NEV one-way trips per week (Q22) while averaging a little less than 4.5 miles per trip (Q23). Based on these figures, the average NEV would travel almost 3,500 miles per year, which is over three and a half times higher than previous estimates (MHM, 2006). The amount of travel and potential benefits associated with NEV use is an area in need of future research.

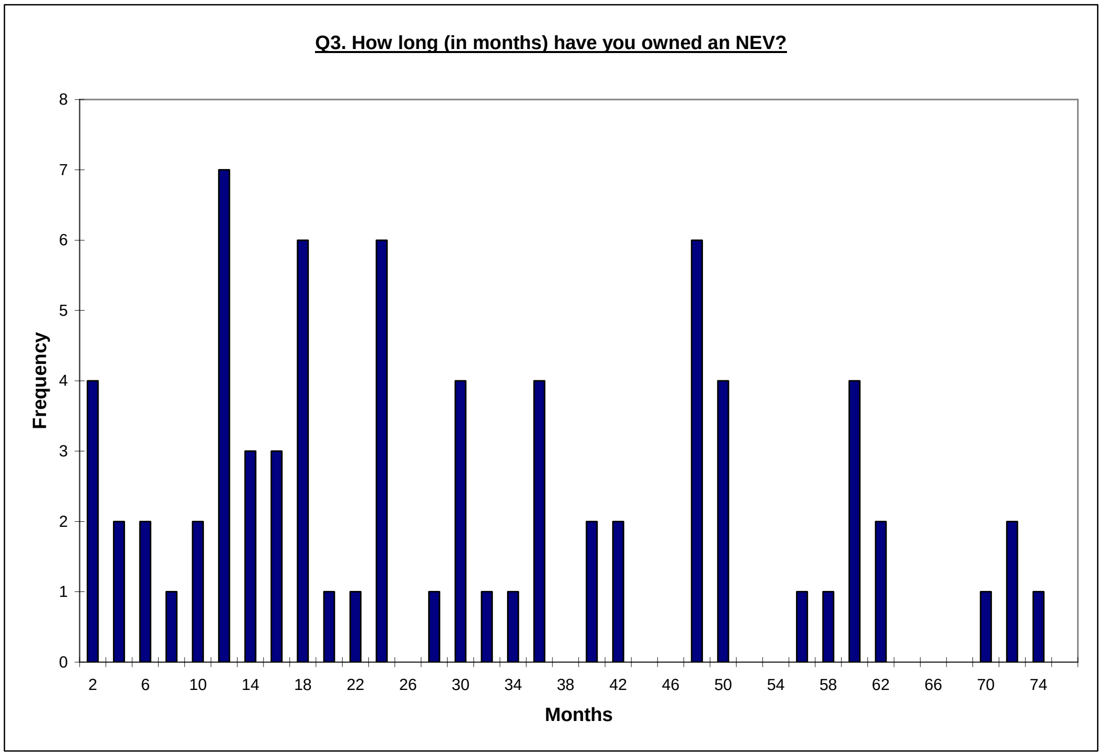

Figure 10. Duration of NEV Ownership by Survey Respondents

The following sections highlight noteworthy findings from the survey pertaining to perceived traffic flow, safety, as well as signage and striping by NEV users, traditional motorists, and bicyclists. The complete survey questionnaire and results are available in the appendix.

Perceived Safety by NEV Users

Table 6 indicates that NEV users perceive the greatest safety when separated from traditional automobiles. Roads with shared NEV lanes were perceived to be between "neither safe nor unsafe" and "somewhat safe" while roads with separate lanes for NEVs were "somewhat safe" to "very safe." Although not in part of the plan, NEV users perceive NEV-only paths to be the most safe.

Table 6. Perceived Safety of NEV Facilities by NEV Users

	Roads with *shared* lanes for NEVs and autos	Roads with *separate* lanes for NEVs and autos	Paths restricted only to NEVs
Very Safe (5)	13 (16.67%)	54 (69.23%)	70 (89.74%)
Somewhat Safe (4)	32 (41.03%)	22 (28.21%)	3 (3.85%)
Neither Safe nor Unsafe (3)	11 (14.10%)	0 (0%)	0 (0%)
Somewhat Unsafe (2)	16 (20.51%)	1 (1.28%)	0 (0%)
Very Unsafe (1)	3 (3.85%)	0 (0%)	0 (0%)
No Basis to Judge	3 (3.85%)	1 (1.28%)	5 (6.41%)
Mean	3.48	4.68	4.96

Surprisingly, the findings from Table 6 (Q6 – Q8) do not seem to coincide with the results from Question 9 which asked, "Where do you prefer to drive your NEV?" The results, shown in Table 7, indicate that most NEV users prefer to travel on facilities with separated NEV lanes paths restricted only to NEVs. This finding can be interpreted two ways. Because paths do not currently exist as part of the plan, NEV users may not have considered it to be a viable choice.

Table 7. Preferred Facilities by NEV Users

Facility Type	Response
Shared Lanes with Automobiles	0%
Separated NEV lanes	76.9%
NEV-only paths	8.97%
No preference	14.1%

The result from Question 9 may also indicate that NEV users prefer the additional separation from traditional automobiles available through on-street NEV lanes but also prefer the flexibility of being on the street, like a traditional automobile, without being relegated to off-street paths. As a result, the City may want to consider experimenting with NEV-only paths and enhancing traditional road facilities for NEVs before attempting to securing right-of-way for off-street NEV paths. This second explanation is supported by Question 10 where exactly half (50%) of all NEV users indicated that they would not drive longer distances to travel on dedicated NEV facilities. In other words, NEV facilities will only be effective if they provide direct access to destinations equivalent to traditional automobiles.

Over 88% of respondents indicated that the current NEV signs (Q13), were easy to read and understand, and 90% of respondents indicated that the current pavement markings (Q14), were easy to read and understand. All of the remaining 12% of respondents who indicated that NEV signs were not easy to understand provided similar comments to suggest that a public education campaign is needed for the general public and traditional automobilists who do not know what "NEV" means. In fact, one NEV user responded to this issue by asking, "What does the N stand for?" Some of these education issues also manifest themselves when the NEV parking spaces are used by traditional automobiles. It is possible that signage may need to be designed to contain the phrase “neighborhood electric vehicle,” instead use of the acronym.

Other responses (Q11 & Q12) seem to suggest that the NEV transportation plan seem to be working. The interaction between vehicles and NEV is important, yet the majority of NEV users do not indicate having problems merging from NEV lanes through traditional vehicle lanes (87%) or problems crossing mixed traffic to make left turns (83%). These findings are important reassurance to the City as it continues to implement more of the NEV Transportation Plan.

From the survey, it was revealed that exactly half (50%) of all NEV users surveyed cross or use a road designated for NEVs with a speed limit over 35 mph at least “occasionally” (Q15), implying that a large portion of NEV users in the City have benefited from AB2353 becoming law.

Perceived Safety of NEVs by Traditional Automobile Users

The survey results indicate that the majority of traditional motorists (54.8%) feel that NEVs affect the travel speeds on traditional roads where traditional automobiles and NEVs *share* lanes (Q29), but only a fraction (15.08%) feel that NEVs affect the travel speeds on roads where traditional automobiles and NEVs have *separate* lanes (Q30).

When traditional automobilists were questioned about their interaction with NEVs, most respondents indicated that they feel safe (either “very safe” or “somewhat safe”) around NEVs (Table 8). The general perception by traditional automobilists is that traditional roads with separated NEV lanes are safer than traditional roads without NEV facilities, which, in turn, are safer than traditional roads with shared lanes. These findings seem to suggest that designated shared facilities are less desirable for traditional motorists than traditional roads without NEV designations, while traditional roads with separate facilities are the most desirable. Regardless of the facility type, a large majority of traditional motorists (70% to 88%) do not appear to feel their safety is threatened by NEVs.

Table 8. Perceived Safety of NEV Facilities by Traditional Auto Users

Facility	Traditional roads	Traditional roads with *shared* lanes for NEVs and autos	Traditional roads with *separate* lanes for NEVs and autos
Very Safe (5)	69 (54.76%)	57 (45.60%)	80 (64.00%)
Somewhat Safe (4)	43 (34.13%)	32 (25.60%)	30 (24.00%)
Neither Safe nor Unsafe (3)	6 (4.76%)	13 (10.40%)	6 (4.80%)
Somewhat Unsafe (2)	6 (4.76%)	14 (11.20%)	6 (4.80%)
Very Unsafe (1)	1 (0.79%)	5 (4.00%)	0 (0%)
No Basis to Judge	1 (0.79%)	4 (3.20%)	3 (2.40%)
Mean	4.38	4.01	4.51

Regardless of the facility type, 55% of traditional automobile users feel that NEVs affect the travel speed on roads where NEVs and traditional automobiles either share lanes (Q29), while only 19% of those respondents believe that NEVs affect travel speeds when both have separate lanes (Q30). Many traditional motorists commented that NEVs affect their driving speed, especially when on 35 mph roads where NEVs reach a top speed of 25 mph: "Traditional automobiles normally travel above the speed limits. NEVs have a maximum speed of 25 mph. Conflicts can and do occur especially on roadways posted at 30-35 mph." For this reason, it is critical that NEV lanes be available where appropriate to avoid impeding traditional automobiles." This finding appears to match the findings from the previous section where an analysis of the speeds indicated a reduction in average speed on the facility. It may be that NEVs exhibit a "calming effect" on traditional traffic.

As expected, traditional motorists perceived greater safety with NEVs in separated lanes than in shared lanes. Interestingly, they also perceived traditional roads as being safer than traditional roads with shared lanes for NEVs. It is possible that "traditional roads" was interpreted by some survey respondents to mean "traditional roads without the presence of NEVs" while it may have been interpreted by others to mean "traditional roads with the presence of NEVs but without NEV provisions."

Perceived Safety of NEVs by Bicyclists

Organized bicyclists have struggled for years to get adequate shoulders and roadside striping, and the needs of bicyclists were considered during the NEV planning process (Cosgrove et al, 2007). Some bicyclists are willing to use the new NEV/bike lanes but are reluctant to see a bicycle lane converted to a wider shared NEV/bike lane. Approximately 40% of all bicyclists surveyed also feel that the presence of NEVs affected their bicycling speed (Q44). Over 34% of bicyclists surveys do not believe that the combination NEV/bike signs easy to read and understand (Q45), and almost 49% of bicyclists find the NEV/bike pavement markings and striping easy to read and understand (Q46). Most of the comments by these bicycle respondents, like the traditional motorist respondents, indicate a need for better education by road users, "Many bicyclists don't know what an NEV is." The large proportion of the 49% who had a difficult time reading and understanding the pavement markings attributed their response to faded striping or pavement markings. It should be noted that the NEV/bike lane markings or striping in the NEV Transportation Plan are new and are not faded. Some of the sentiment expressed by survey respondents may be a reflection of bicycle lane striping in other parts of the city which may be fading.

Others commented that the wider lanes present a potential safety hazard by traditional vehicles that misinterpret the NEV/bike lane as a smaller automobile lane. One respondent stated, “I think it is difficult for drivers who visit our city to understand that the bicycle-NEV lane is not to be entered by other motor vehicles. It is close to the same size as a regular lane and is used by some drivers to pass on the right.” Another stated, “The new NEV/Bike lane is 7 feet wide. The standard automobile lane is 12 feet wide. A 7-foot wide lane tends to look like another car lane to some drivers. This is dangerous and a potential liability to the City of Lincoln.” These concerns can be mitigated with proper signage and public education efforts aimed at general motorists.

From Table 9, we can see that bicyclists generally perceive traditional roads without bicycle lanes as being somewhat unsafe, while they perceive traditional roads with shared bicycle/NEV lanes as being neither safe nor unsafe. While shared bicycle/NEV lanes appear to help separate conflicts with motor vehicles, they seem to introduce new potential conflicts with bicyclists who travel at similar speeds. The primary issue in these instances seems to relate to conflicts when a passing event occurs, which may be because the speeds of these two modes are close and it may be more difficult to pass.

Table 9. Perceived Safety of NEV Facilities by Bicyclists

	Traditional roads without bicycle lanes or paths	Traditional roads with shared bicycle/NEV lanes	Traditional roads with bicycle-only lanes	On separated bicycle-only paths
Very Safe (5)	2 (5.26%)	2 (5.26%)	10 (26.32%)	28 (73.68%)
Somewhat Safe (4)	7 (18.42%)	16 (42.11%)	22 (57.89%)	7 (18.42%)
Neither Safe nor Unsafe (3)	7 (18.42%)	5 (13.16%)	3 (7.89%)	0 (0%)
Somewhat Unsafe (2)	11 (28.95%)	7 (18.42%)	2 (5.26%)	2 (5.26%)
Very Unsafe (1)	10 (26.32%)	6 (15.79%)	0 (0%)	0 (0%)
No Basis to Judge	1 (2.63%)	2 (5.26%)	1 (2.63%)	1 (2.63%)
Mean	2.46	3.03	4.08	4.65

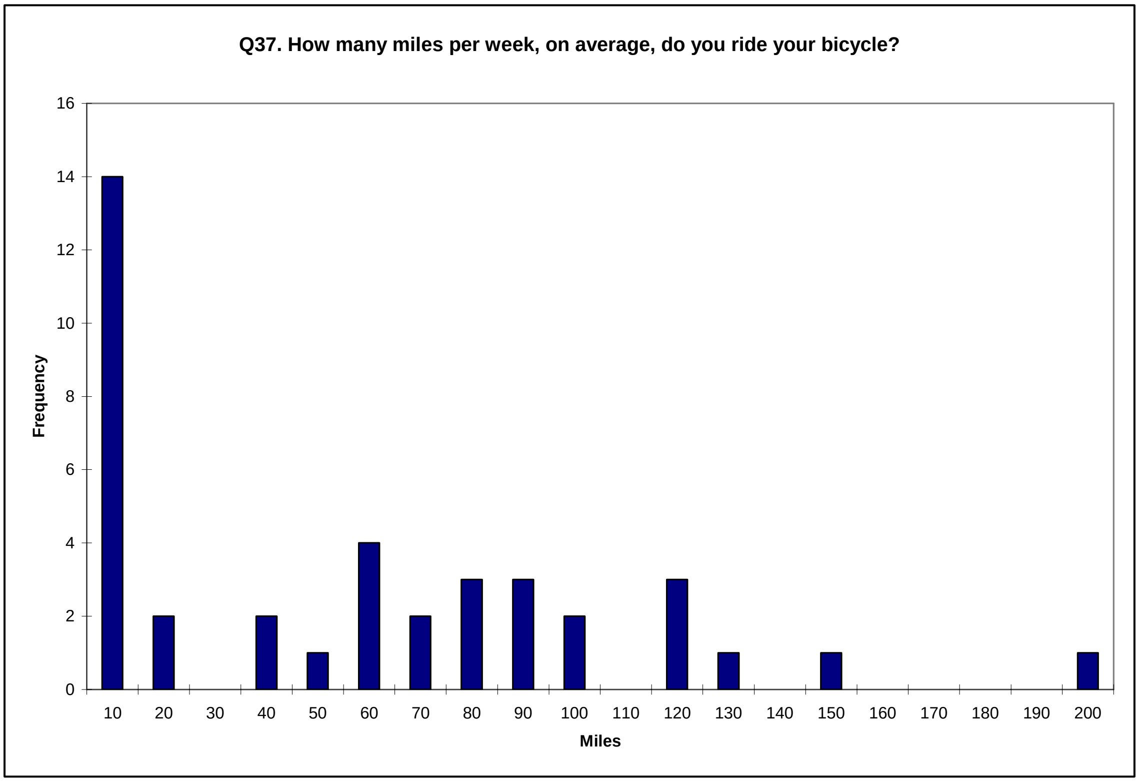

Figure 11. Bicycling Respondents Average Weekly Mileage

Figure 11 indicates that the survey participants who bicycle may not be a typical bicyclist. These findings may be expected as a result of encouraging bicyclists in the local bicycle club to participate in the survey during the summer months. The average and median weekly bicycling distance were both found to be a little a 55 miles per week.

Six of the 38 respondents (16%) indicated that they had been involved in "an accident or an incident" with an NEV (Q38). The comments of those six respondents, however, did not seem to involve crashes or collisions but "close calls" due to the interactions between NEVs and bicyclists. All six comments involved common driver courtesy when using a shared space. The bicyclists expressed particular concern about the quiet nature of NEVs which surprise or startle bicyclists especially when an NEV passes a bicyclist. NEVs are quieter than traditional automobiles and bicyclists may not have rear-view mirrors, so a potential conflict can arise when an NEV passes a slower moving bicyclist from the rear. For example, one respondent, "It is difficult to hear an NEV approaching from the rear when you are on a bicycle and I have been startled by them if they come too close to me as they pass." Another respondent indicated, "They have come up behind me fast then cut out into traffic to get past me. They… have often almost clipped me either when cutting out or cutting back in."

There were also two respondents who also expressed issues sharing the right-of-way. One crash, which was not reported to the police, that was identified occurred in a Class II bicycle lane and seemed to involve an NEV failing to provide adequate space for the bicyclist while passing through a work zone. Neither the NEV nor the bicyclist yielded. "The NEV came along side me and pushed me into the cones and maintenance truck. Driver (male) looked back but never stopped. [I] could not get the license plate number." One respondent stated that an "NEV driver indicated displeasure with our group [while] riding in the NEV lane," and another complained about NEVs "not giving me space to ride along side them."

These issues between bicyclists and NEVs also became apparent when bicyclists were asked "Does the presence of an NEV affect your bicycle riding speed?" Most of the 40% of bicycle respondents who claimed that NEVs affect their travel behavior made reference to the quiet operation and speed capabilities of NEVs as well as aggressive or inconsiderate driving behavior by some NEV users.

Based on these findings, it is recommended that public awareness programs continue to educate both bicyclists and NEV users who may be traveling at similar speeds on shared facilities. Some education campaigns have already started to help NEV drivers interact with bicyclists, such as the driving tips provided on LincolnNEV.com website: http://www.lincolnev.com/driving.html. Similar public awareness efforts can emanate from the local bicycle and NEV user clubs.

This issue needs to be addressed because the City plans to encourage NEV users and bicyclists to continue to share right-of-way as all NEV striped lanes will be with sufficient width to allow lane sharing with bicycles. Striping a single, dual-use lane will be less expensive to implement and maintain than multiple- lane striping for each use.

Travel Impacts of NEVs

While not a focus of this study, the potential benefits of travel impacts of NEVs were explored in the survey. According to the survey, almost one quarter (24%) of NEV owners indicated that they had sold or disposed of a traditional automobile after they acquired their NEV. NEV users also reported an average almost 15 one-way trips per week and a little less than 4.5 miles per trip. Based on these figures, the average NEV would travel almost 3,500 miles per year, which is over three times higher than previous estimates (MHM, 2006). The results from the survey also indicate that NEVs generate fewer auto trips, fewer bicycle trips, but the same number of walking and transit trips (Table 10). Clearly, there is a discrepancy here because the same respondents also indicated that they take about the same number of trips overall, shown in the last column of Table 10 below. These findings indicate NEV use has been used to substitute primarily for traditional vehicle travel and some bicycle-related travel, but they do not seem to create an increase in the use of public transit as suggested by the NEV Transportation Plan (MHM, 2006). Clearly, the amount of travel and potential benefits associated with NEV use (and foregone travel by other modes) is an area in need of future research.

Table 10. Travel Behavior and Use of Other Modes Prior to Owning an NEV

Mode	Automobile	Bicycle	Transit	Walking	More Trips
More (1)	71 (91.03%)	8 (10.26%)	1 (1.28%)	6 (7.69%)	5 (6.41%)
Same (0)	3 (3.85%)	17 (21.79%)	9 (11.54%)	43 (55.13%)	50 (64.10%)
Less (-1)	4 (5.13%)	2 (2.56%)	1 (1.28%)	6 (7.69%)	5 (6.41%)
No Basis to Judge	0 (0%)	51 (65.38%)	67 (85.90%)	23 (29.49%)	18 (23.08%)
Mean	0.86	0.22	0	0	0

Community Cohesion

It is hypothesized that NEV travel provides an opportunity to develop a cohesive community because NEVs travel at lower speeds and invite attention from passers-by (Cosgrove, 2007). Because NEVs have a limited travel range (approximately thirty miles on one battery charge.), NEV users will be more likely to shop locally and support local businesses. From the survey, 94% of NEV respondents indicated that they use their NEV to attend or participate in community or social activities, and 81% would still attend or participate in these activities without their NEV. These findings indicate that NEVs do help develop community cohesion as some of the activities are NEV-based, such as the Lincoln Hills Low-Speed Vehicle (LSV) Users Group meetings and activities. Because most respondents indicated that they would participate in many of the same activities that are not NEV-based without an NEV, however, it is unclear if the NEVs provide more cohesion than traditional forms of transportation. This area would also be better understood with more research through a detailed travel study.

FINDINGS AND RECOMMENDATIONS

This evaluation of the Lincoln NEV Transportation Plan indicates that the City of Lincoln is meeting its goals of maintaining safety while increasing mobility to its residents. Based on these findings, the provisions in AB2353 should be continued in the City of Lincoln and the City of Rocklin in the County of Placer, and possibly expanded statewide. This evaluation shows no safety impacts with the implementation of the NEV Transportation Plan. While speeds may decrease slightly, traffic flow does not appear to be impeded. No crashes or incidents involving NEVs have been reported within the City, and survey responses indicate that traditional motorists feel safe around NEVs. Although bicyclists and NEV users have both indicated that they feel safer in their own lanes than in shared lanes, only 16% of all bicyclists surveyed indicated that they had a problem sharing space with NEVs in shared NEV/bicycle lanes. The primary issue in these instances seems to relate to conflicts when a quiet and generally faster NEV tries to pass and overtake a bicycle, which may be because these two modes operate at similar speeds and it may be more difficult to pass.

With regards to traffic flow, the survey indicates that traditional automobile drivers feel that NEVs slightly decrease the travel speed. A speed study on East Lincoln Parkway confirmed this finding, but it should be noted that the reduced speed was still above the posted speed limit. With regard to signage and pavement markings, most NEV users, traditional motorists, and bicyclists confirm that the current signage and striping is easy to read and understand. However, it is clear that work still needs to be done to better educate the general public and all road users about what an "NEV" is.

Based on these findings, it is recommended that the provisions in AB2353 should be continued in the cities of Lincoln and Rocklin. The program can be successfully implemented statewide, but it is recommended that a more comprehensive analysis be conducted when more of the approved NEV Transportation Plan has been implemented. A more comprehensive analysis would help to better evaluate the potential safety concerns that may exist on higher speed facilities. At this time, only a small fraction of the total lane-miles in the NEV Transportation Plan are located on higher-speed facilities, and there have been some safety concerns by NEV users sharing facilities with traditional automobiles and by bicyclists sharing facilities with NEV users.

FUTURE WORK AND REFINEMENTS TO LINCOLN'S NEV TRANSPORTATION PLAN

To better evaluate Lincoln's NEV Transportation Plan and the associated benefits to the City, more comprehensive studies are needed. For the NEV Transportation Plan to continue to be successful, the City of Lincoln will need to continue to work with its residents as well as members of the NEV community to continue to evaluate potential safety and traffic issues related to signage, striping, and pavement marking. The user survey in this report was limited to the front of Safeway Market and resulted in a very limited sampling of users. To obtain a more representative sample of Lincoln residents, additional sampling in the downtown core or at other mixed-use areas of the City should be considered. The traffic engineering studies were limited to one facility on East Lincoln Parkway and resulted in a limited assessment of traffic impacts of NEVs. Additional data collection on other high-speed facilities should be considered where both speed and level of service (LOS) are evaluated.

As a result of this evaluation, the City Lincoln may consider addressing several items related to the implementation of the existing NEV Transportation Plan. These items include, but are not limited to:

- Exploring striping concepts to help facilitate the merging of NEVs across multiple general purpose lanes to make a left-hand turn at an intersections,
- Providing increased enforcement on NEV parking facilities,
- Implementing Class I NEV routes along major arterials and collectors where practical.

Along with continued evaluation of the NEV Transportation Plan, future research needs to address the energy and air quality impacts associated with trips generated by NEVs and substituted for other modes. There is a clear need for detailed travel studies by NEV users, which can help to provide additional insight on some of the following questions:

- What is the modal split of NEVs in the City of Lincoln?
- What are typical NEV trip characteristics, including trip length, frequency, and purpose?
- What household characteristics affect NEV trip generation?
- What factors affect the substitution of traditional automobile trips by NEVs?
- What roadway characteristics affect NEV route choice?

Through continued study and evaluation of these issues, NEVs can continue to add to the mobility of residents in the City of Lincoln and Rocklin and eventually throughout the State of California.

STATEWIDE NEV POLICY IMPLEMENTATION

To encourage statewide implementation of NEVs, the Cities of Lincoln and Rocklin may want to develop a statewide task force to coordinate efforts with other cities that are interested in similar NEV Transportation Plans. It is also recommended that the Cities of Lincoln and Rocklin continue to work with state legislature to coordinate these efforts.

There are several communities that are currently pursuing drafting legislation to allow them to stripe NEV lanes on roadways with speed limits above 35 mph. Orange County was successful in drafting legislation (California Senate Bill 936) and in obtaining approval to begin developing an NEV Transportation Plan, similar to that of Lincoln and Rocklin, shown in Appendix G. Cities in Yolo County such as Davis and Woodland have also expressed interest in developing an NEV Transportation Plan. If a statewide NEV policy is implemented, it could include the standardization of signage, striping, and design specifications, all of which could help Caltrans and federal transportation agencies expedite the approval process while helping to ensure consistency among local jurisdictions throughout the state.

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APPENDIX A. APPROVED SIGNAGE AND PAVEMENT MARKING

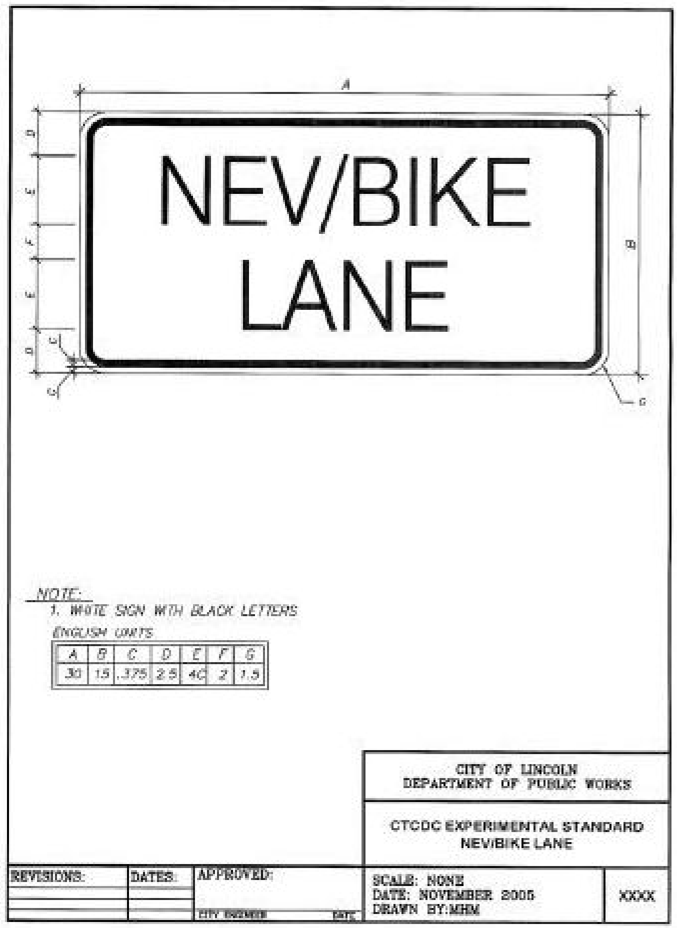


Figure 12. Combination NEV/Bike Lane Sign

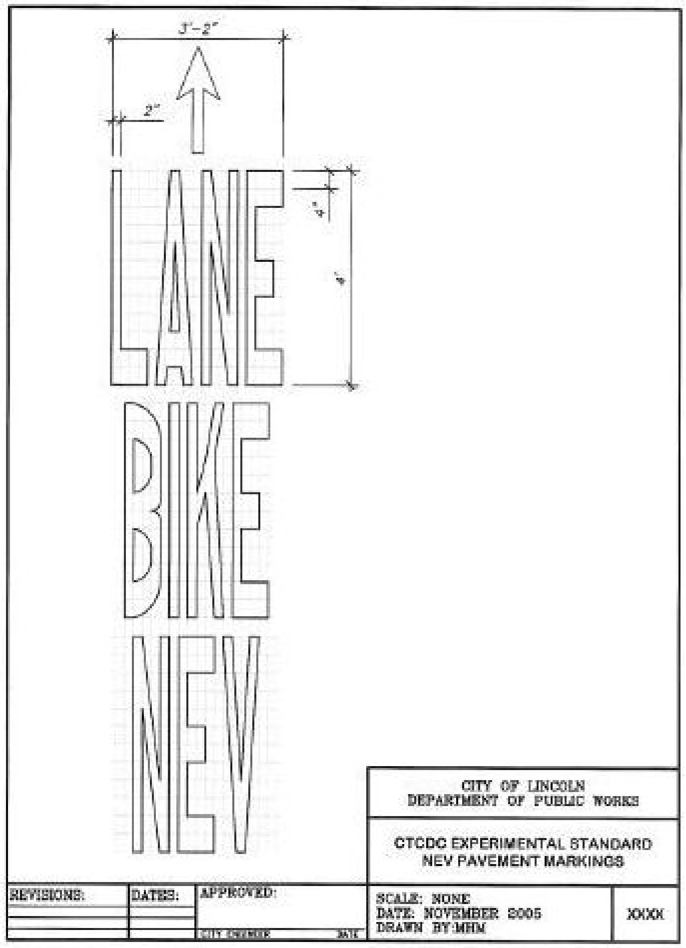


Figure 13. Combined NEV/Bicycle Lane Pavement Marking

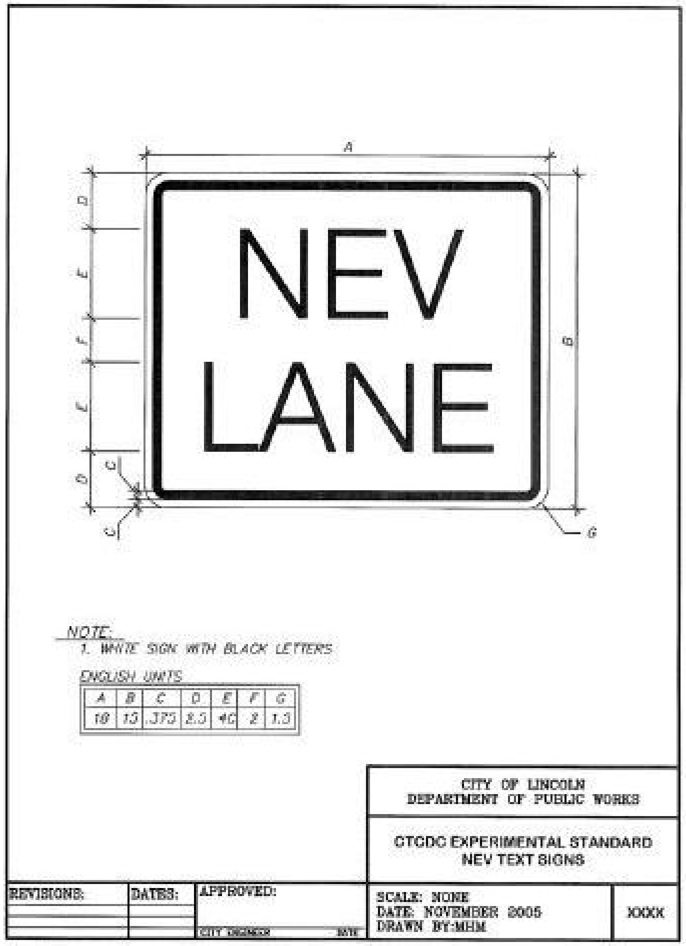


Figure 14. NEV Lane Sign

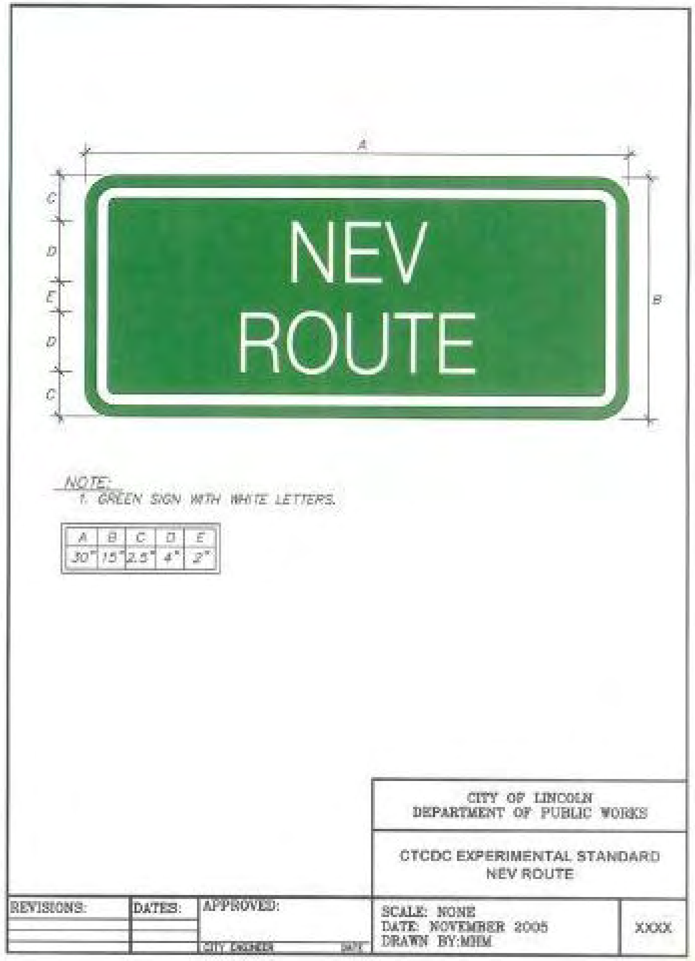


Figure 15. NEV Route Sign

APPENDIX B. STATISTICAL ANALYSIS OF DIFFERENCES IN MEAN SPEEDS

The t-test is used to assess whether the observed difference between the two mean speeds are *statistically* different from each other. The t-test can be used to determine if the difference between the mean (average) speeds is large enough, given the amount of variability or spread among the observed speeds.

The formula for the t-test is a ratio. The numerator of the ratio is just the difference between the two mean speeds, while the denominator is a measure of the variability or dispersion of the speeds. The difference in the average speed between 2005 and 2007 is thought to be attributable to changes along the roadway (i.e., the introduction of NEVs), while the bottom part of the formula is a measure of variability of the speed (s^2), given the number of observations (N).[1] The formula shows the formula for the t-test and how the numerator and denominator are related to the distributions.

$$t_{calc} = \frac{\overline{X}_{2005} - \overline{X}_{2007}}{\sqrt{\frac{s_{2005}^{2}}{N_{2005}} + \frac{s_{2007}^{2}}{N_{2007}}}}$$

The calculated t-statistic is compared with a t-statistic in a table to determine if it is too large to be attributable to the randomness of the observed speeds. Instead, we must infer that the difference is due to the some other source, like the addition of an NEV lane.

Table 11. T-Test for Northbound Traffic

	2005	**2007**
Mean, mph	39	36
Standard Deviation, mph	4.6	4.6
Sample Size, N	162	351
Calculated t- statistic	6.9	

Table 12. T-Test for Southbound Traffic

	2005	**2007**
Mean, mph	40	38
Standard Deviation, mph	4.4	5.2
Sample Size, N	101	258
Calculated t- statistic	3.4	

In both cases, the calculated t-statistics of 6.9 and 3.4, respectively, are greater than the value of 1.96 associated with a 95% confidence level, indicating that the difference in speeds is statistically significant in both directions.

[1] The variability or variance (s^2) is equal to the standard deviation (s) squared.

APPENDIX C. LINCOLN TRANSPORTATION SURVEY

The goal of this survey is to obtain your opinion of the transportation choices, particularly with regard to public opinion about the introduction of neighborhood electric vehicles (NEVs) in the City of Lincoln. Your views, experiences and insights will be greatly appreciated. It is hoped that this survey results could help the City of Lincoln prioritize future transportation planning, so your participation and input will make a difference. This survey is anonymous and your answers will not be associated with your name. If you have any questions, please call (916) 278-5348.

A. NEV USERS

Q1. Do you use a Neighborhood Electronic Vehicle (NEV) as a mode of transportation?
☐ Yes, go to Q2. ☐ No, jump to Q28.

Q2. How many NEVs do you own?
☐ One ☐ Two ☐ Three or more

Q3. How long (in months) have you owned an NEV? (If you own multiple NEVs, please enter the number of months for the NEV you have owned the longest.)
Enter numerical response: __________

Q4. How many individuals does the NEV (which you use most frequently) seat (including the driver)?
☐ One ☐ Two ☐ Three ☐ Four ☐ Five or more

Q5. Have you ever been in an accident or crash with your NEV?
☐ No ☐ Yes
If "Yes," please explain:____.

Q6 through Q8. Please indicate how safe you feel driving your NEV ….

Q6. …On traditional roads with <u>lanes shared</u> by traditional automobiles and NEVs
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q7. …On traditional roads with <u>separate lanes</u> designated for NEVs:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q8. …On <u>paths</u> restricted only to NEVs
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q9. Where do you prefer to drive your NEV?
- ☐ Shared lanes with traditional automobiles
- ☐ Separated NEV lanes
- ☐ NEV-only paths
- ☐ No preference

Q10. Do you drive longer distances to avoid traveling off dedicated NEV facilities?
☐ Yes ☐ No ☐ Not sure

Q11. Do you have problems merging from NEV lanes through into lanes with regular vehicles and mixed traffic?
☐ Yes ☐ No

Q12. Do you have problems crossing mixed traffic to make left turns?
☐ Yes ☐ No

Q13. Are the current NEV signs easy to read and understand?
☐ Yes ☐ No
If "No," please explain:____.

Q14. Are the current NEV pavement markings and striping easy to read and understand?
☐ Yes ☐ No
If "No," please explain:____.

Q15. While in your NEV, how often do you find yourself crossing or using a road designated for NEVs with a speed limit over 35 mph?
☐ Very Often ☐ Occasionally ☐ Rarely ☐ Never ☐ Not Sure

Q16 through 20. Before owning my NEV, I ….

Q16. … Drove a traditional automobile:
☐ More. ☐ With the same frequency as I do now. ☐ Less.

Q17. ... Rode my bicycle:
☐ More. ☐ With the same frequency as I do now. ☐ Less.

Q18. … Used public transportation:
☐ More. ☐ With the same frequency as I do now. ☐ Less.

Q19. … Walked:
☐ More. ☐ With the same frequency as I do now. ☐ Less.

Q20. … Traveled outside of my home
☐ More. ☐ With the same frequency as I do now. ☐ Less.

Q21. Did you sell or get rid of a traditional vehicle after acquiring your NEV?
☐ Yes ☐ No

Q22. How many trips (one-way) do you make in your NEV each week? (For example, if you go to the grocery store and back, you would be making two one-way trips.)

Enter numerical response: ___________

Q23. Approximately, how far (on average) is each of your NEV trips?

☐ Less than one mile ☐ 1 – 2 miles ☐ 3 – 4 miles
☐ 5 – 6 miles ☐ 7 – 8 miles ☐ 9 – 10 miles
☐ 11 miles or more

Q24. Do you use your NEV to attend or participate in community or social activities?

☐ Yes ☐ No

Q25. What types of community or social activities do you use your NEV to attend or participate in?

Enter open-ended response: ___________

Q26. Would you still attend or participate in these activities without your NEV?

☐ Yes ☐ No ☐ Not Applicable

Q27. Would you suggest expanding or reducing the NEV system in the City of Lincoln?

☐ Expanding ☐ Reducing ☐ Neither

B. TRADITIONAL MOTORISTS

Q28. Do you use an automobile as a form of transportation?

☐ Yes, go to Q29. ☐ No, jump to Q36.

Q29. Do you think NEVs affect the travel speed on roads where NEVs and traditional automobiles share lanes?

☐ Yes ☐ No

If "Yes," please explain:____.

Q30. Do you think NEVs affect the travel speed on roads where NEVs and traditional automobiles have separate lanes?

☐ Yes ☐ No

If "Yes," please explain:____.

Q31. While driving your traditional automobile, have you ever been in an accident or incident with a neighborhood electric vehicle (NEV)?

☐ Yes ☐ No

If "Yes," please explain:____.

Q32 though Q34. Please indicate how safe you feel driving your automobile ….

Q32. …On traditional roads:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q33. … On traditional roads with lanes shared by traditional automobiles and NEVs:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q34. … On traditional roads with separate lanes designated for NEVs.
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

C. BICYCLISTS

Q35. Do you use a bicycle as a mode of transportation?
☐ Yes, go to Q36. ☐ No, jump to Q48.

Q36. How many days per week do you typically ride your bicycle?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

Q37. How many miles per week, on average, do you ride your bicycle?
Please enter numeric response: _________

Q38. Have you ever been in an accident or incident with an NEV?
☐ Yes ☐ No
If "Yes," please explain:____.

Q39 through Q43. Please indicate how safe you feel riding your bicycle ….

Q39. … On traditional roads without bicycle lanes or paths:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q40. … On traditional roads with shared bicycle/NEV lanes:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q41. … On traditional roads with bicycle-only lanes:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q42. … On separated bicycle/NEV paths:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q43. … On separated bicycle-only paths:
☐ Very Safe ☐ Somewhat Safe ☐ Neither Safe Nor Unsafe
☐ Somewhat Unsafe ☐ Very Unsafe ☐ No Basis to Judge

Q44. Does the presence of an NEV affect your bicycle riding speed?
☐ Yes ☐ No
If "Yes," please explain:____.

Q45. Are the current bicycle/NEV signs easy to read and understand?
☐ Yes ☐ No ☐ No Basis to Judge
If "No," please explain:____.

Q46. Are the current bicycle/NEV pavement markings and striping easy to read and understand?
☐ Yes ☐ No ☐ No Basis to Judge
If "No," please explain:____.

Q47. Do you use your bicycle to attend community or social activities?
☐ Yes ☐ No

D. GENERAL INFORMATION (ALL RESPONDENTS)

Q48. In what city do you live?
☐ Lincoln ☐ Other: ____________________________

Q49. Gender: ☐ Male ☐ Female

Q50. Marital status: ☐ Married ☐ Single ☐ Other

Q51. Age:
☐ Under 21 ☐ 36-40 ☐ 56-60
☐ 21-25 ☐ 41-45 ☐ 61-65
☐ 26-30 ☐ 46-50 ☐ 66-70
☐ 31-35 ☐ 51-55 ☐ Over 70

Q52. Employment status: ☐ Full-time ☐ Part-time ☐ Retired ☐ Unemployed

Q53. Please indicate your highest level of education:
☐ Some high school ☐ Technical college degree (A.A.)
☐ High school diploma ☐ College degree (Bachelors degree)
☐ Post-graduate degree

Q54. Including yourself, how many people live in your household?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

Q55. How many people living in your household work outside the home?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

Q56. How many children under age 6 live in your household?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

Q57. How many children 6 to 16 live in your household?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

Q58. How many automobiles (not including NEVs or golf carts) are in your household?
☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

Q59. Do you have a disability that prevents you from driving an automobile?
☐ Yes ☐ No

Q60. Do you have a condition (other than a disability) that prevents you from driving an automobile?
☐ Yes ☐ No

Q61. What is your approximate annual household income?

☐ No Income	☐ under $15,000	☐ $15,000 –24,999
☐ $25,000 – 34,999	☐ $35,000 – 44,999	☐ $45,000 –54,999
☐ $55,000 – 64,999	☐ $65,000 – 74,999	☐ $75,000 – 84,999
☐ $85,000 – 99,999	☐ $100,000 – 150,000	☐ over 150,000

Q62. Would you be willing to participate in future transportation studies for the City of Lincoln?
☐ Yes ☐ No

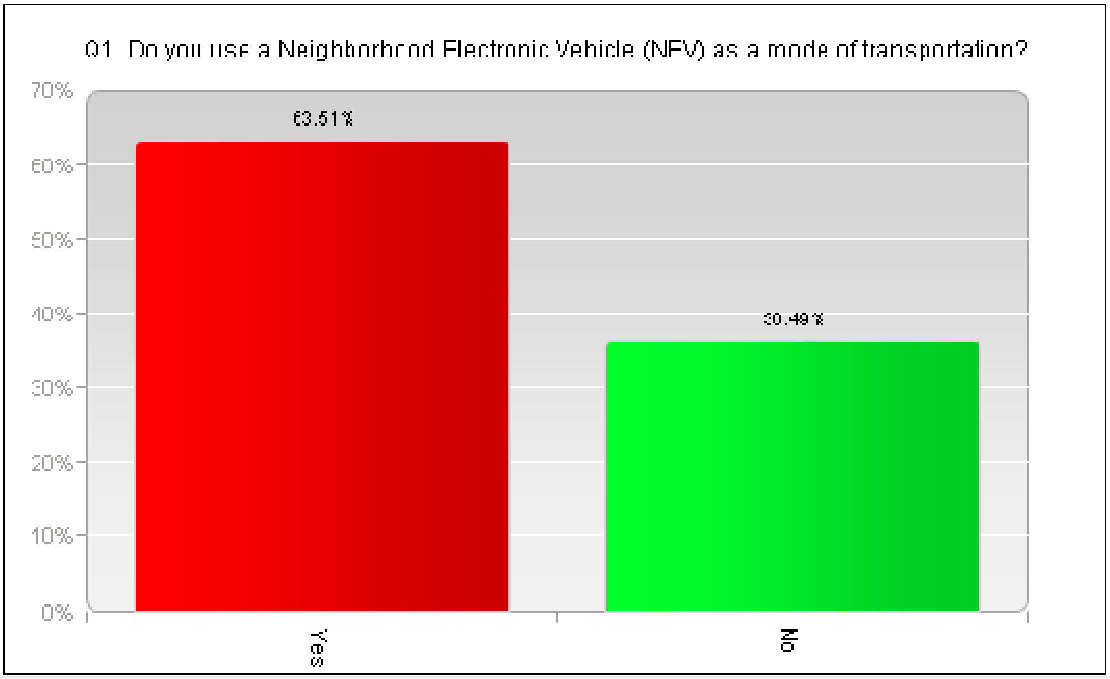
If "Yes," please include your name, and telephone number or e-mail address below so that we may contact you for further information and assistance.

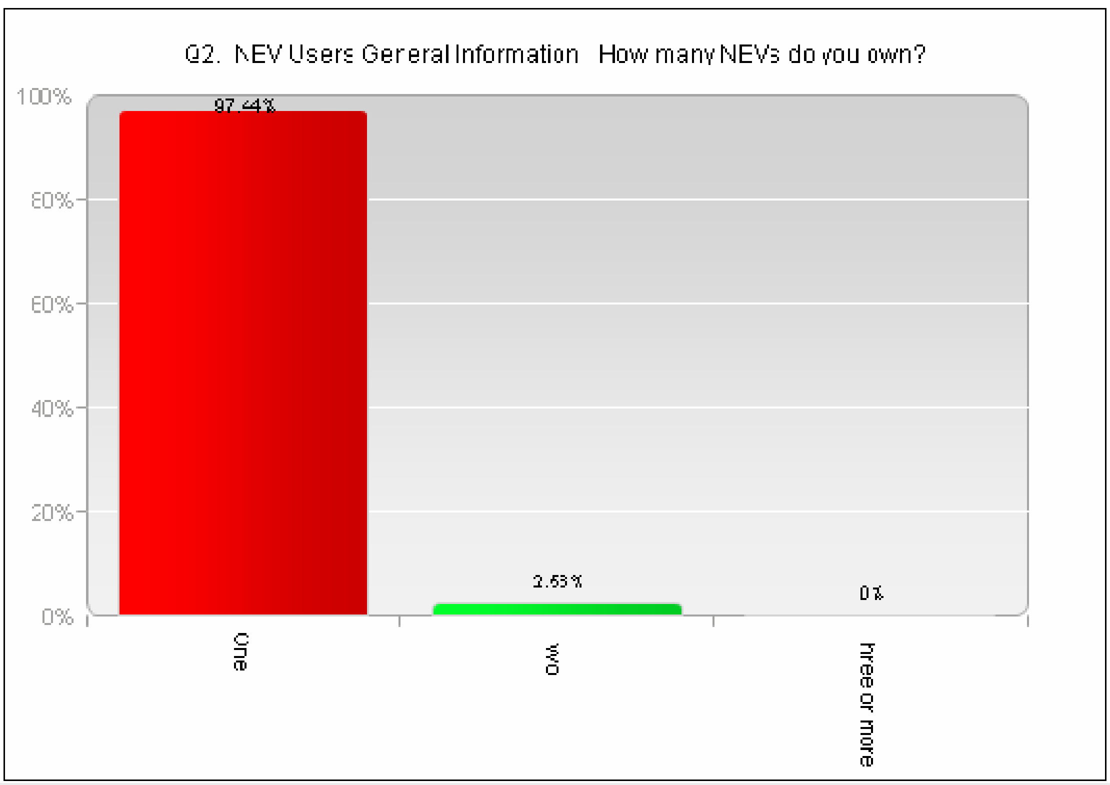
Name: ______________________________

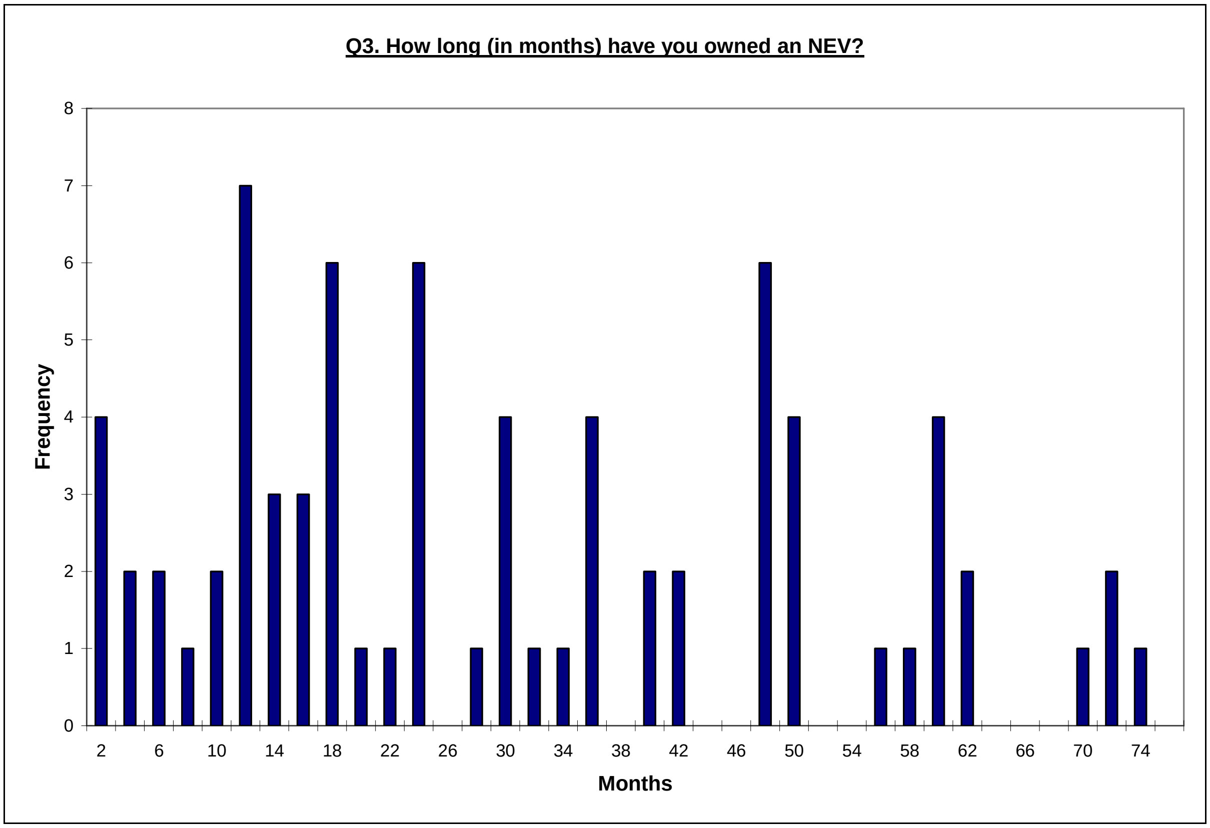
Phone Number: ______________________________ (please include area code)
or
E-Mail Address: _____________________________

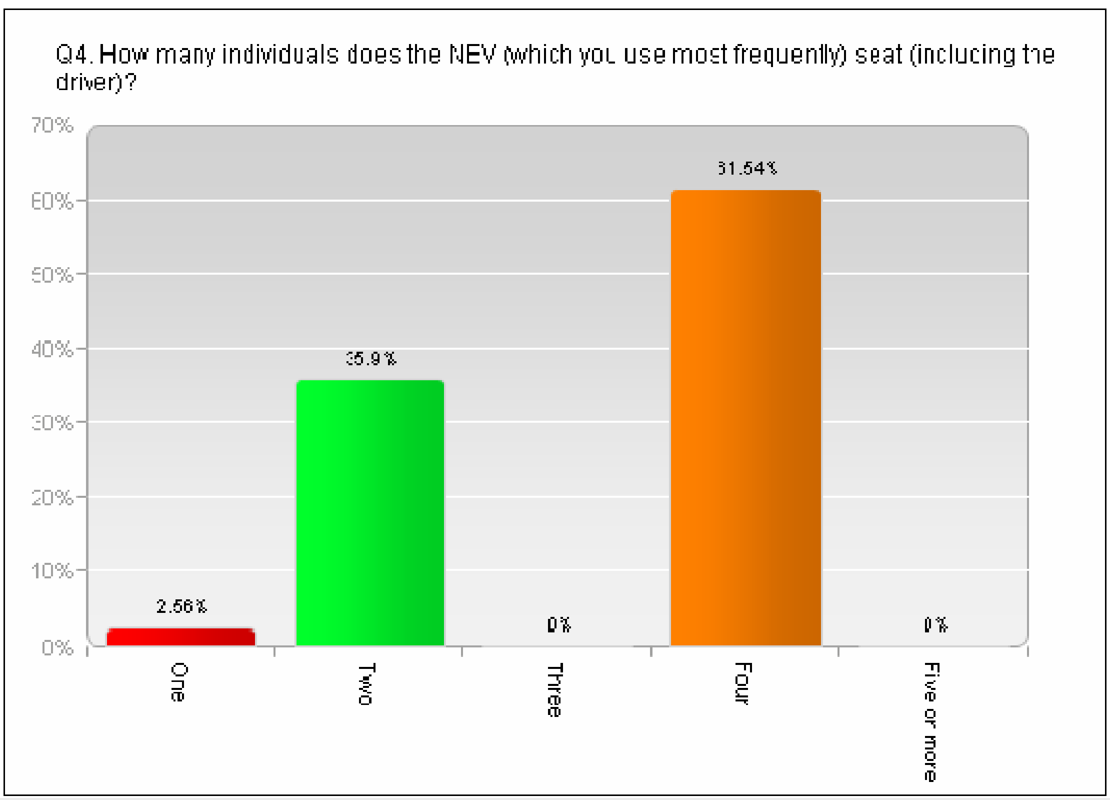
THANK YOU FOR YOUR PARTICIPATION!

APPENDIX D. LINCOLN TRANSPORTATION SURVEY RESULTS



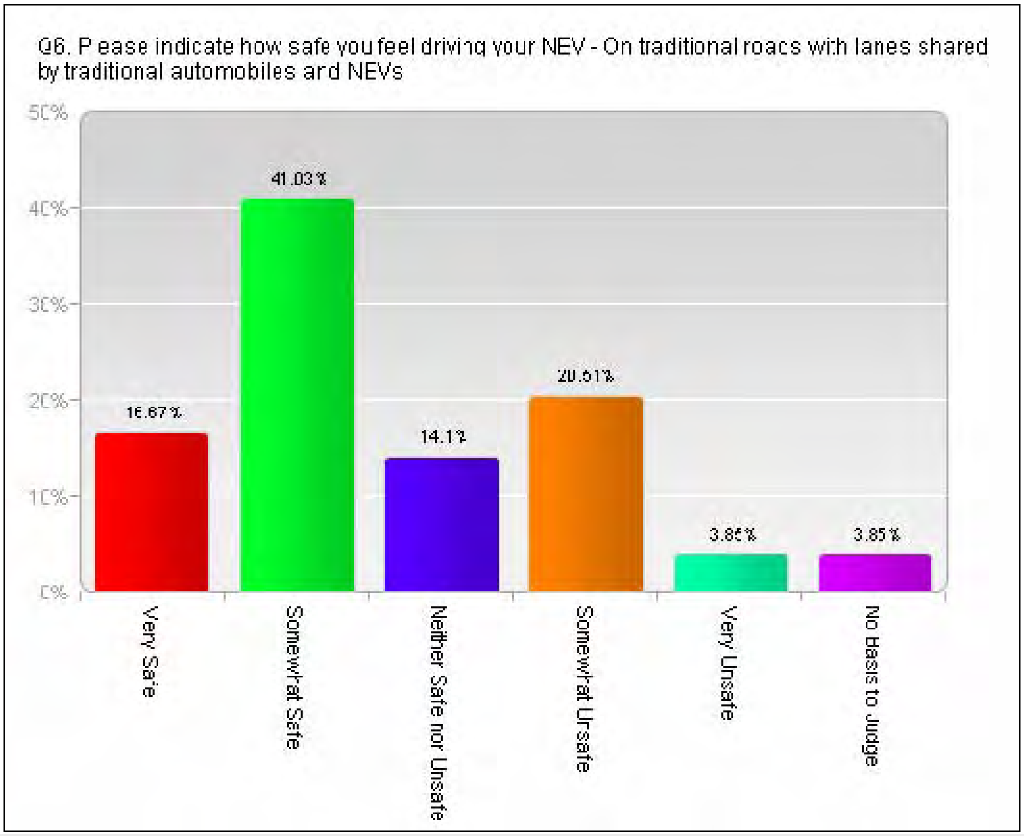


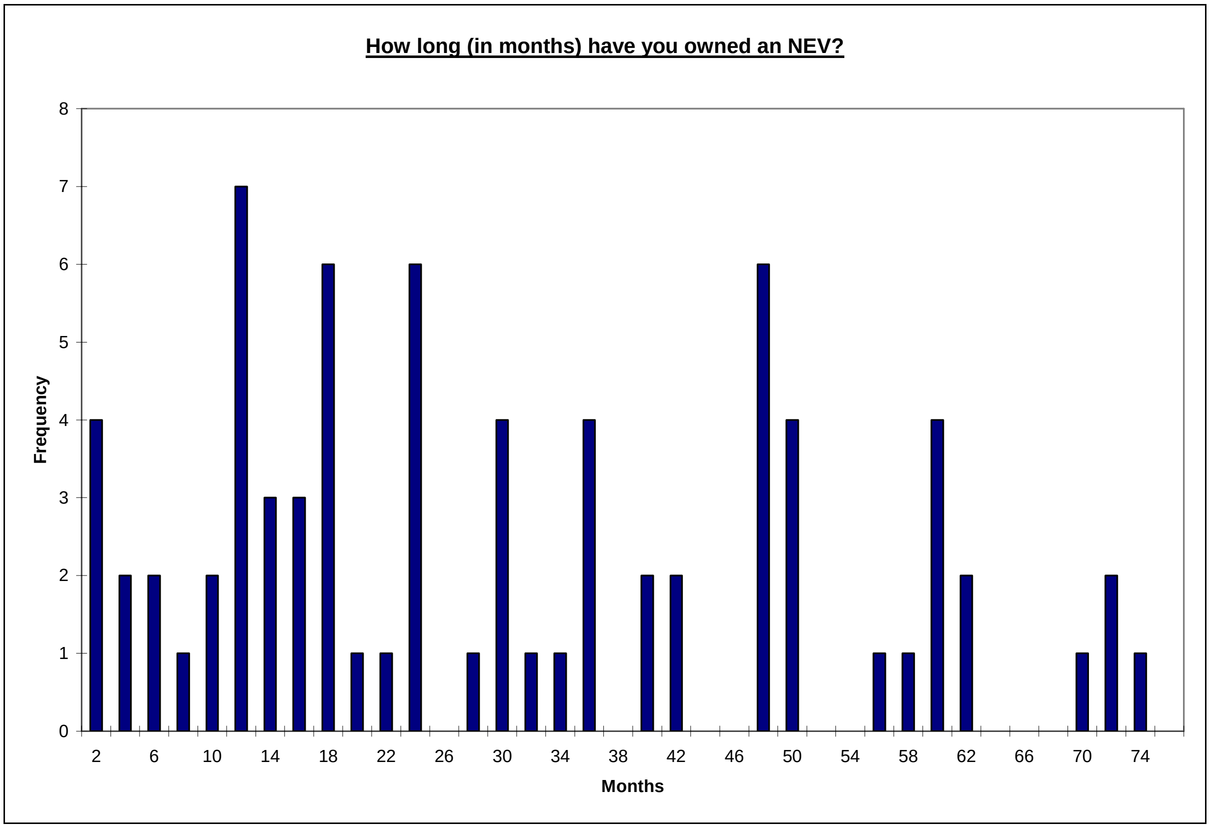

Q3. How long (in months) have you owned an NEV?
Frequency
Months
0
1
2
3
4
5
6
7
8
2
6
10
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74

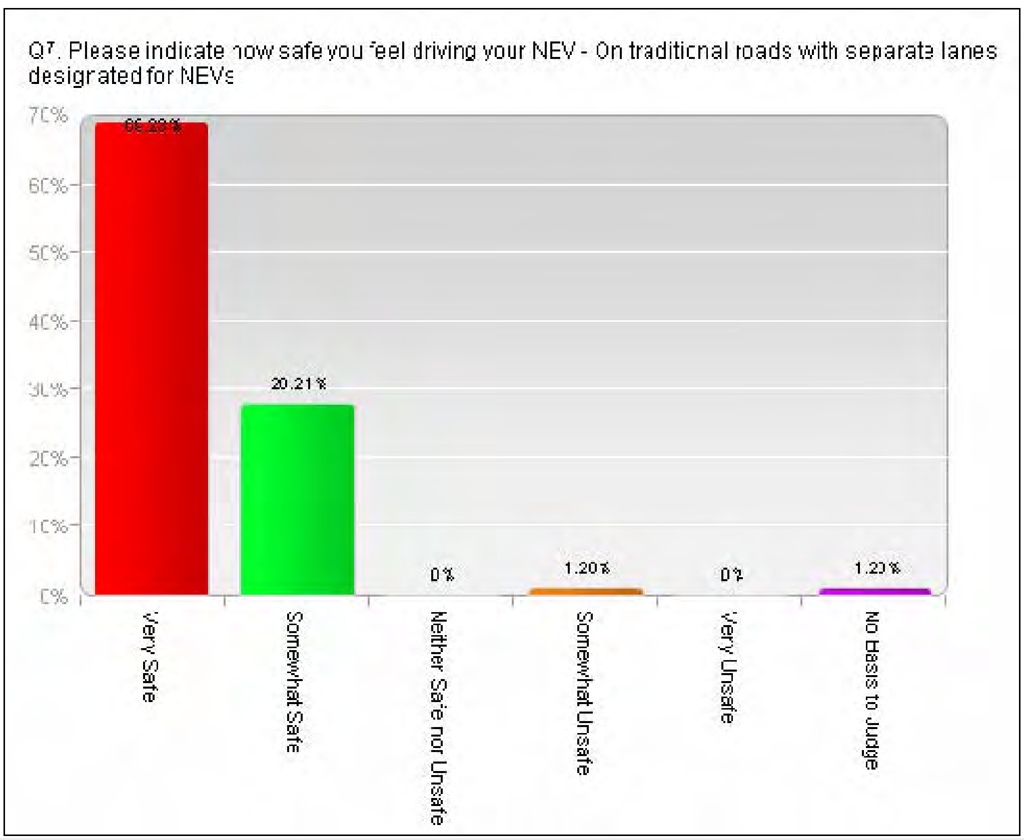

Q4. How many individuals does the NEV (which you use most frequently) seat (including the driver)?
70%
60%
50%
40%
30%
20%
10%
0%
2.56%
35.9%
0%
61.54%
0%
One
Two
Three
Four
Five or more

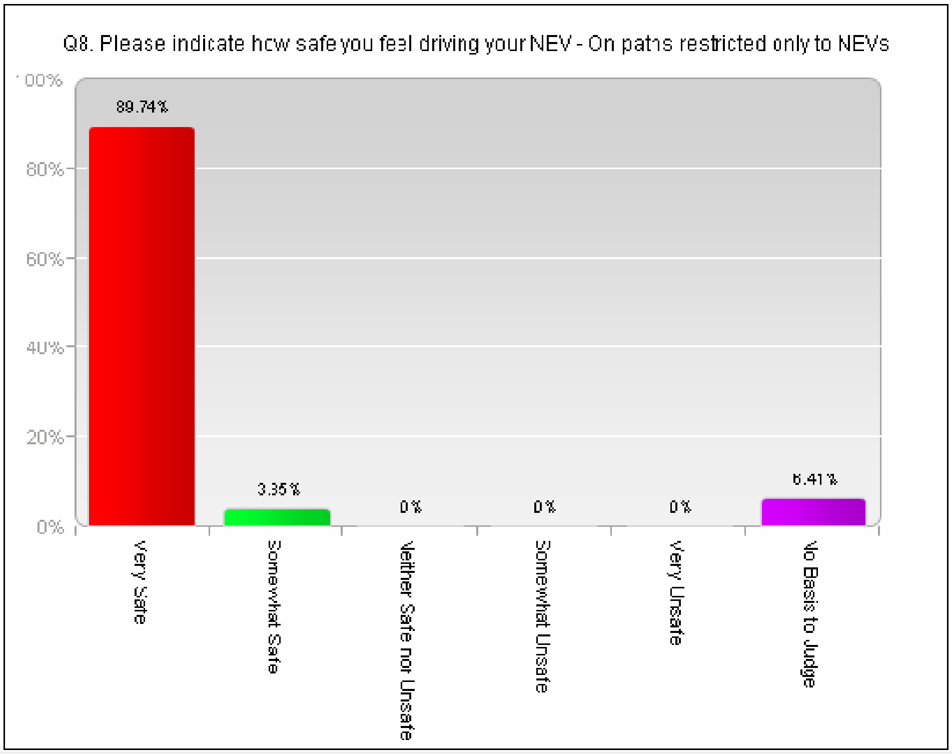
Q5. Safety Have you ever been in an accident or crash with your NEV?		
Count	**Percent**	
1	1.28%	Yes (please describe):
77	98.72%	No
78	Respondents	

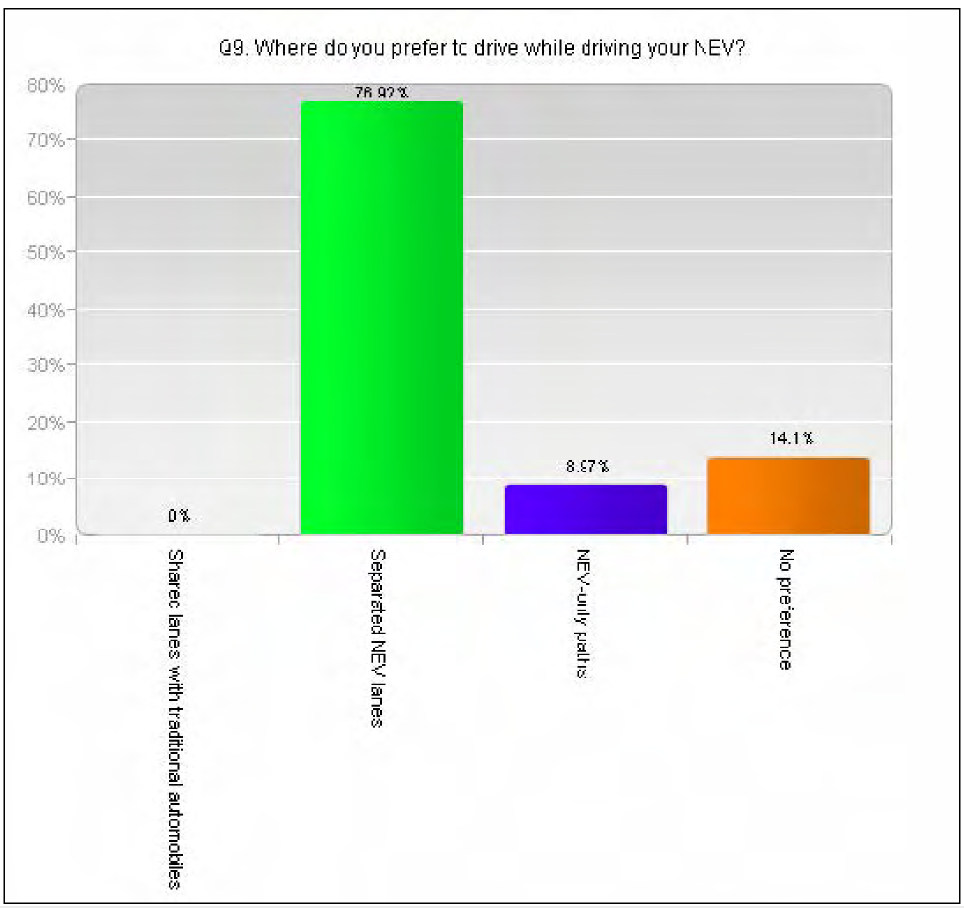
Note: The one "yes" response simply indicated "ran a red light" but the respondent did not elaborate on who was at fault or what the outcome was.

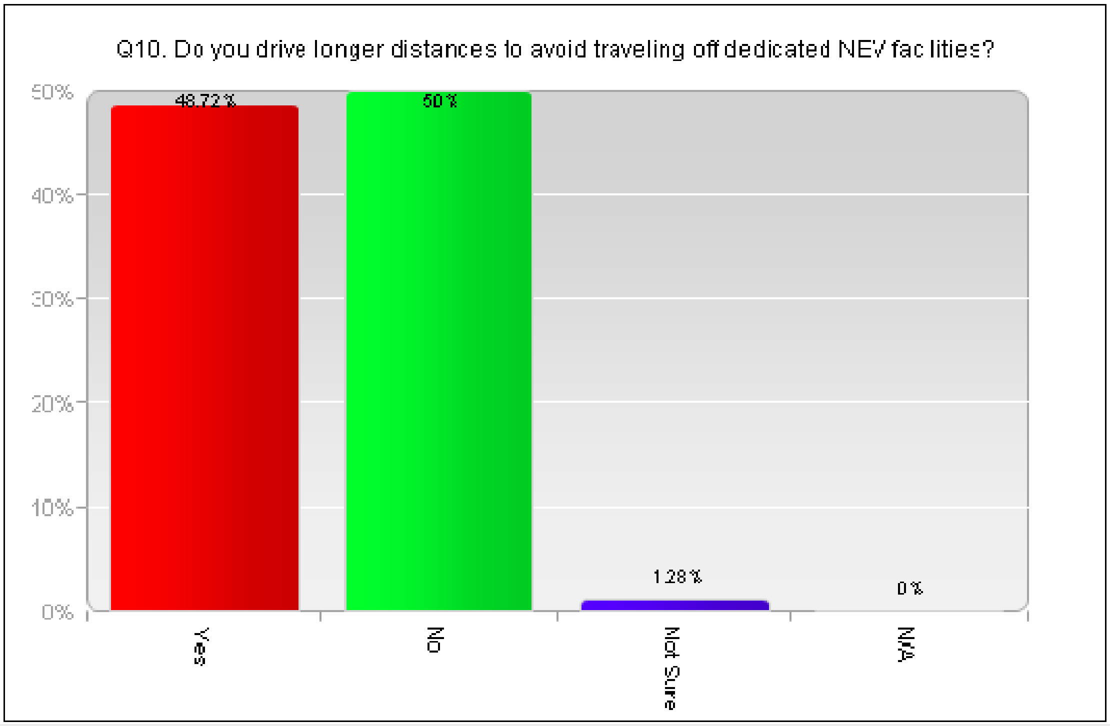


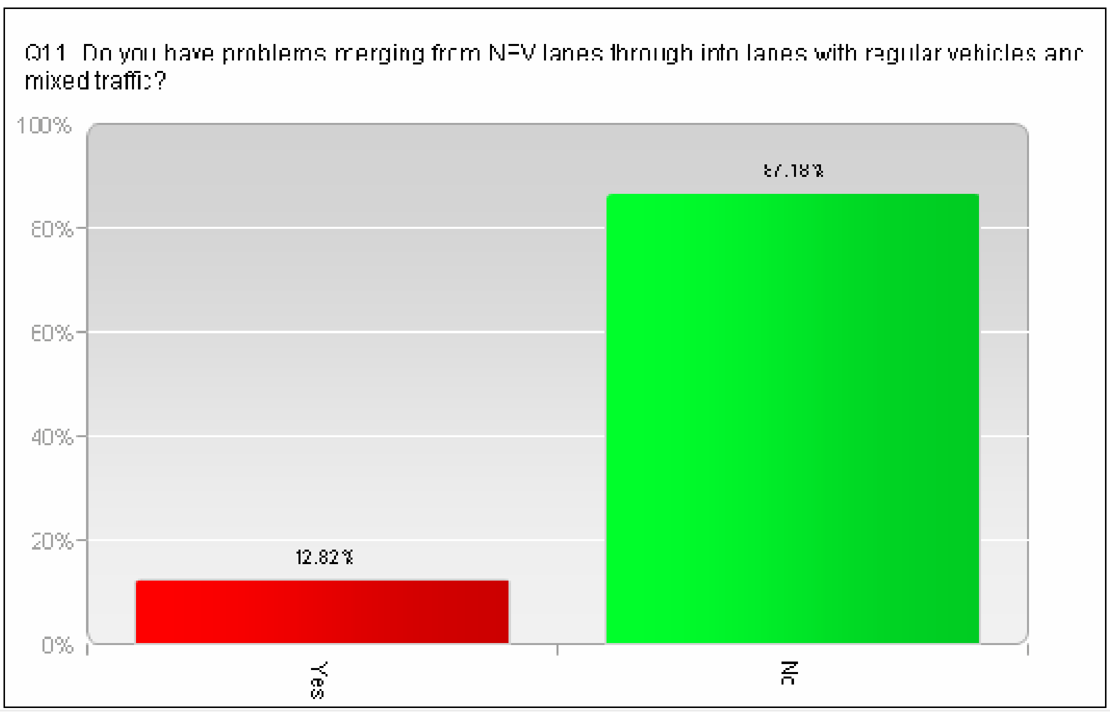

How long (in months) have you owned an NEV?
Frequency
0
1
2
3
4
5
6
7
8
Months
2
6
10
14
18
22
26
30
34
38
42
46
50
54
58
62
66
70
74

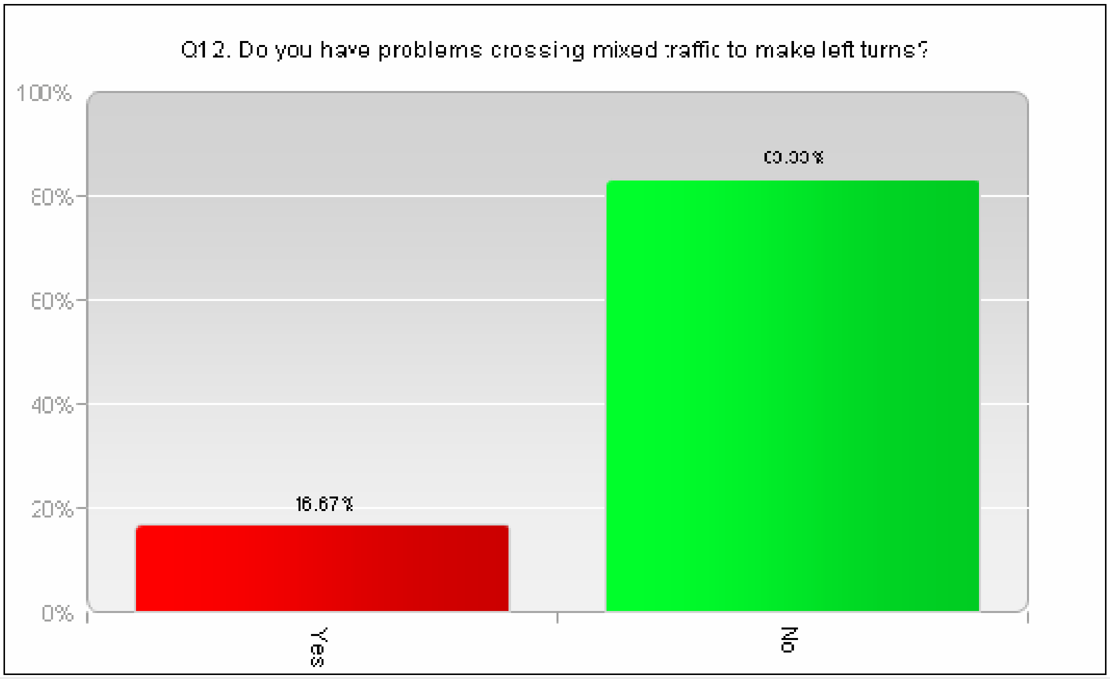

Q7. Please indicate how safe you feel driving your NEV - On traditional roads with separate lanes designated for NEVs
70%
60%
50%
40%
30%
20%
10%
0%
20.21%
0%
1.20%
0%
1.20%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

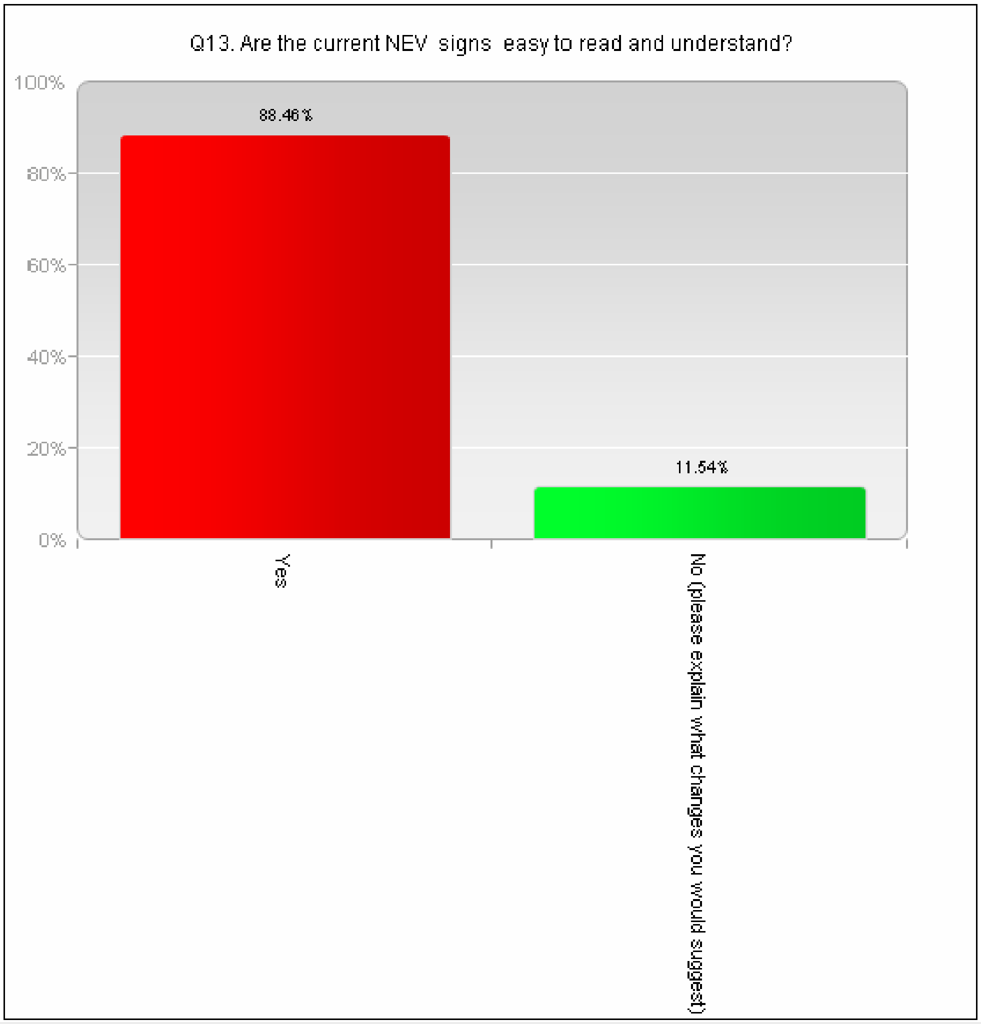

Q8. Please indicate how safe you feel driving your NEV - On paths restricted only to NEVs
100%
80%
60%
40%
20%
0%
89.74%
3.35%
0%
0%
0%
6.41%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

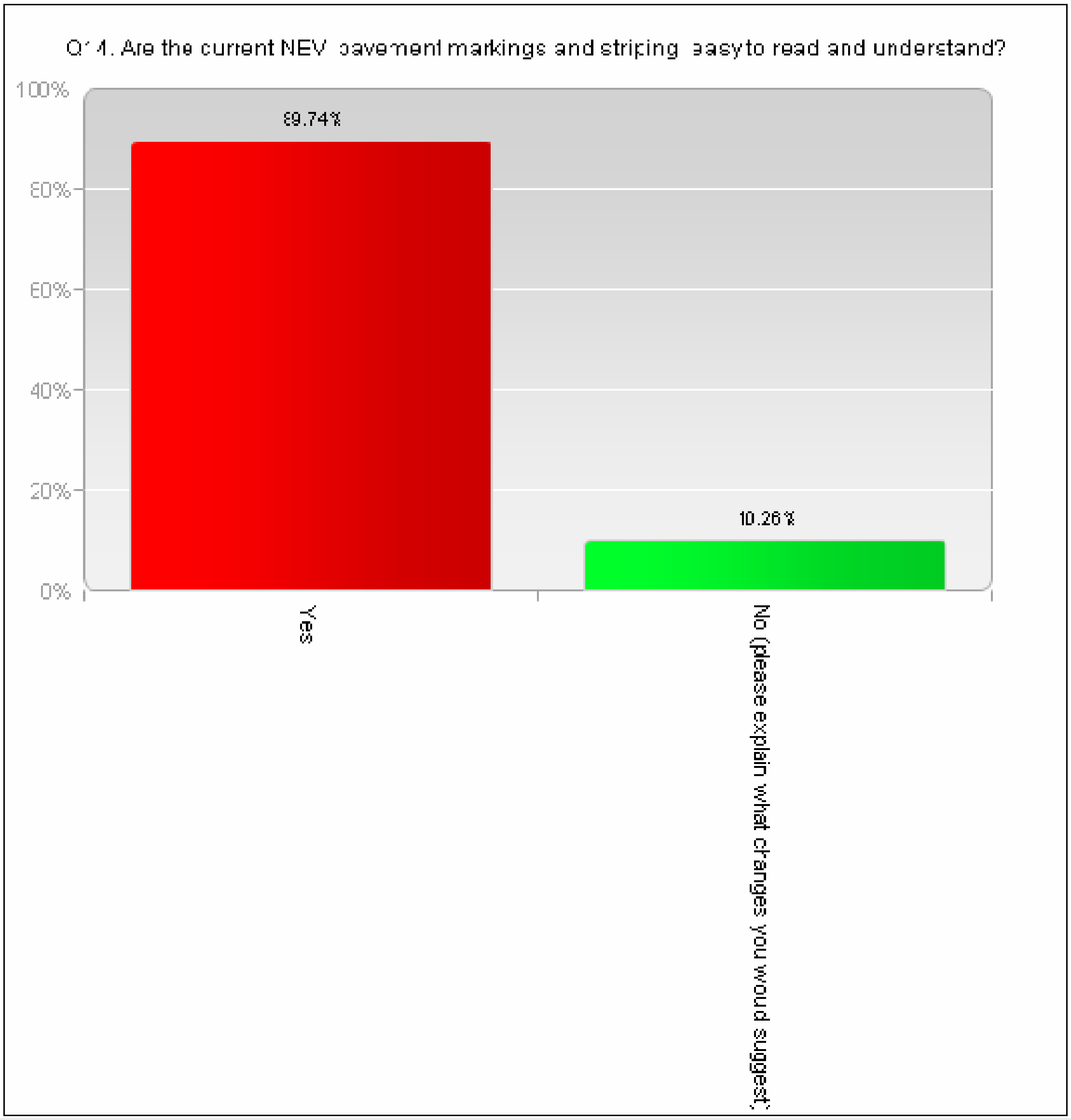

Q9. Where do you prefer to drive while driving your NEV?
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
76.92%
8.97%
14.1%
Shared lanes with traditional automobiles
Separated NEV lanes
NEV-only paths
No preference

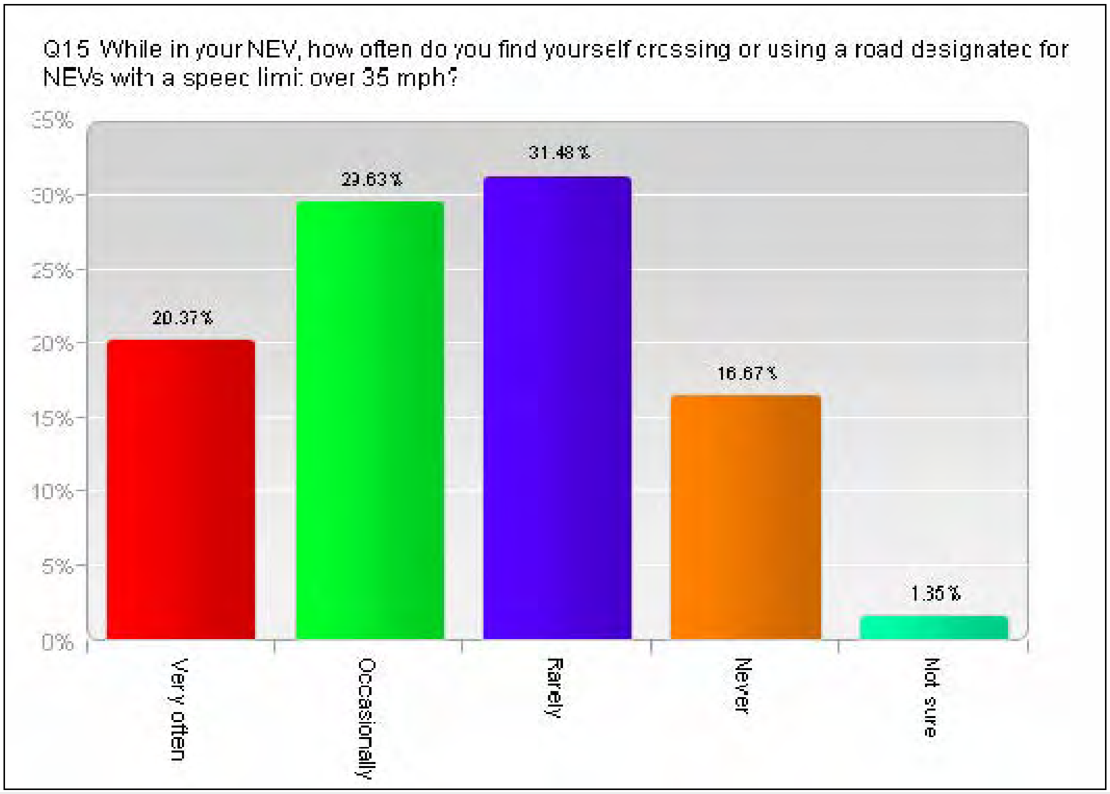

Q10. Do you drive longer distances to avoid traveling off dedicated NEV fac lities?
50%
40%
30%
20%
10%
0%
48.72 %
50 %
1.28 %
0 %
Yes
No
Not Sure
N/A

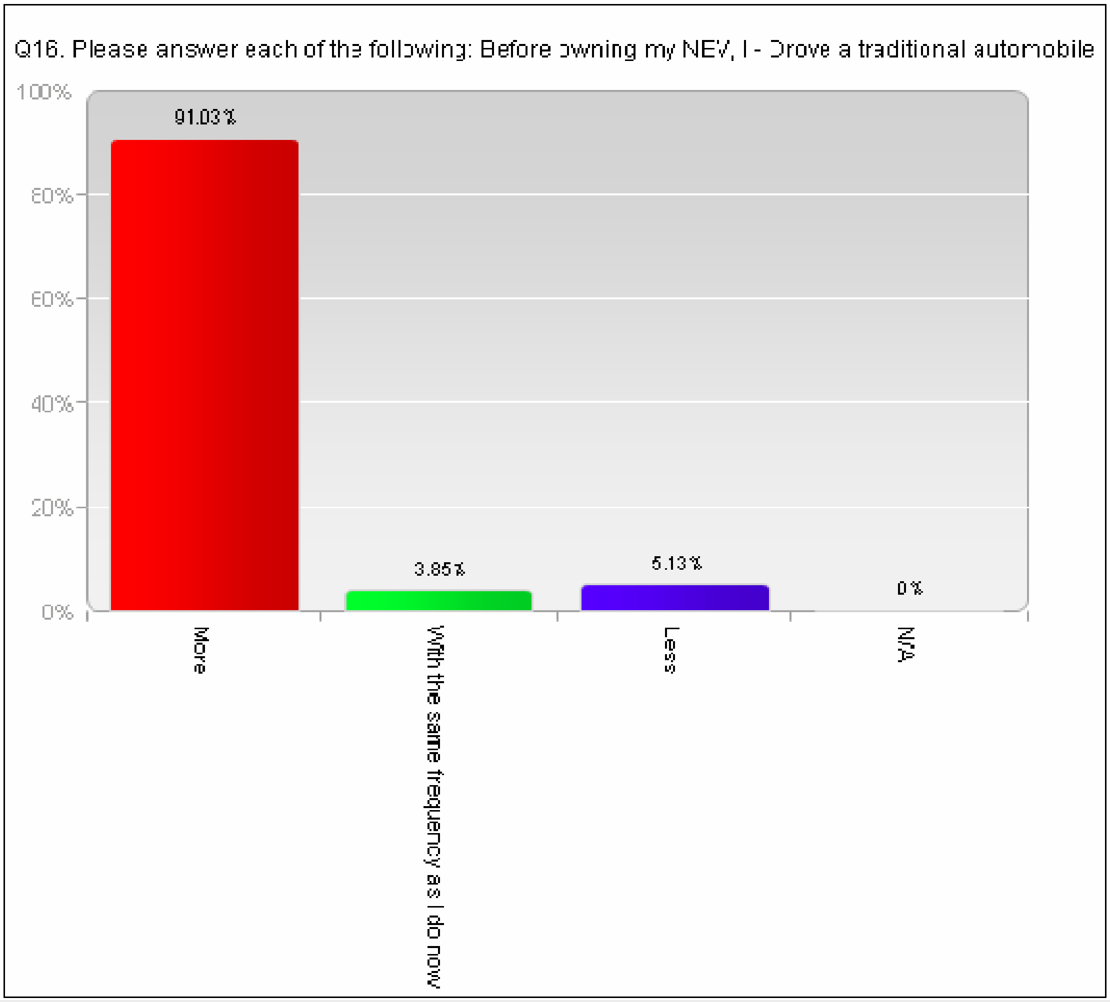

Q11. Do you have problems merging from NEV lanes through into lanes with regular vehicles and mixed traffic?
100%
80%
60%
40%
20%
0%
87.18 %
12.82 %
Yes
No

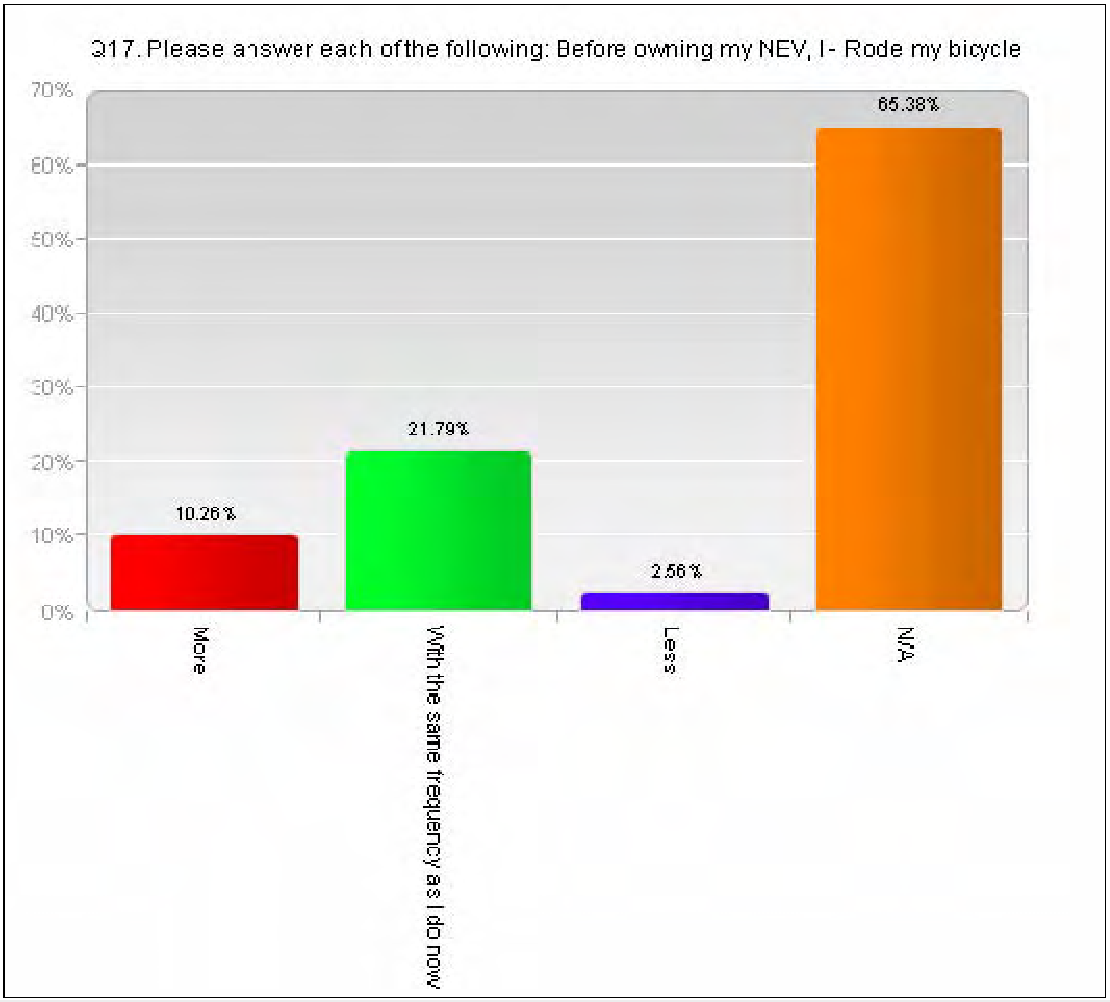

Q12. Do you have problems crossing mixed traffic to make left turns?
100%
80%
60%
40%
20%
0%
16.67%
Yes
No

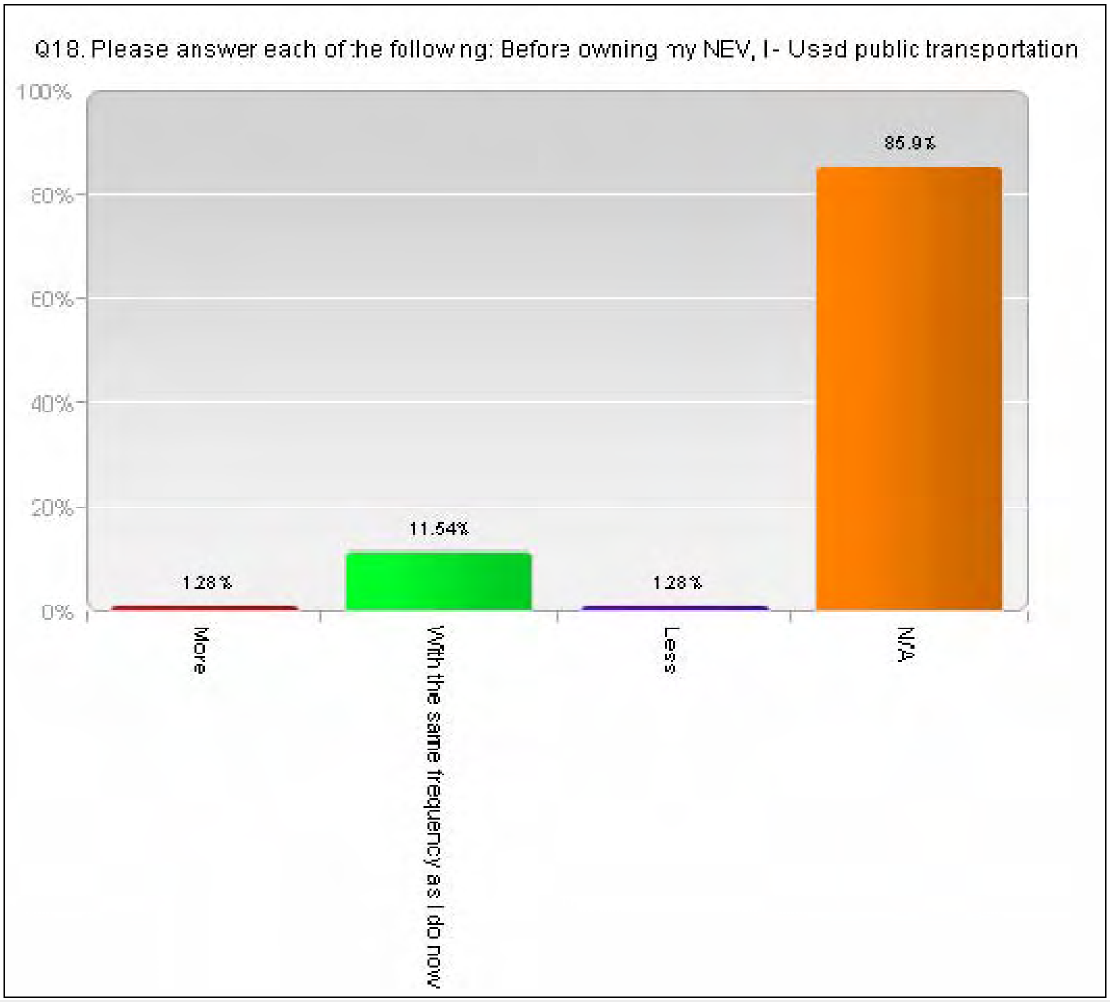

Q13. Are the current NEV signs easy to read and understand?
100%
80%
60%
40%
20%
0%
88.46%
11.54%
Yes
No (please explain what changes you would suggest)

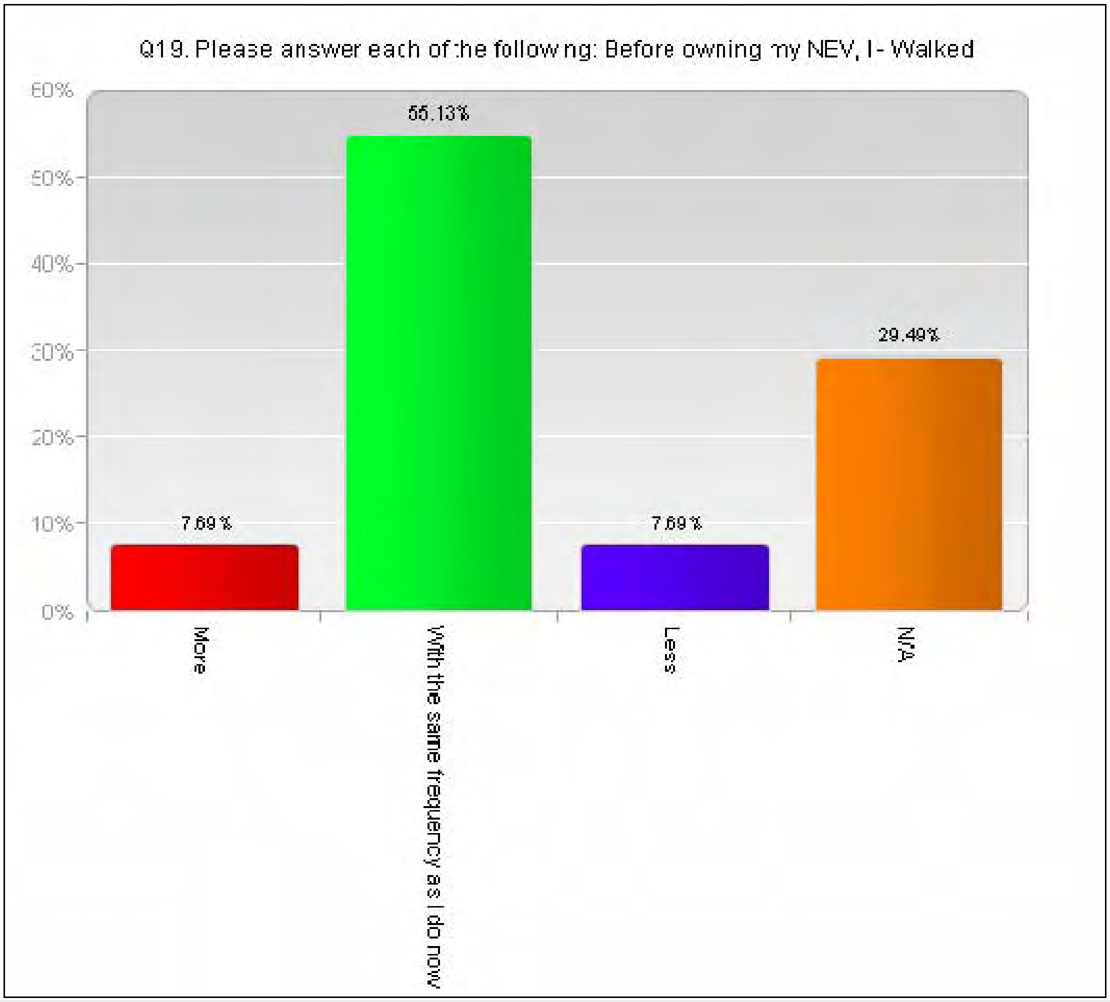

Q14. Are the current NEV pavement markings and striping easy to read and understand?
100%
80%
60%
40%
20%
0%
89.74%
10.26%
Yes
No (please explain what changes you would suggest)

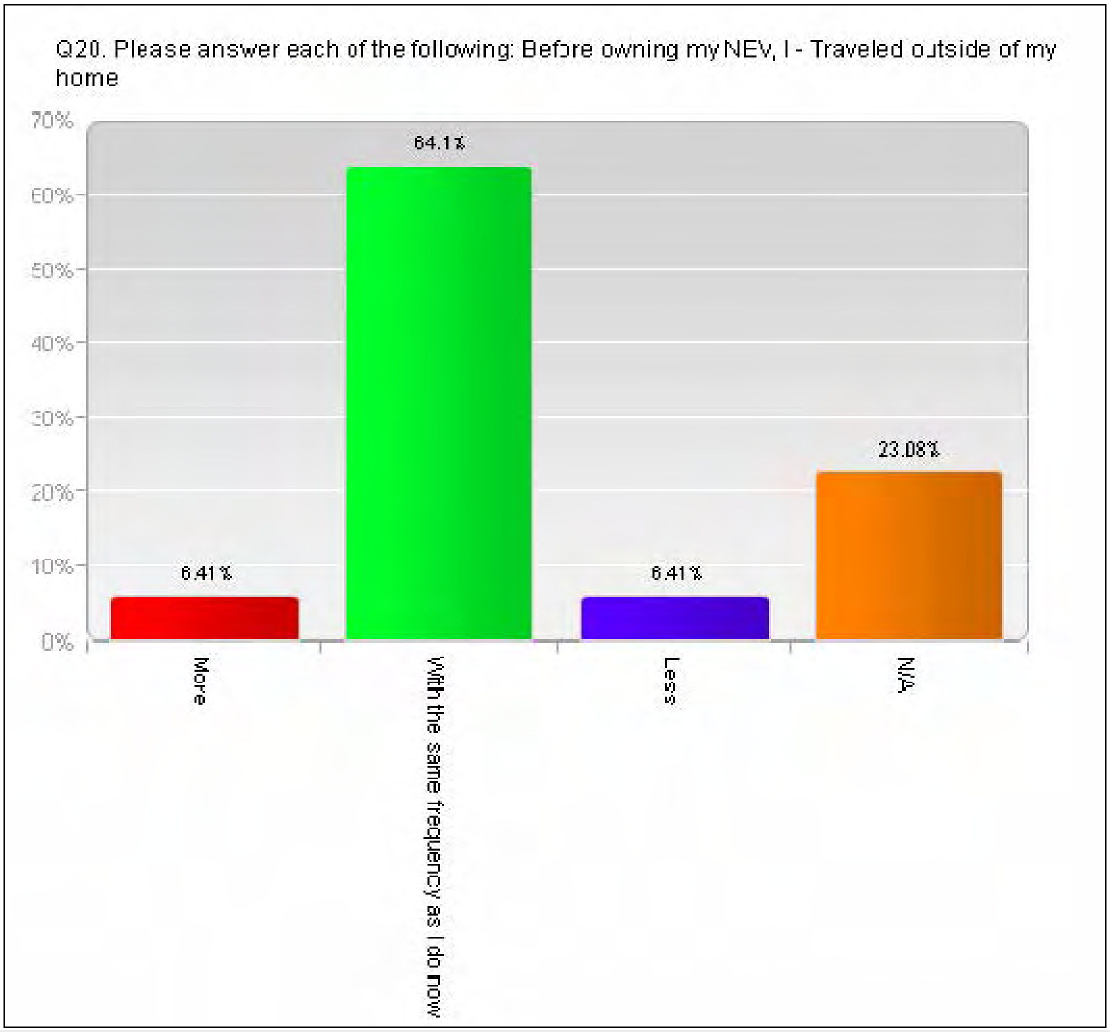

Q15 While in your NEV, how often do you find yourself crossing or using a road designated for NEVs with a speed limit over 35 mph?
35%
30%
25%
20%
15%
10%
5%
0%
20.37%
29.63%
31.48%
16.67%
1.85%
Very often
Occasionally
Rarely
Never
Not sure

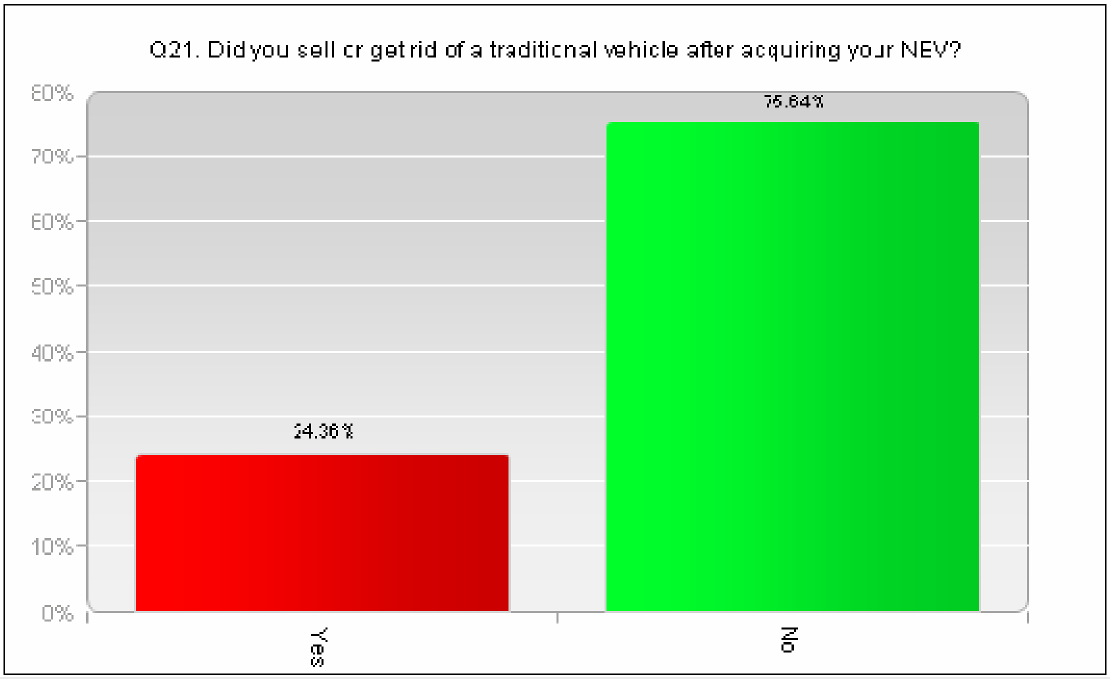

Q16. Please answer each of the following: Before owning my NEV, I - Drove a traditional automobile
100%
80%
60%
40%
20%
0%
91.03 %
3.85 %
5.13 %
0 %
More
With the same frequency as I do now
Less
N/A

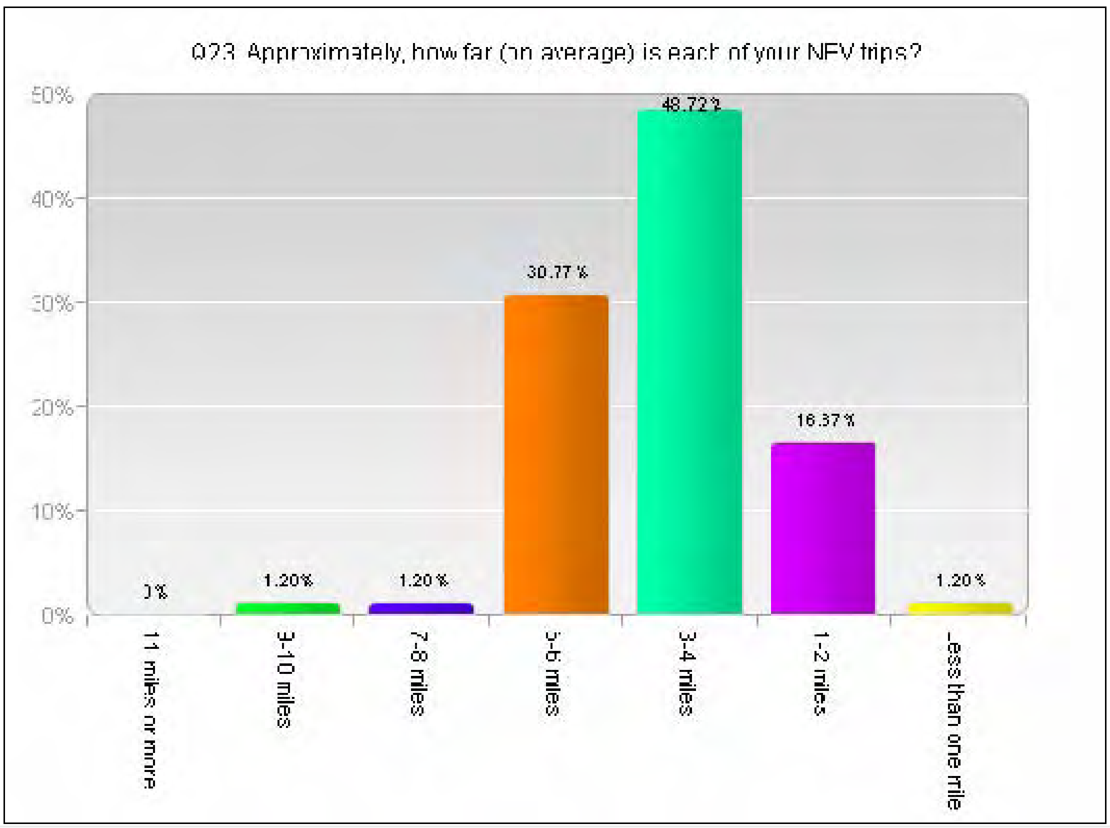

Q17. Please answer each of the following: Before owning my NEV, I- Rode my bicycle
70%
60%
50%
40%
30%
20%
10%
0%
65.38%
21.79%
10.26%
2.56%
More
With the same frequency as I do now
Less
N/A

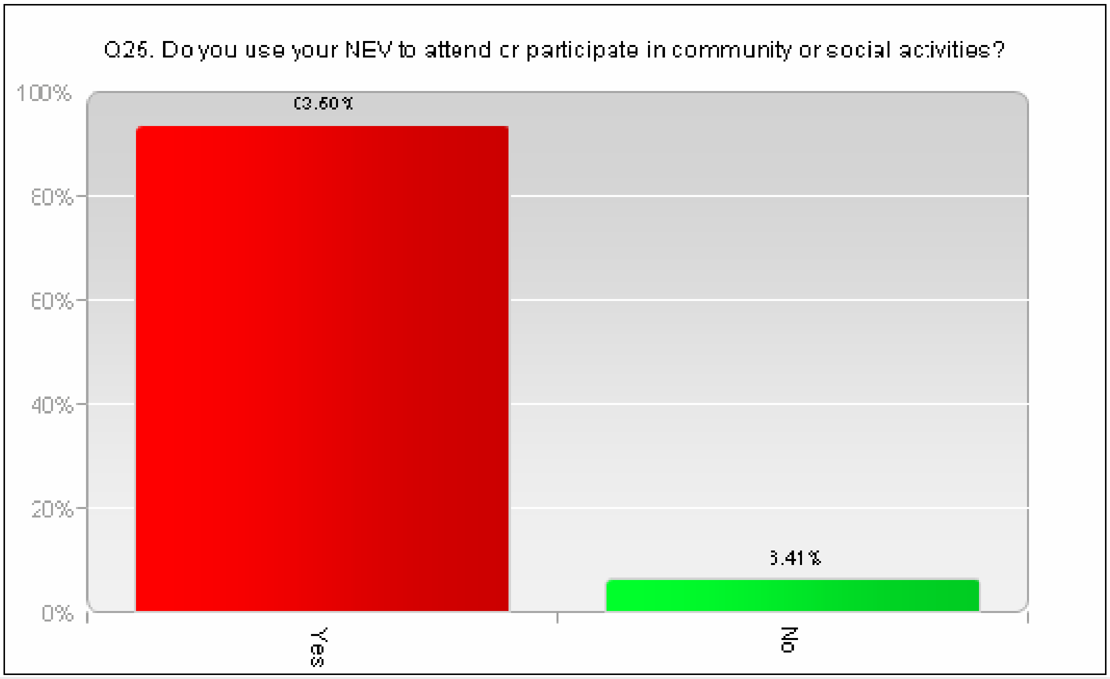

Q18. Please answer each of the following: Before owning my NEV, I - Used public transportation
100%
80%
60%
40%
20%
0%
1.28%
11.54%
1.28%
85.9%
More
With the same frequency as I do now
Less
N/A

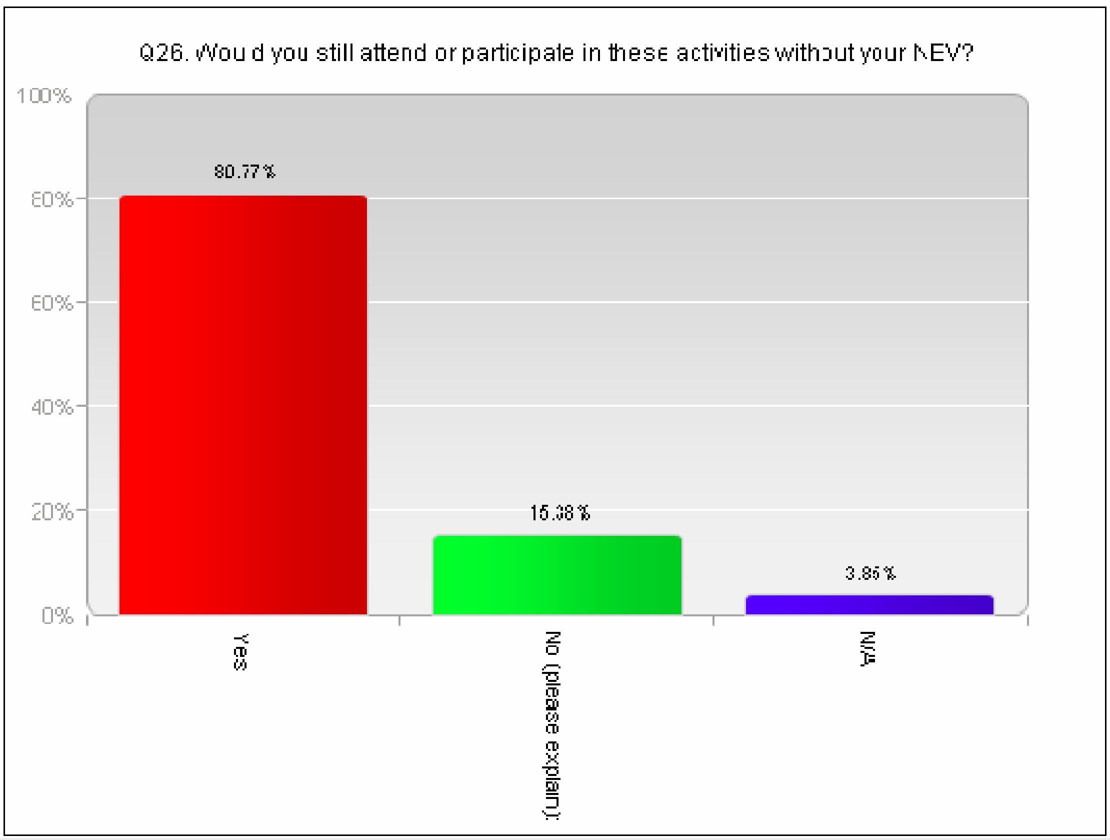

Q19. Please answer each of the following: Before owning my NEV, I - Walked
60%
50%
40%
30%
20%
10%
0%
7.69 %
55.13%
7.69 %
29.49%
More
With the same frequency as I do now
Less
N/A

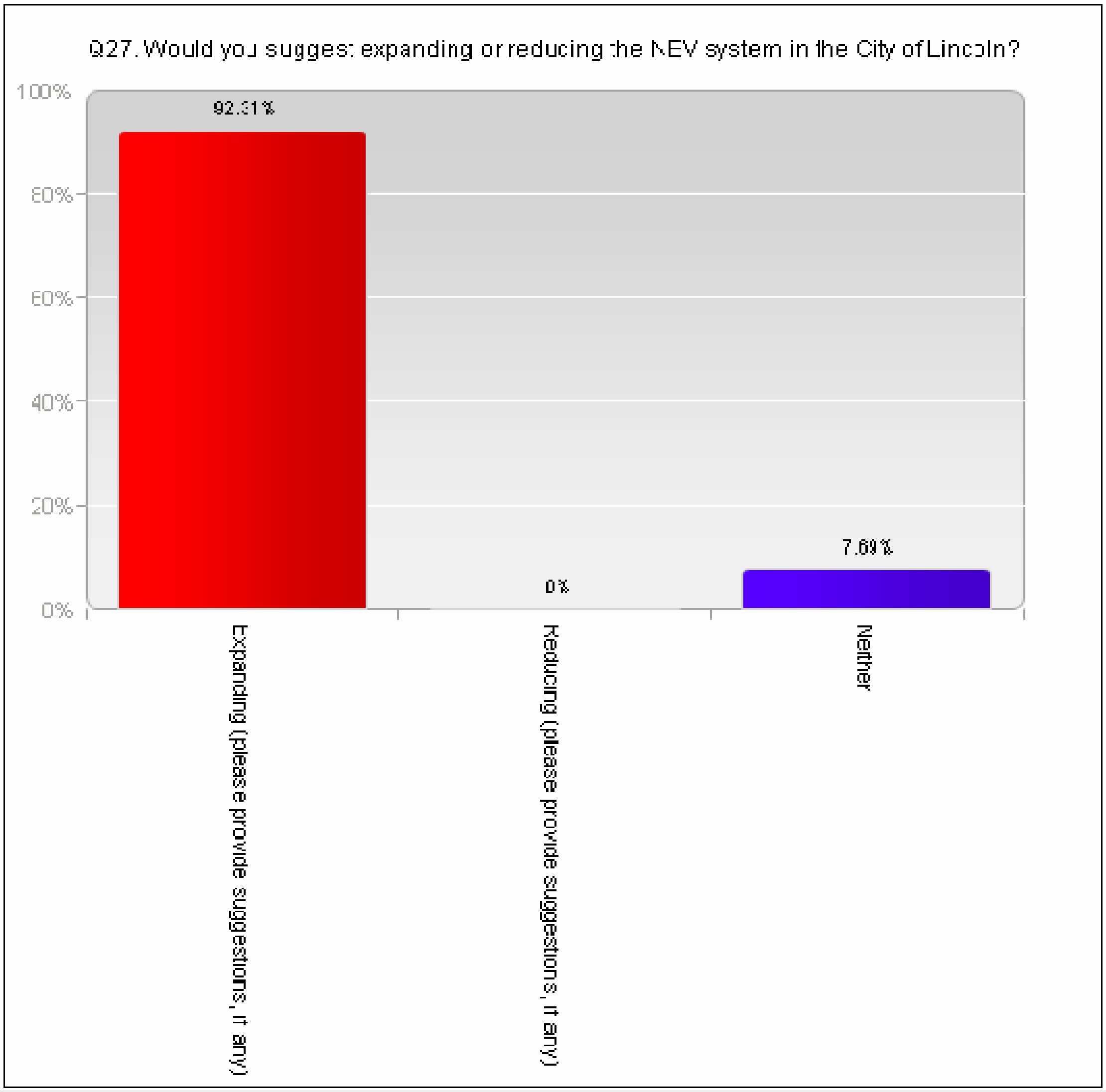

Q20. Please answer each of the following: Before owning my NEV, I - Traveled outside of my home
70%
60%
50%
40%
30%
20%
10%
0%
64.1%
23.08%
6.41%
6.41%
More
With the same frequency as I do now
Less
N/A

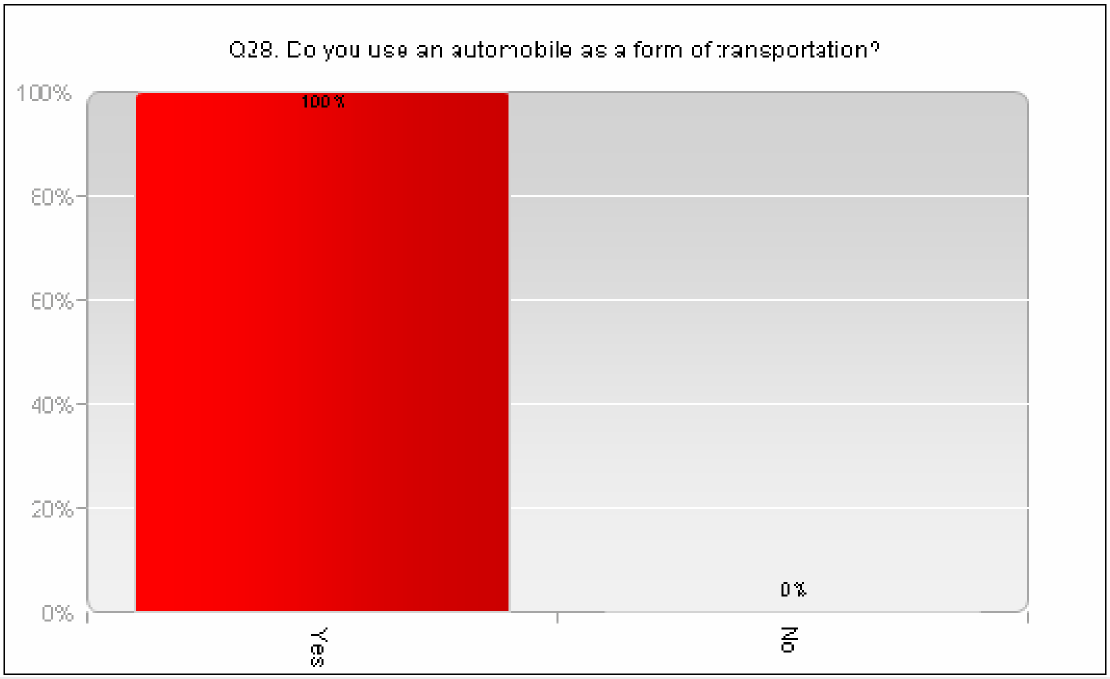

Q21. Did you sell or get rid of a traditional vehicle after acquiring your NEV?
80%
70%
60%
50%
40%
30%
20%
10%
0%
24.36 %
75.64 %
Yes
No

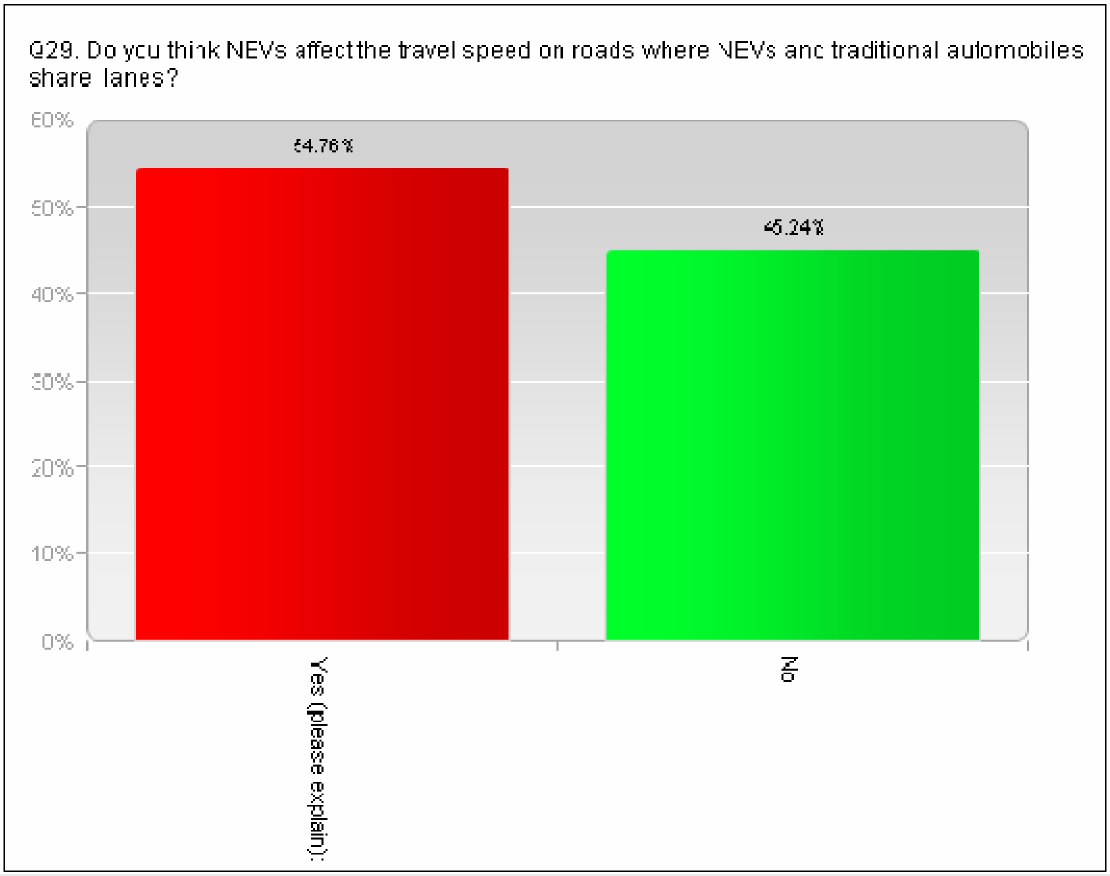

Q23. Approximately, how far (on average) is each of your NEV trips?
50%
40%
30%
20%
10%
0%
0 %
1.20 %
1.20 %
30.77 %
48.72 %
16.37 %
1.20 %
11 miles or more
9-10 miles
7-8 miles
5-6 miles
3-4 miles
1-2 miles
Less than one mile

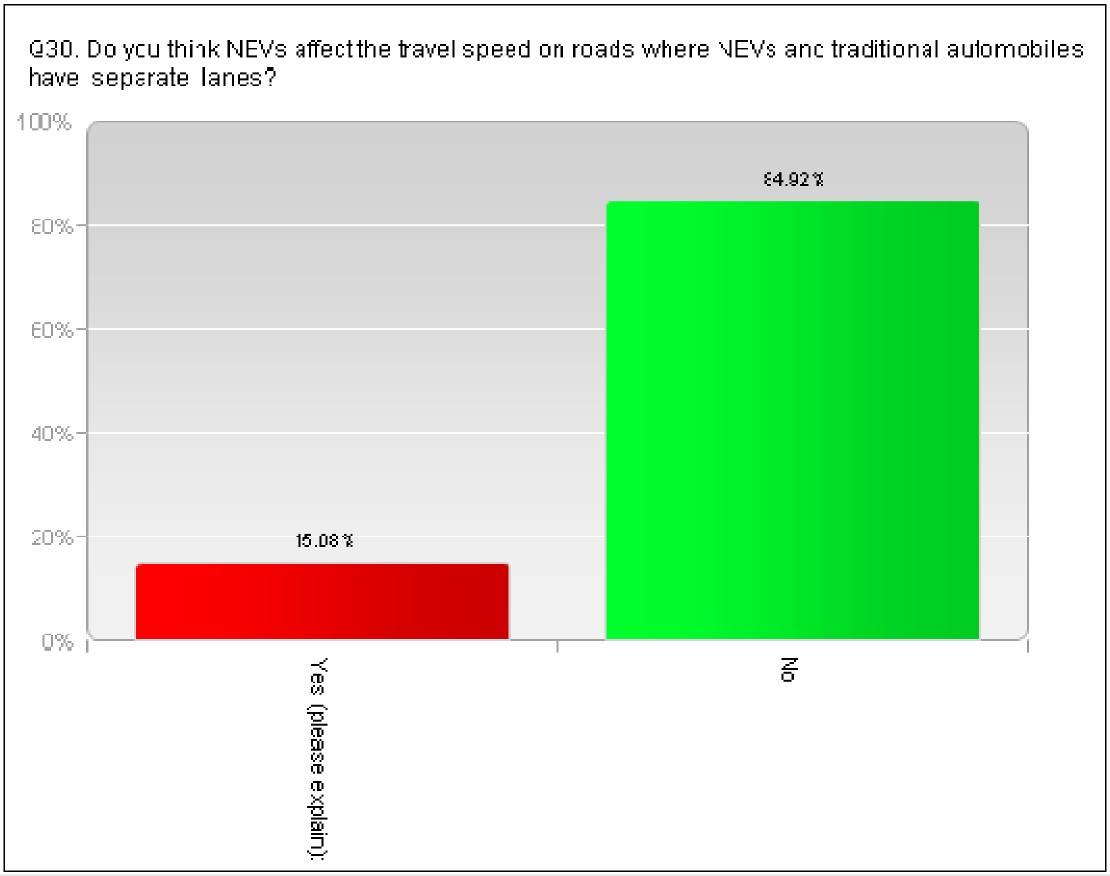

Q25. Do you use your NEV to attend or participate in community or social activities?
100%
80%
60%
40%
20%
0%
Yes
No

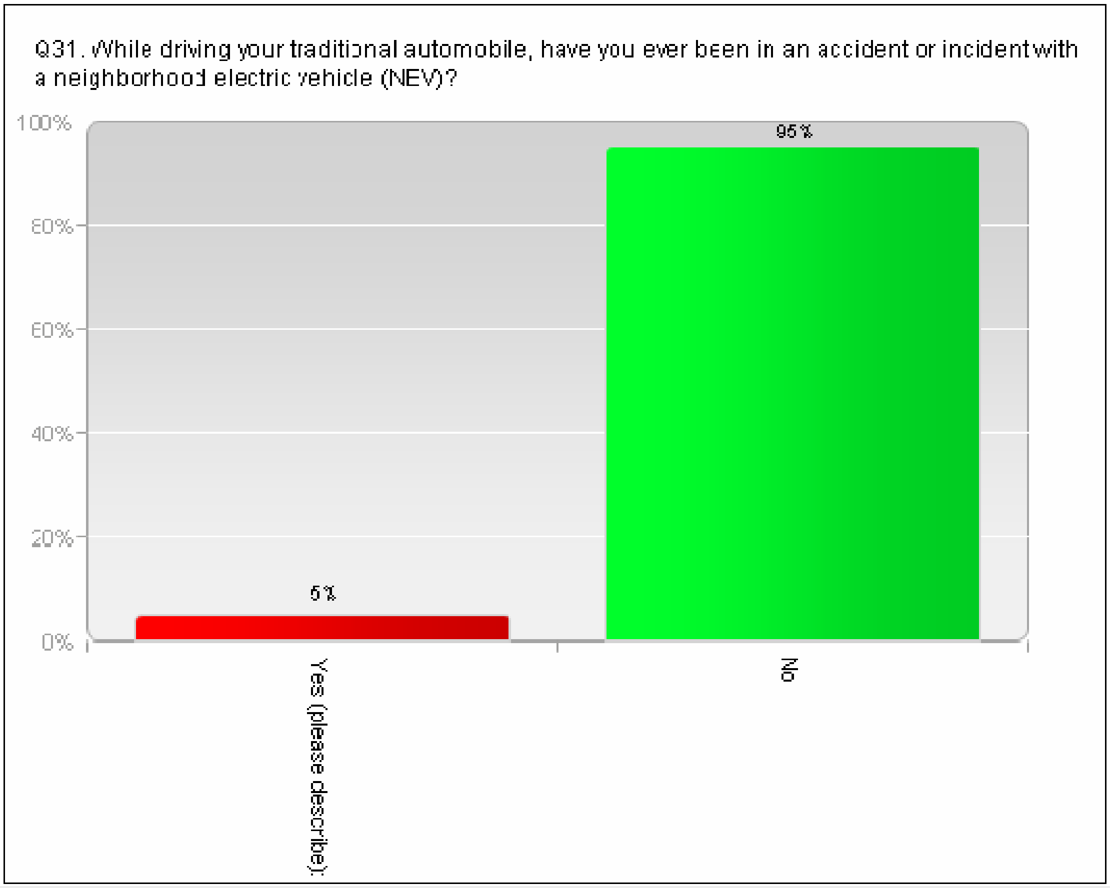

Q26. Would you still attend or participate in these activities without your NEV?
100%
80%
60%
40%
20%
0%
80.77 %
15.38 %
3.85 %
Yes
No (please explain):
N/A

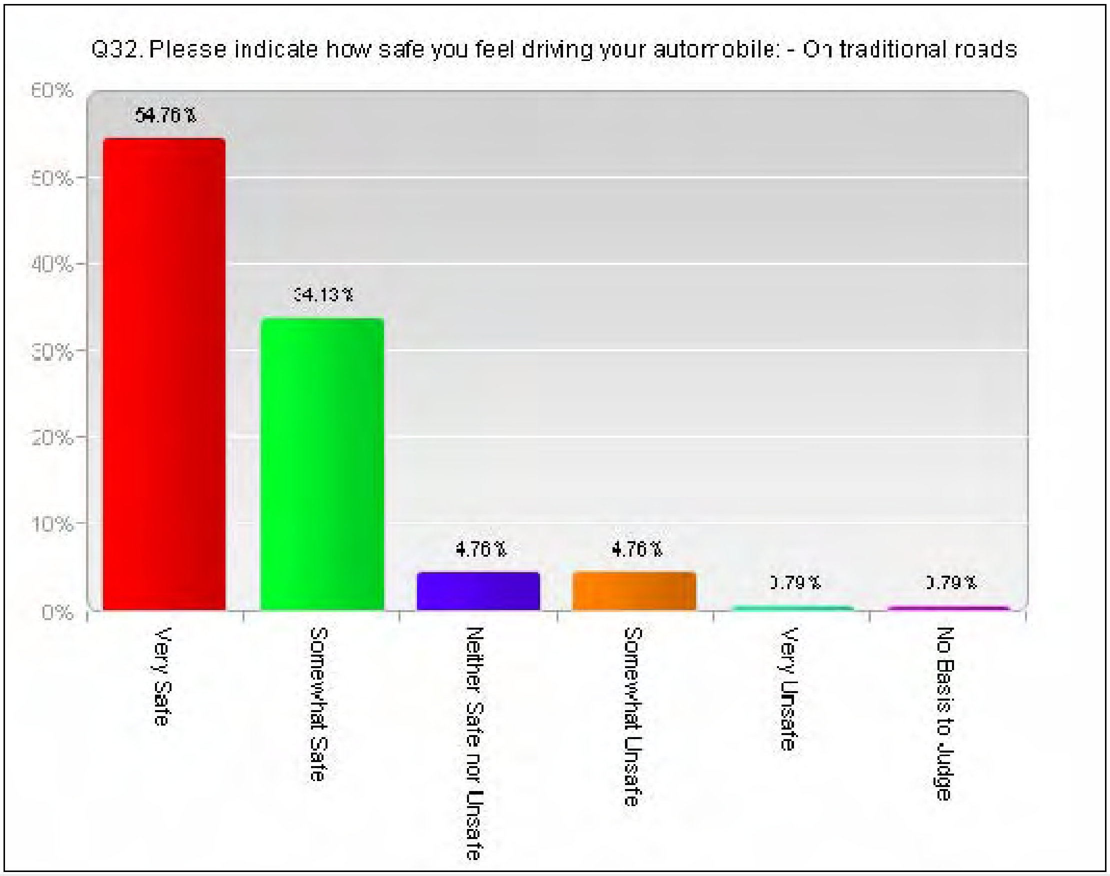

Q27. Would you suggest expanding or reducing the NEV system in the City of Lincoln?
100%
80%
60%
40%
20%
0%
92.31%
0%
7.69%
Expanding (please provide suggestions, if any)
Reducing (please provide suggestions, if any)
Neither

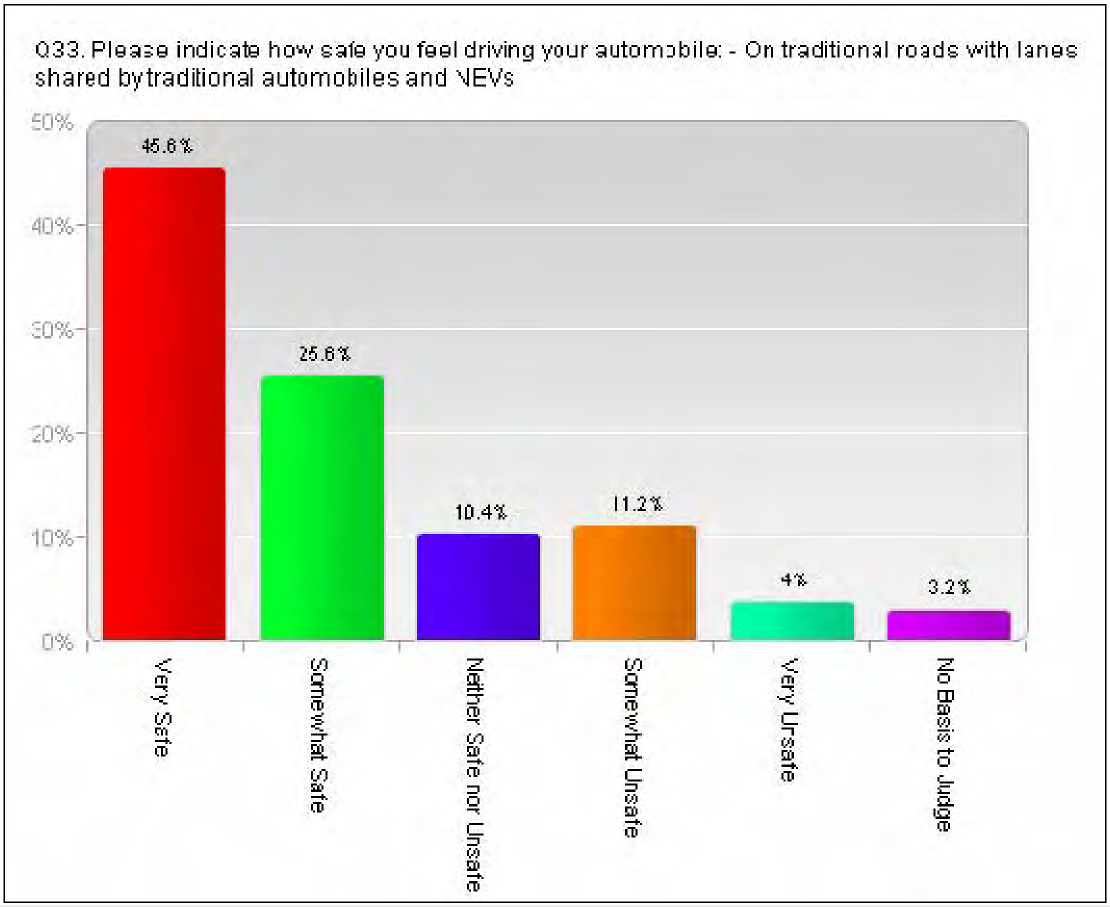

Q28. Do you use an automobile as a form of transportation?
100%
80%
60%
40%
20%
0%
100 %
0 %
Yes
No

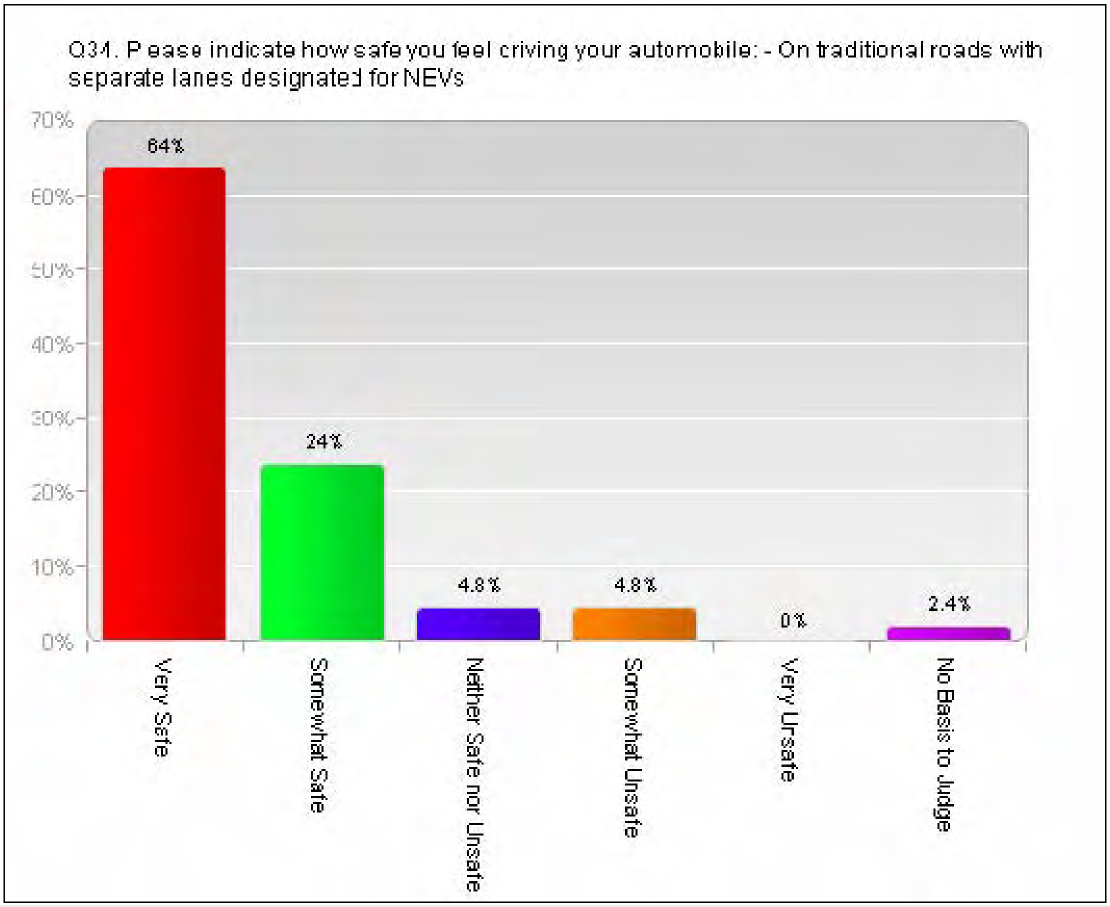

Q29. Do you think NEVs affect the travel speed on roads where NEVs and traditional automobiles share lanes?
60%
50%
40%
30%
20%
10%
0%
54.76 %
45.24 %
Yes (please explain):
No

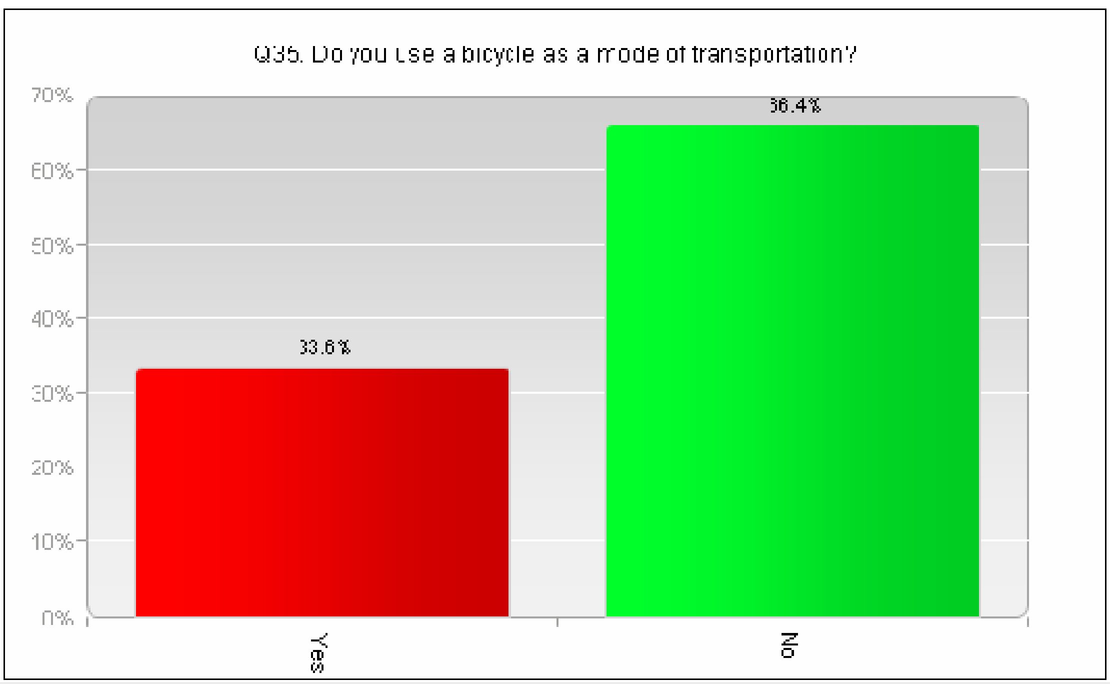

Q30. Do you think NEVs affect the travel speed on roads where NEVs and traditional automobiles have separate lanes?
100%
80%
60%
40%
20%
0%
15.08 %
84.92 %
Yes (please explain):
No

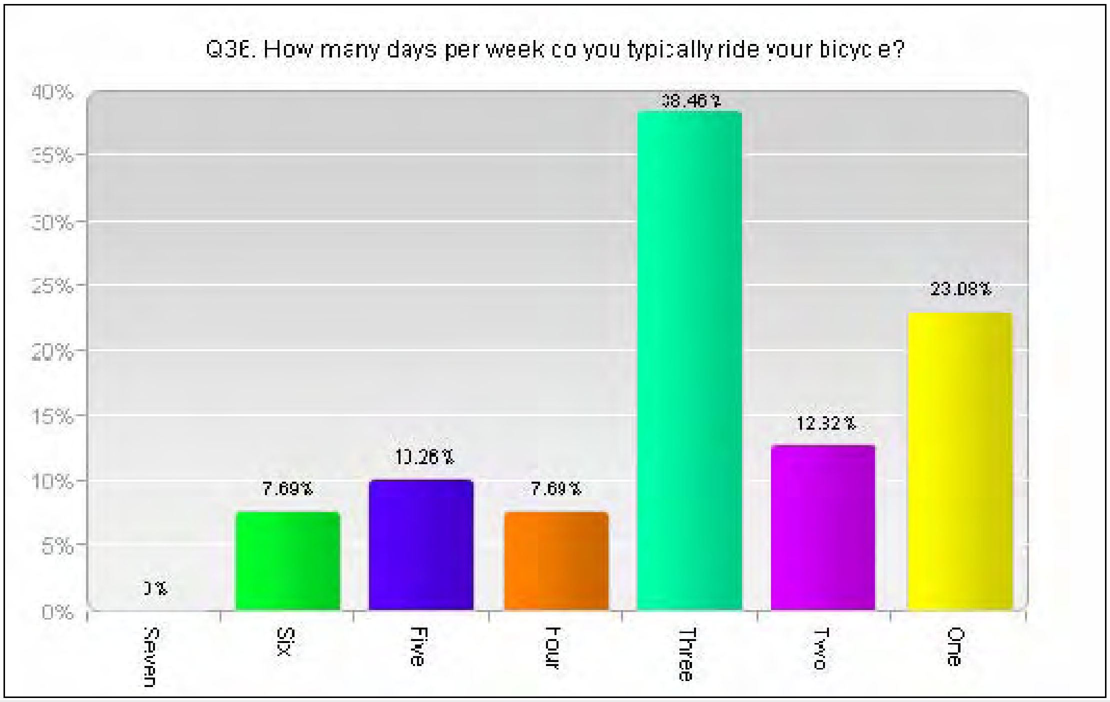

Q31. While driving your traditional automobile, have you ever been in an accident or incident with a neighborhood electric vehicle (NEV)?
100%
80%
60%
40%
20%
0%
5%
95%
Yes (please describe):
No

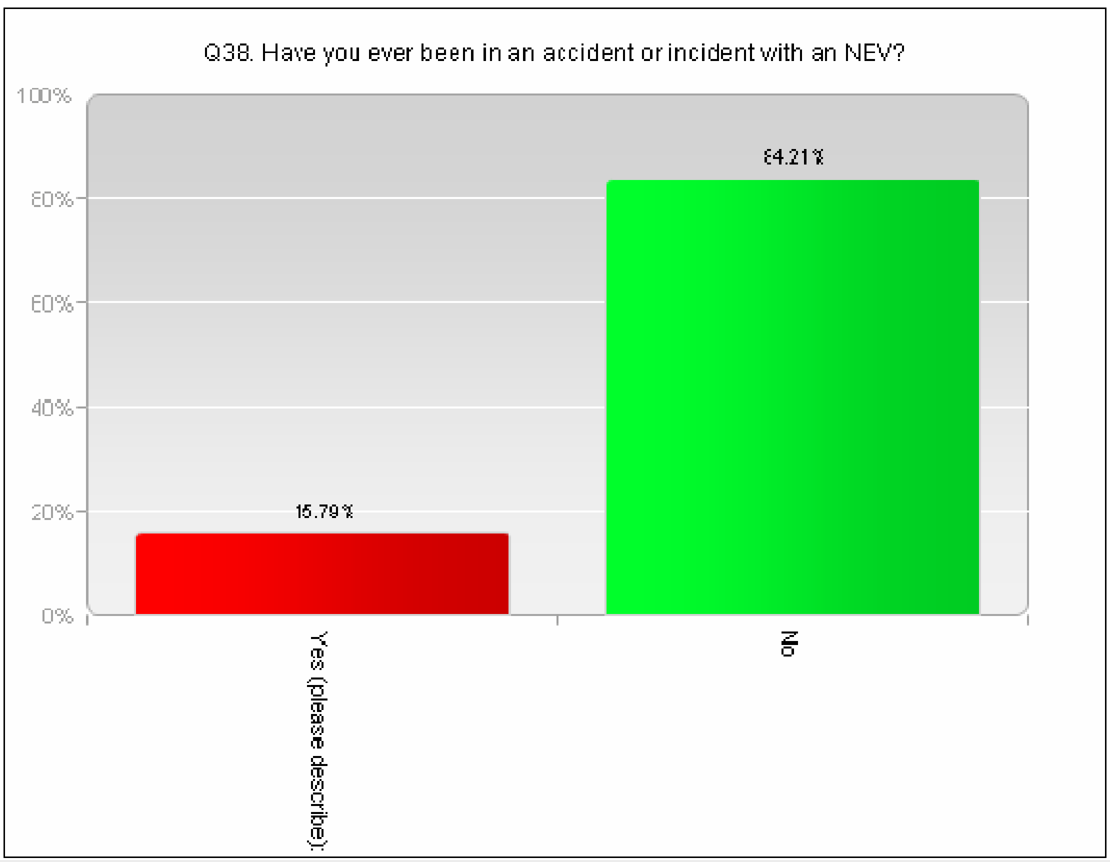

Q32. Please indicate how safe you feel driving your automobile: - On traditional roads
60%
50%
40%
30%
20%
10%
0%
54.76%
34.13%
4.76%
4.76%
0.79%
0.79%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

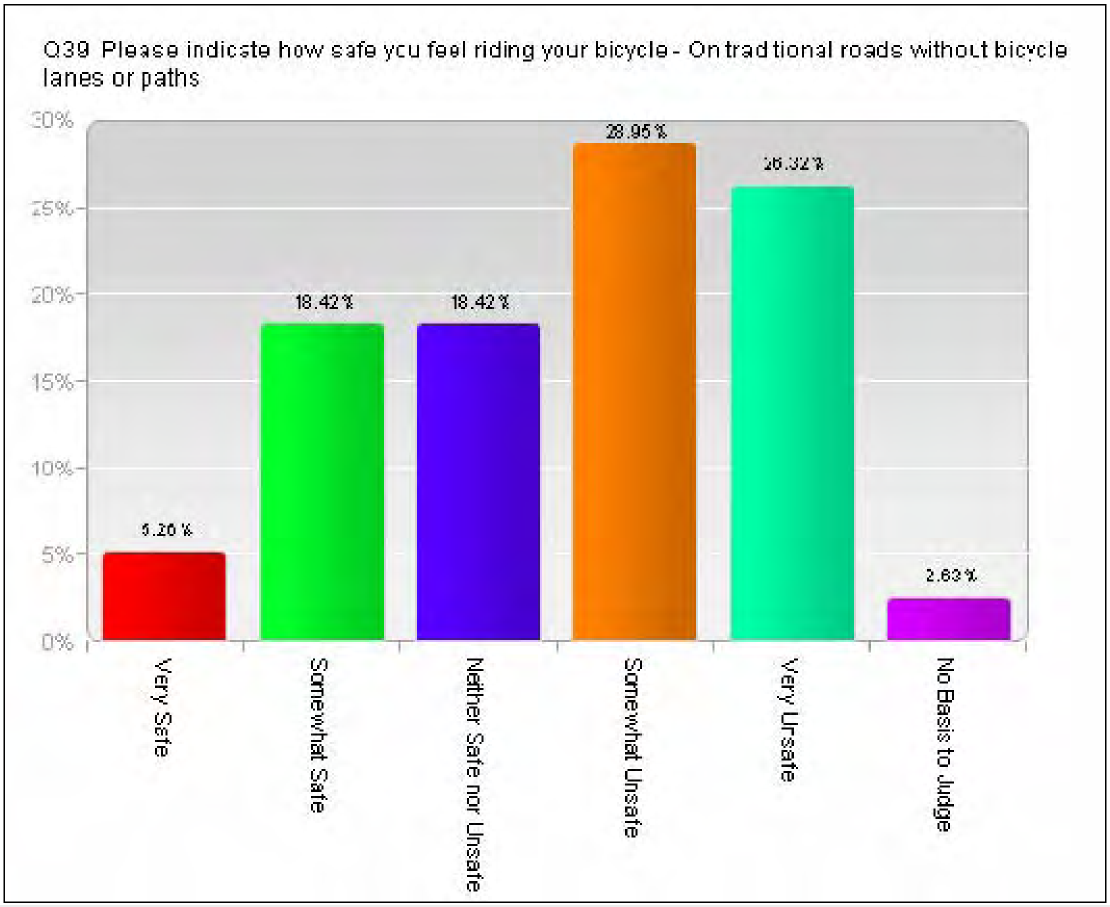

Q33. Please indicate how safe you feel driving your automobile: - On traditional roads with lanes shared by traditional automobiles and NEVs
50%
40%
30%
20%
10%
0%
45.6%
25.6%
10.4%
11.2%
4%
3.2%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

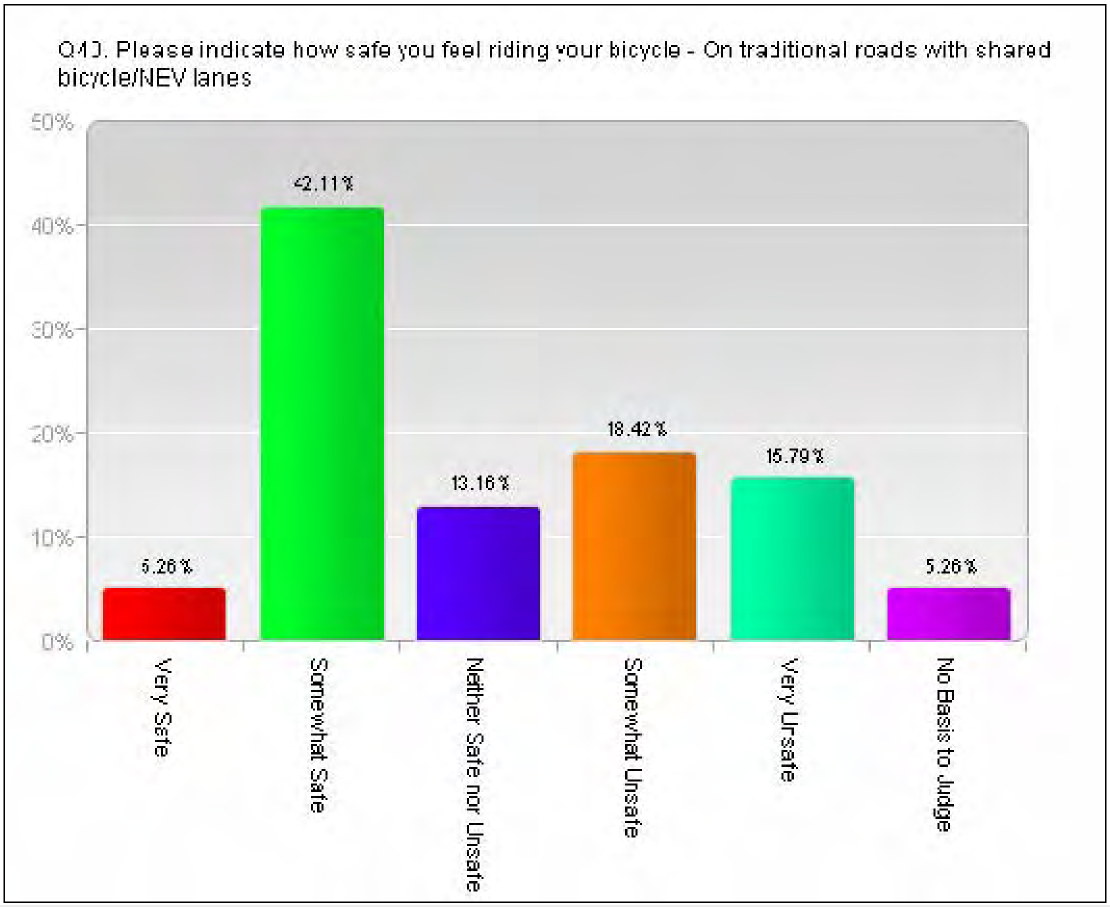

Q34. Please indicate how safe you feel driving your automobile: - On traditional roads with separate lanes designated for NEVs
70%
60%
50%
40%
30%
20%
10%
0%
64%
24%
4.8%
4.8%
0%
2.4%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

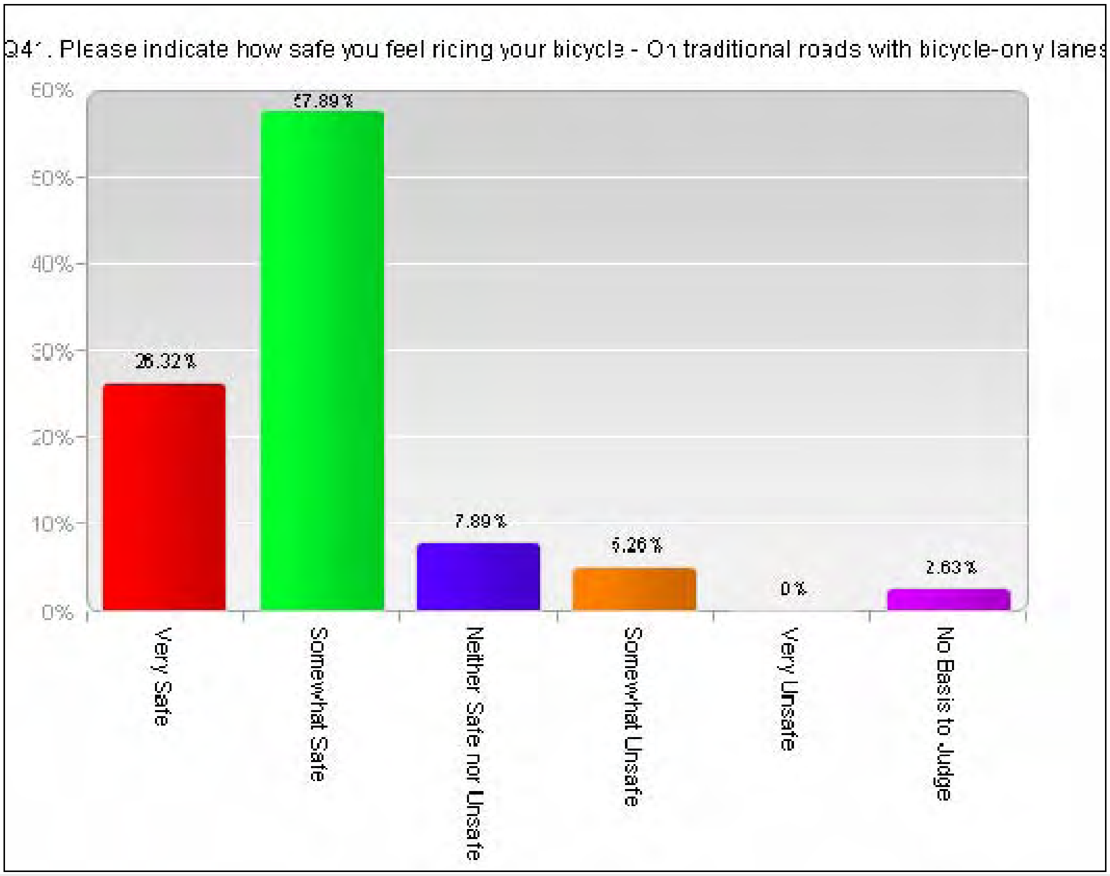

Q35. Do you use a bicycle as a mode of transportation?
70%
60%
50%
40%
30%
20%
10%
0%
33.6%
66.4%
Yes
No

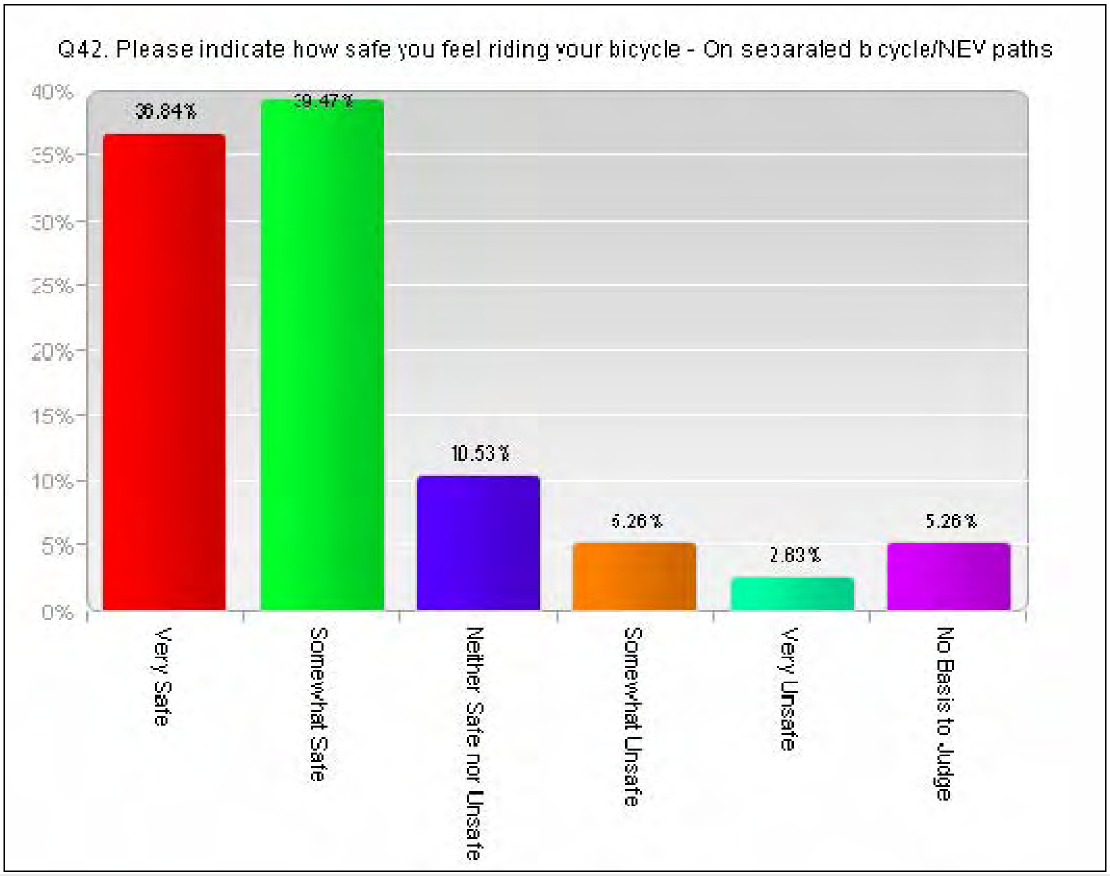

Q36. How many days per week do you typically ride your bicycle?
40%
35%
30%
25%
20%
15%
10%
5%
0%
0 %
7.69 %
10.26 %
7.69 %
38.46 %
12.32 %
23.08 %
Seven
Six
Five
Four
Three
Two
One

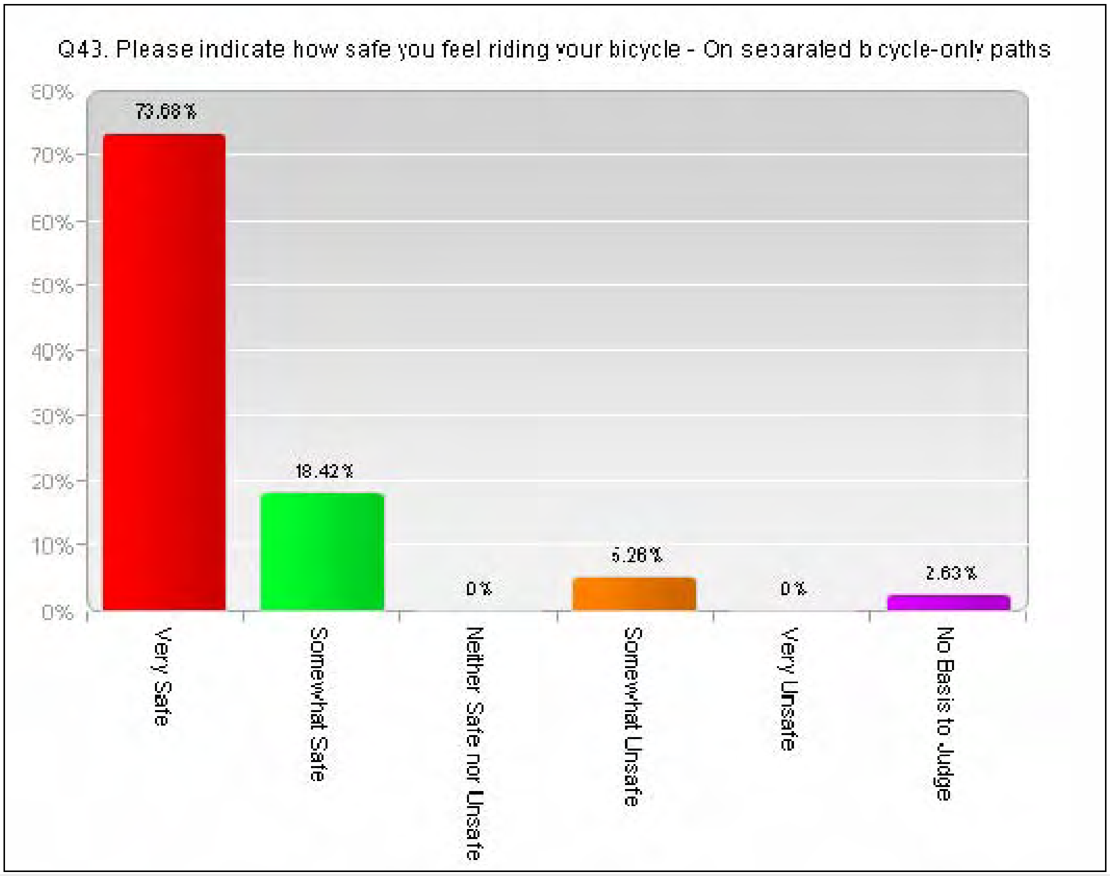

Q38. Have you ever been in an accident or incident with an NEV?
100%
80%
60%
40%
20%
0%
15.79 %
84.21 %
Yes (please describe):
No

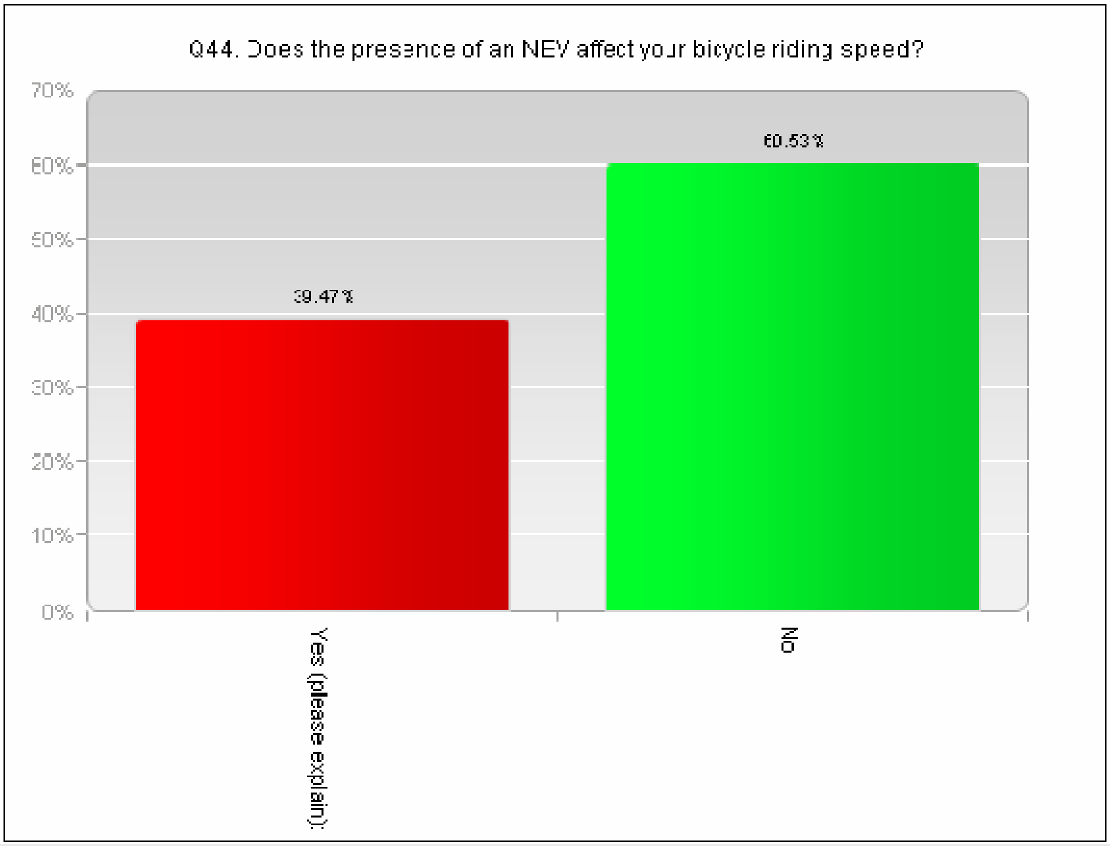

Q39 Please indicate how safe you feel riding your bicycle - On traditional roads without bicycle lanes or paths
30%
25%
20%
15%
10%
5%
0%
5.26 %
18.42 %
18.42 %
28.95 %
26.32 %
2.63 %
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

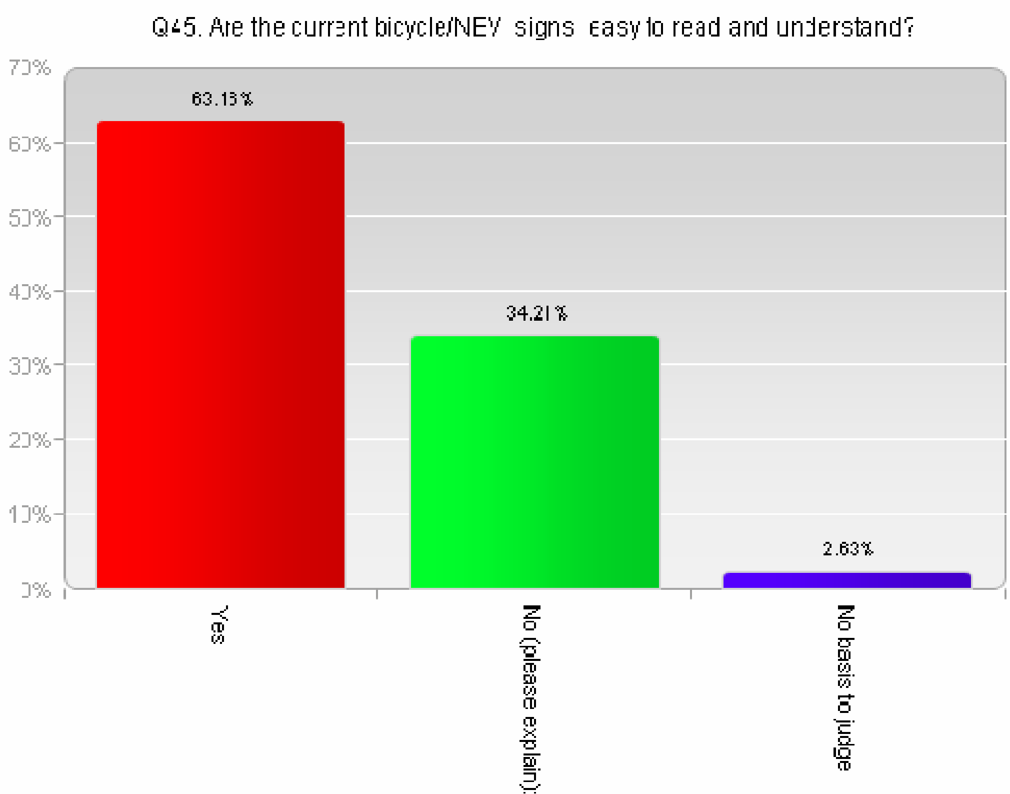

Q40. Please indicate how safe you feel riding your bicycle - On traditional roads with shared bicycle/NEV lanes
50%
40%
30%
20%
10%
0%
5.26 %
42.11 %
13.16 %
18.42 %
15.79 %
5.26 %
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

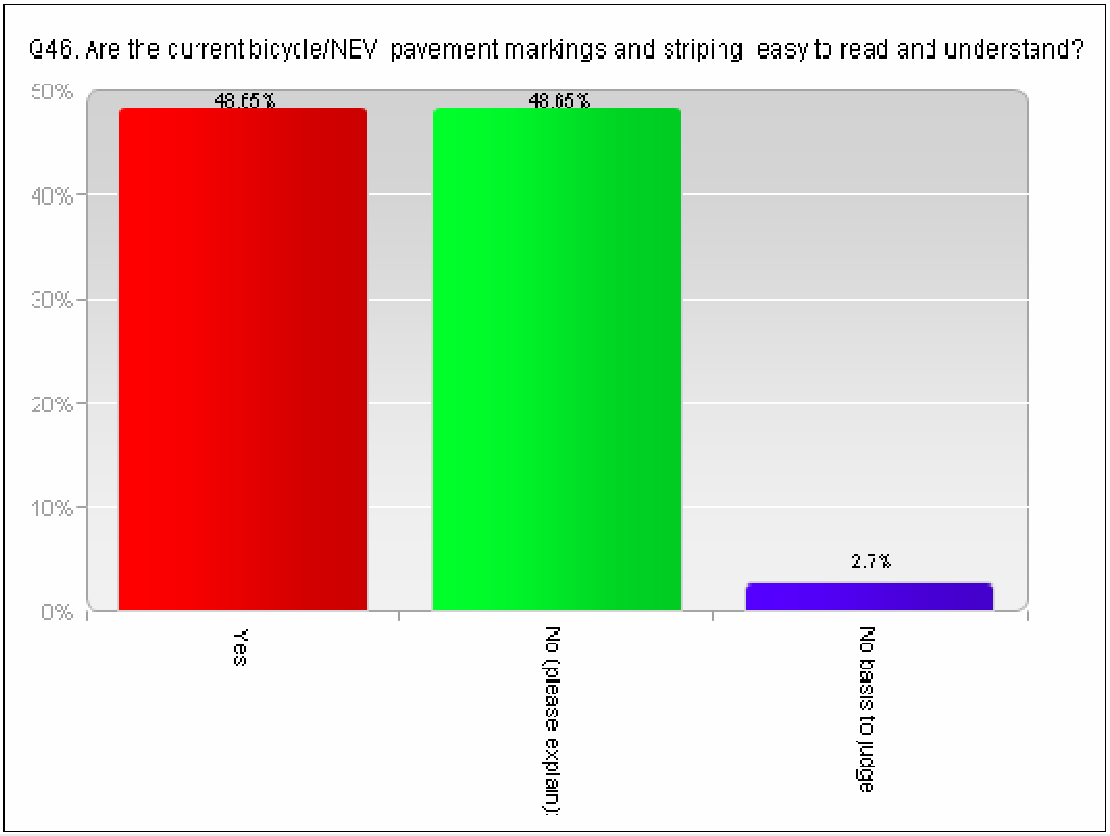

Q41. Please indicate how safe you feel riding your bicycle - On traditional roads with bicycle-only lanes
60%
50%
40%
30%
20%
10%
0%
26.32%
57.89%
7.89%
5.26%
0%
2.63%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

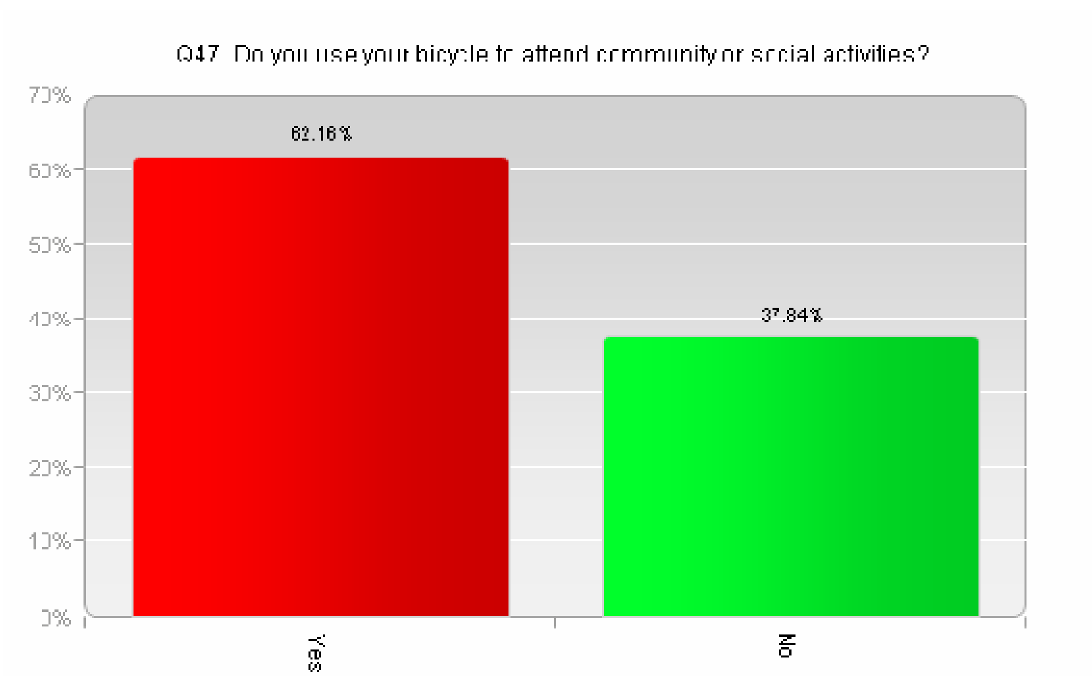

Q42. Please indicate how safe you feel riding your bicycle - On separated bicycle/NEV paths
40%
35%
30%
25%
20%
15%
10%
5%
0%
36.84%
39.47%
10.53%
5.26%
2.63%
5.26%
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

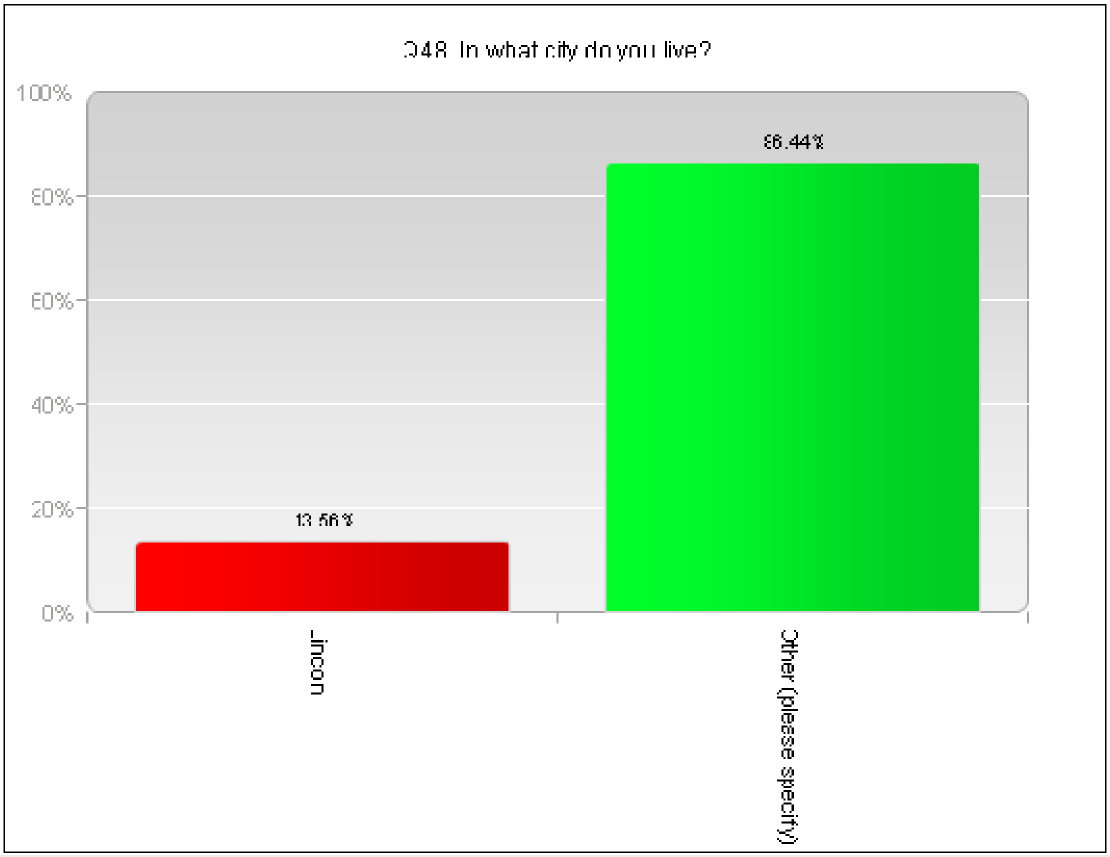

Q43. Please indicate how safe you feel riding your bicycle - On separated bicycle-only paths
80%
70%
60%
50%
40%
30%
20%
10%
0%
73.68 %
18.42 %
0 %
5.26 %
0 %
2.63 %
Very Safe
Somewhat Safe
Neither Safe nor Unsafe
Somewhat Unsafe
Very Unsafe
No Basis to Judge

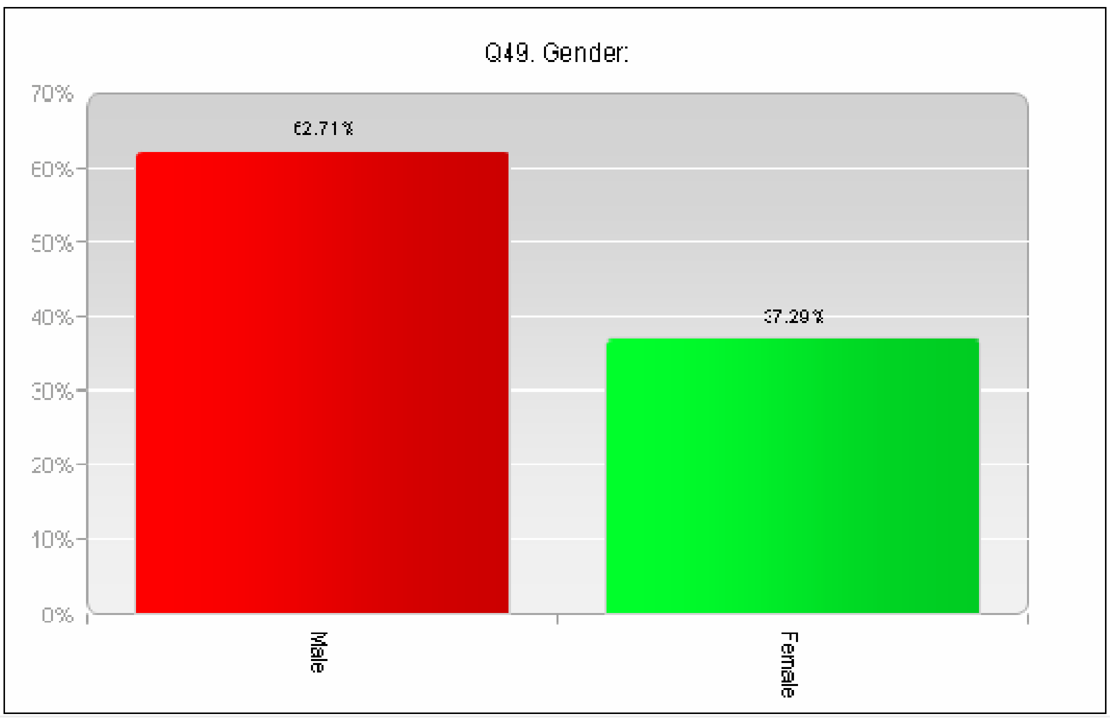

Q44. Does the presence of an NEV affect your bicycle riding speed?
70%
60%
50%
40%
30%
20%
10%
0%
39.47%
60.53%
Yes (please explain):
No

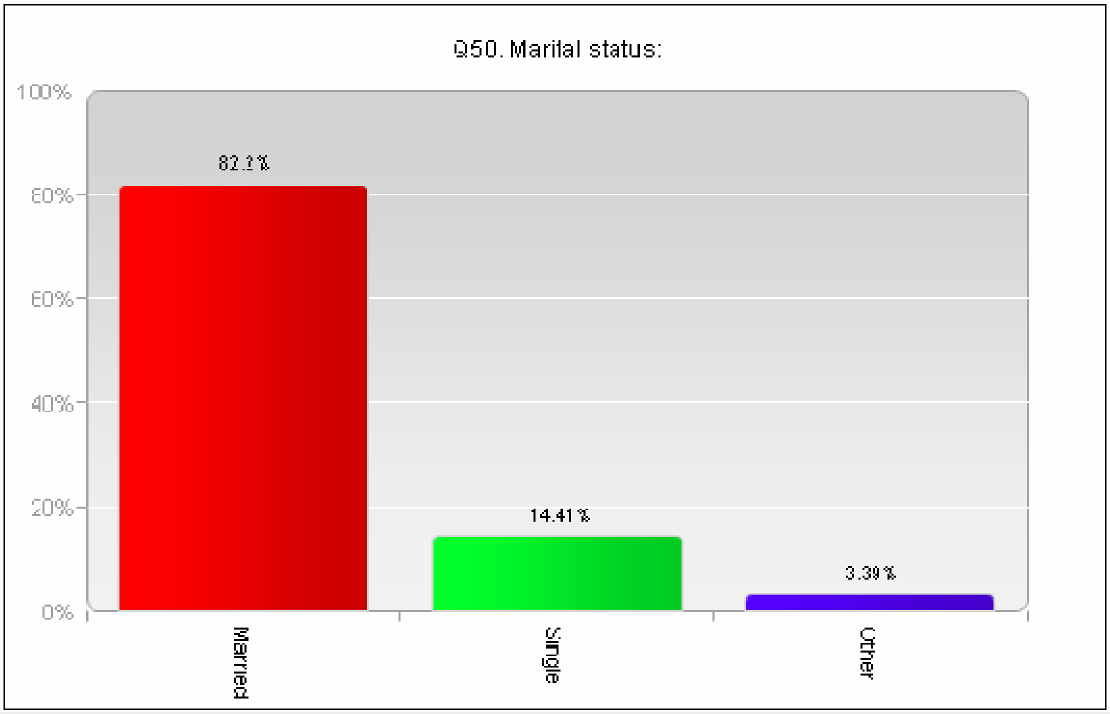

Q45. Are the current bicycle/NEV signs easy to read and understand?
70%
60%
50%
40%
30%
20%
10%
0%
63.16%
34.21%
2.63%
Yes
No (please explain):
No basis to judge

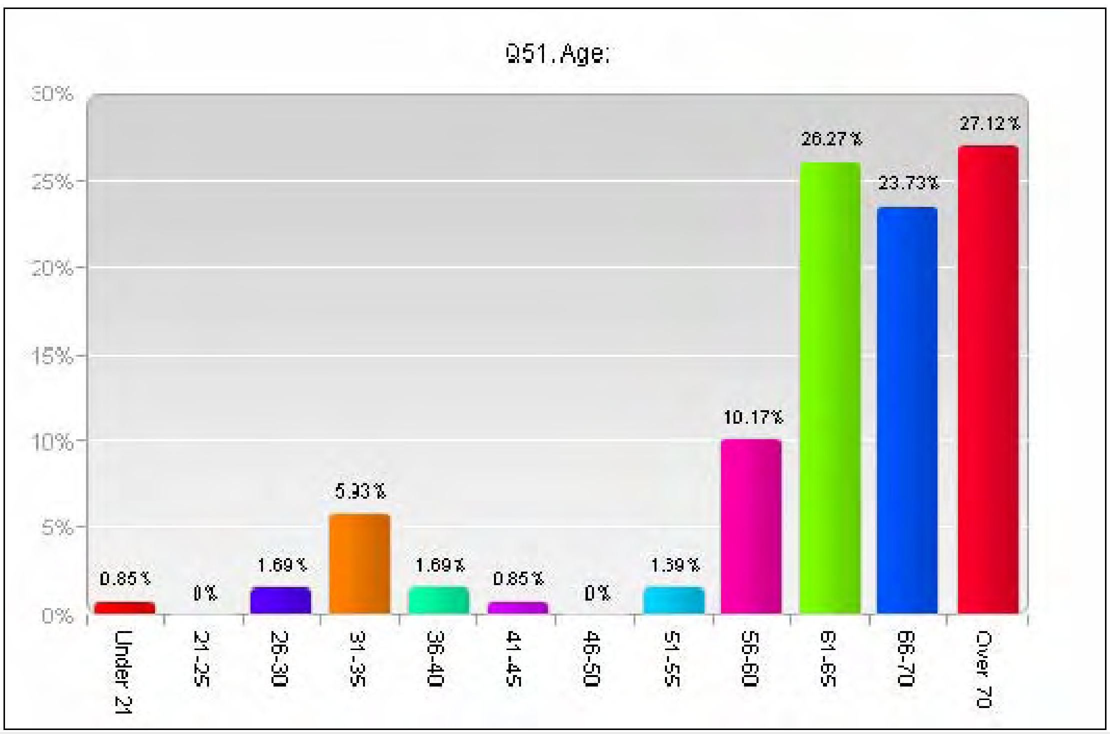

Q46. Are the current bicycle/NEV pavement markings and striping easy to read and understand?
50%
40%
30%
20%
10%
0%
48.65%
48.65%
2.7%
Yes
No (please explain)
No basis to judge

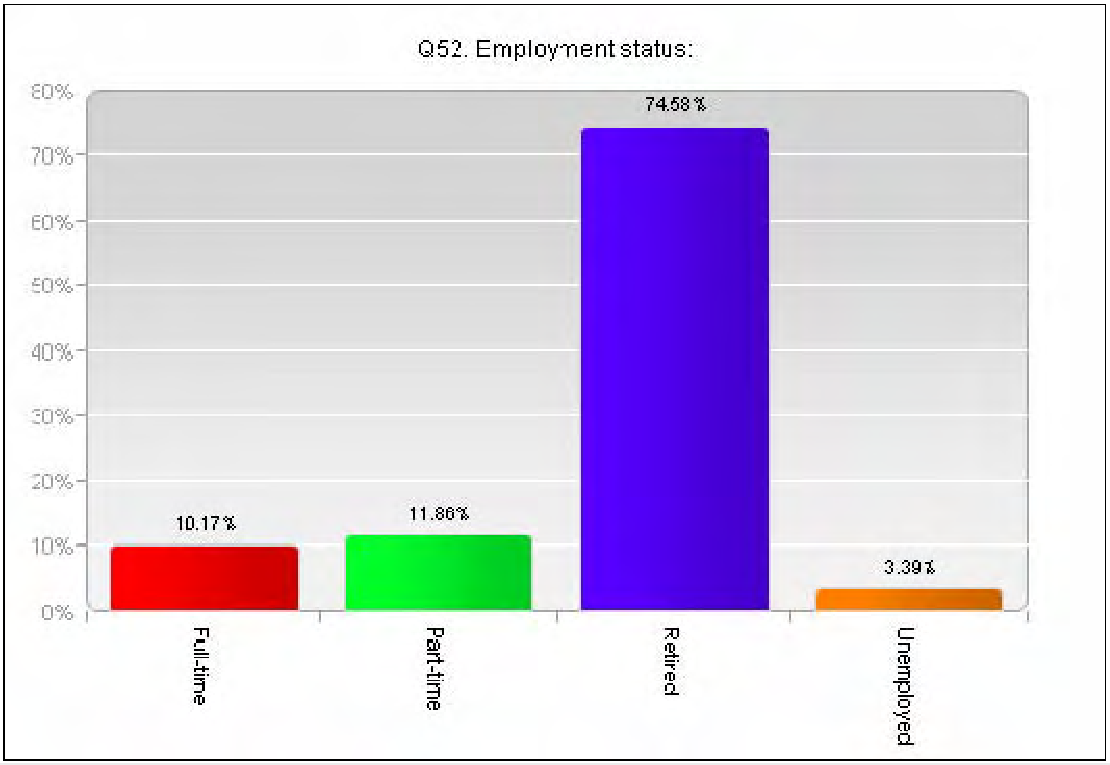

Q47. Do you use your bicycle to attend community or social activities?
70%
60%
50%
40%
30%
20%
10%
0%
62.16%
37.84%
Yes
No

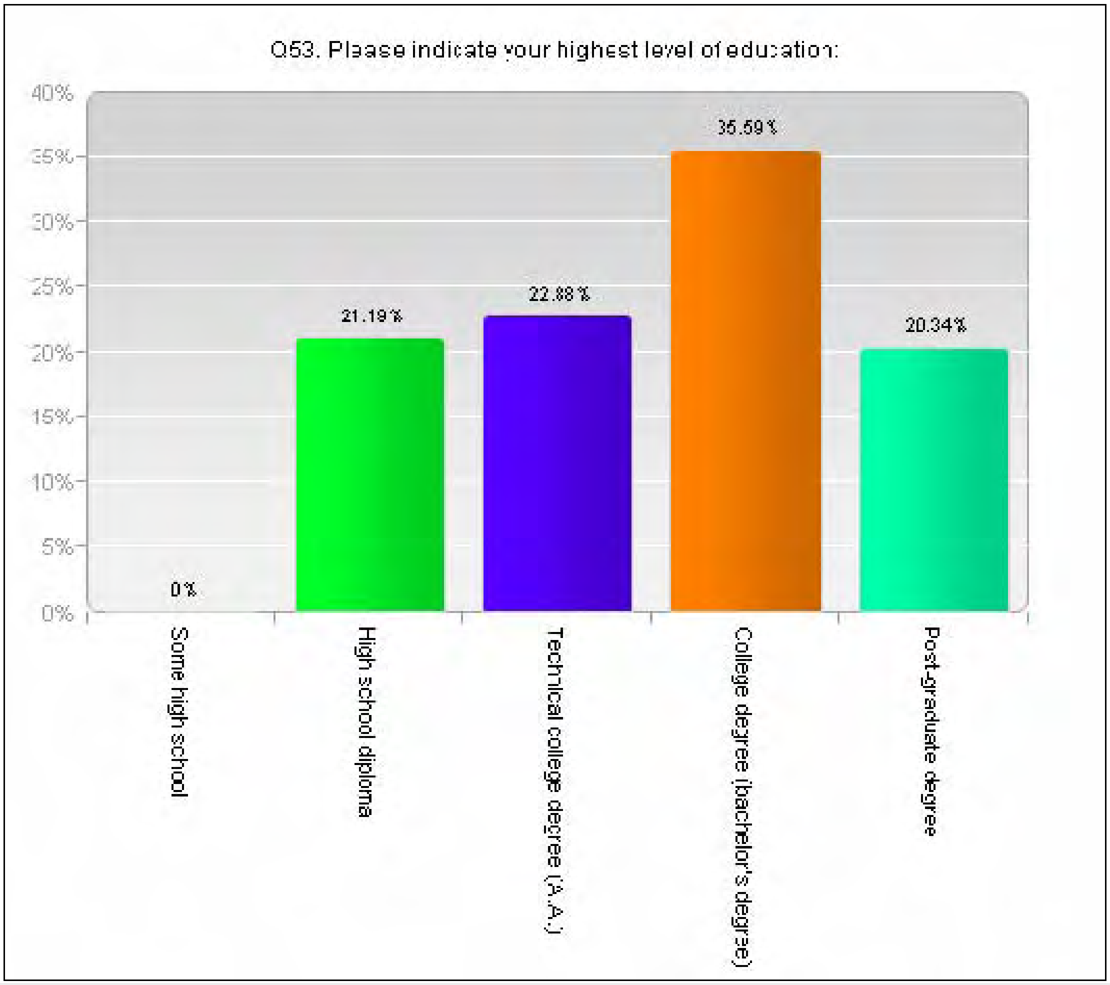

Q48. In what city do you live?
100%
80%
60%
40%
20%
0%
86.44%
13.56%
Lincoln
Other (please specify)

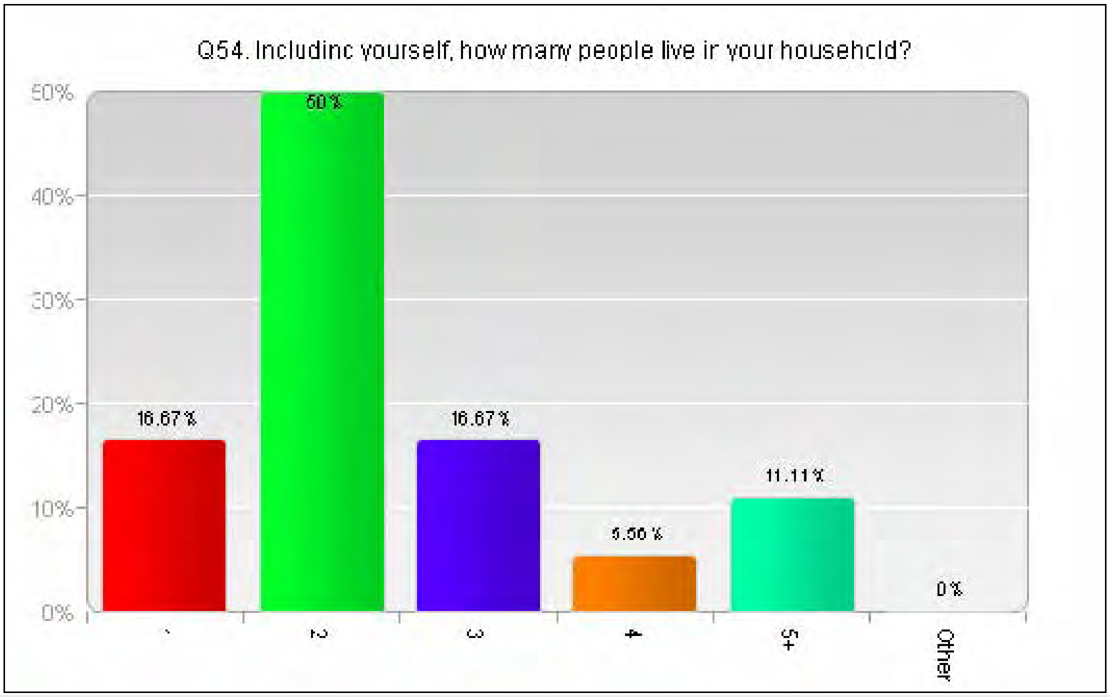

Q49. Gender:
70%
60%
50%
40%
30%
20%
10%
0%
62.71%
37.29%
Male
Female

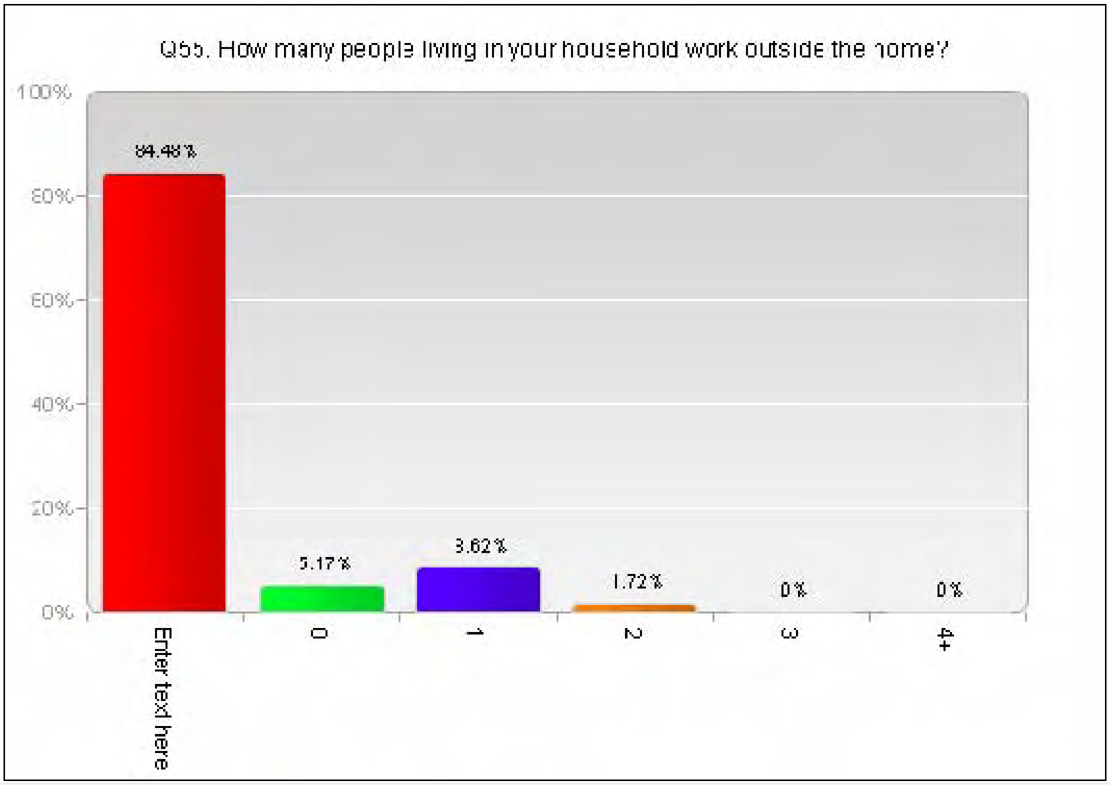

Q50. Marital status:
100%
80%
60%
40%
20%
0%
82.1 %
14.41 %
3.39 %
Married
Single
Other

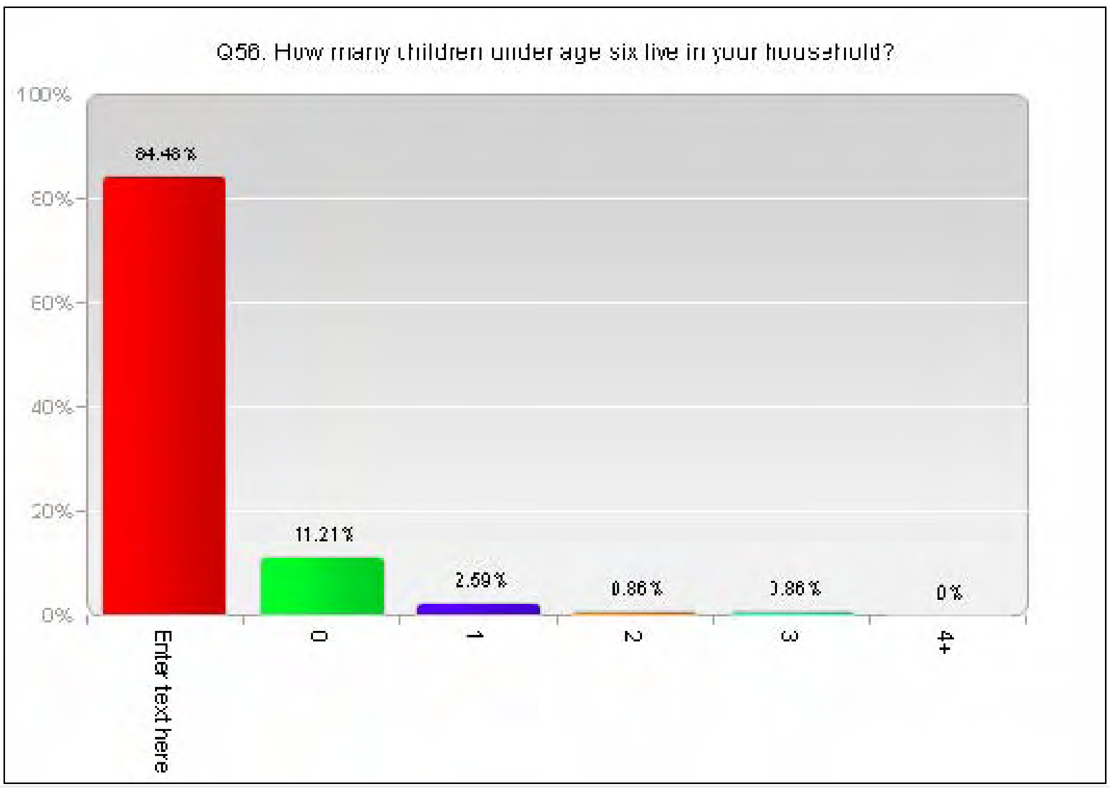

Q51. Age:
30%
25%
20%
15%
10%
5%
0%
0.85 %
0 %
1.69 %
5.93 %
1.69 %
0.85 %
0 %
1.39 %
10.17%
26.27 %
23.73%
27.12 %
Under 21
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
Over 70

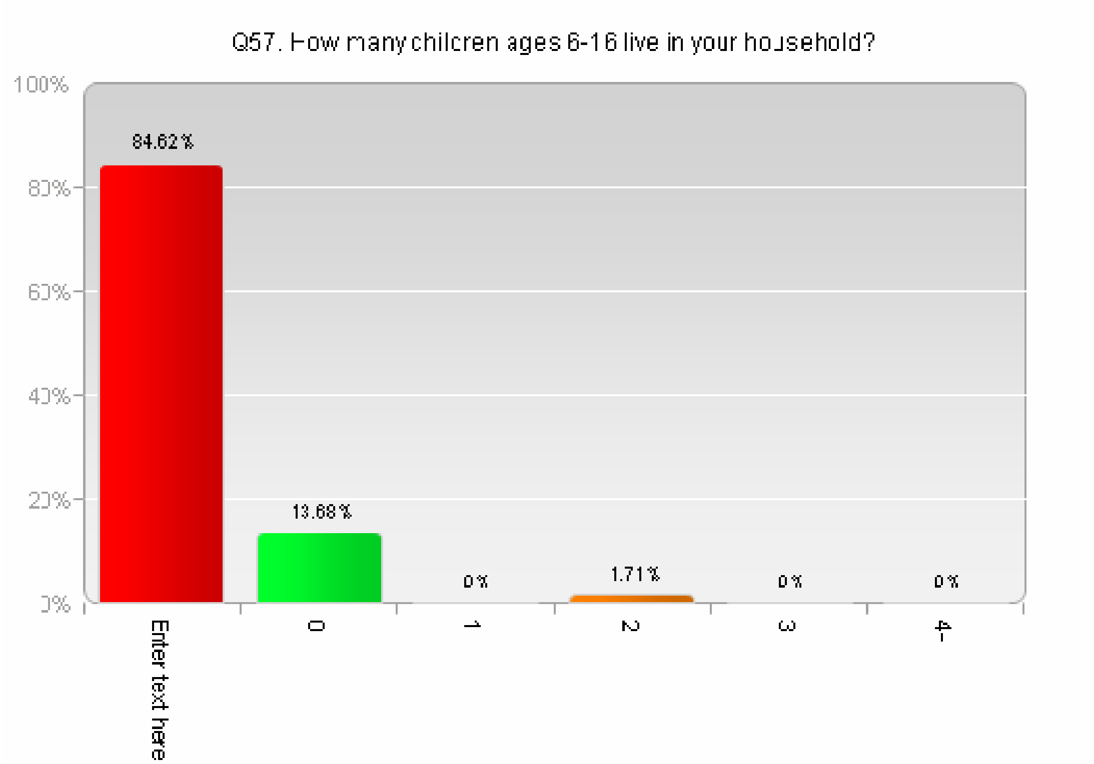

Q52. Employment status:
80%
70%
60%
50%
40%
30%
20%
10%
0%
74.58 %
10.17 %
11.86%
3.39 %
Full-time
Part-time
Retired
Unemployed

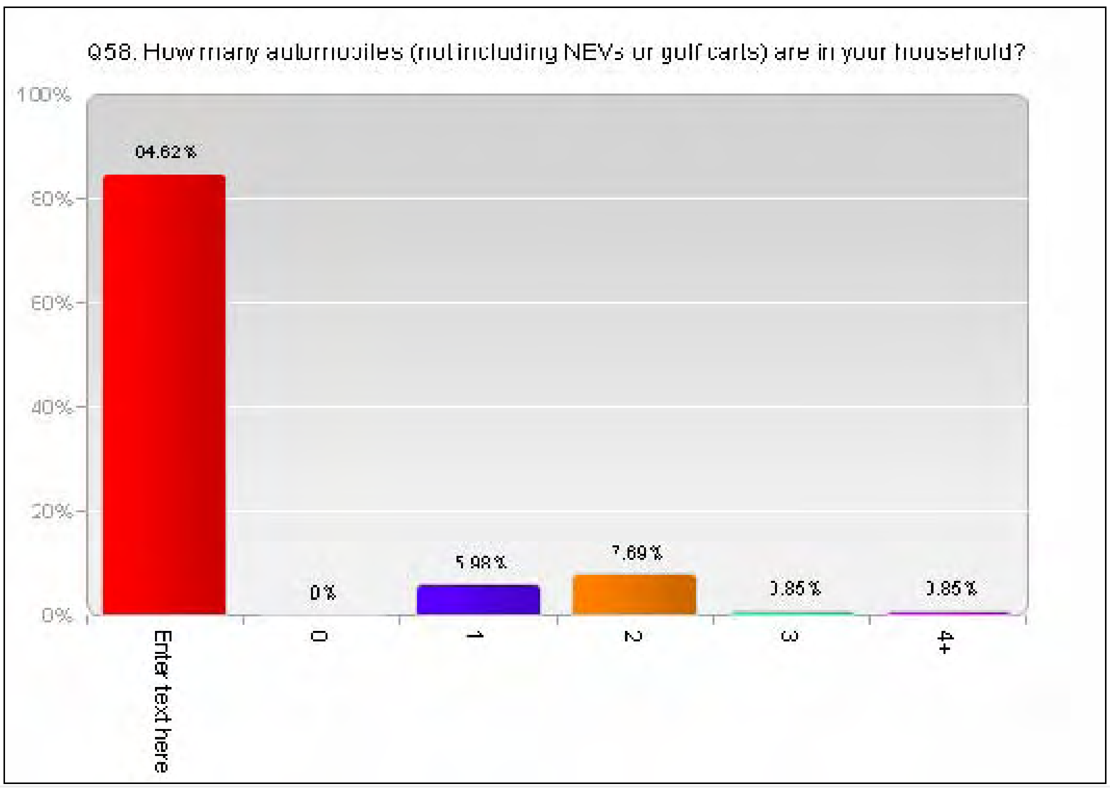

Q53. Please indicate your highest level of education:
40%
35%
30%
25%
20%
15%
10%
5%
0%
0 %
21.19 %
22.88 %
35.59 %
20.34 %
Some high school
High school diploma
Technical college degree (A.A.)
College degree (bachelor's degree)
Post-graduate degree

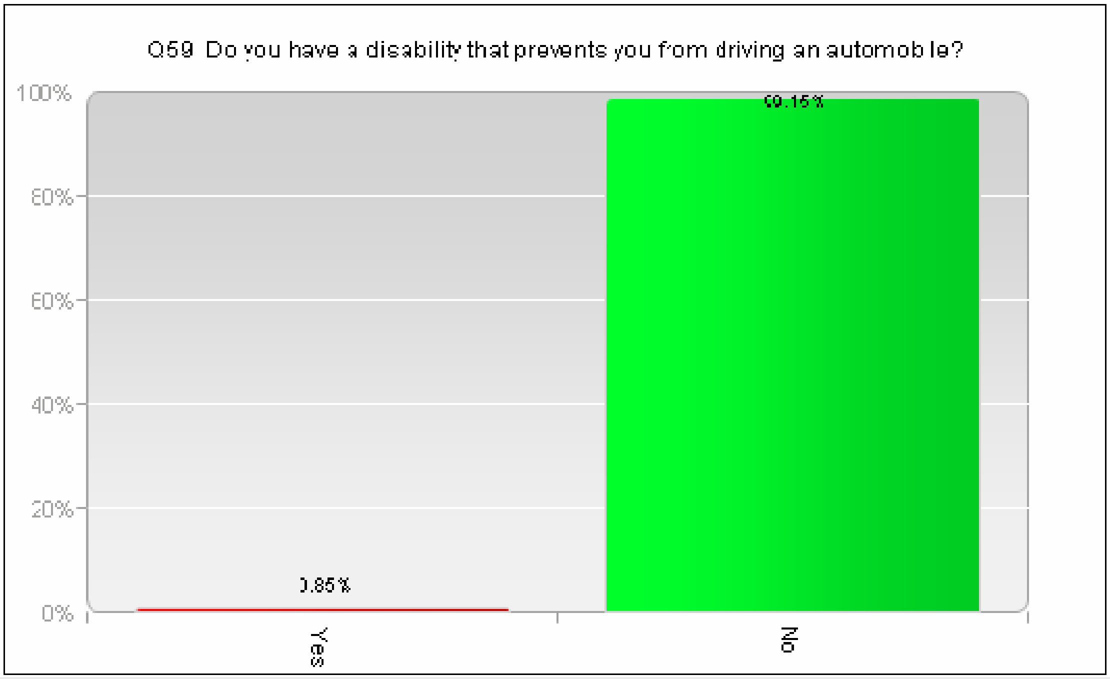

Q54. Including yourself, how many people live in your household?
50%
40%
30%
20%
10%
0%
16.67 %
50 %
16.67 %
5.56 %
11.11 %
0 %
1
2
3
4
5+
Other

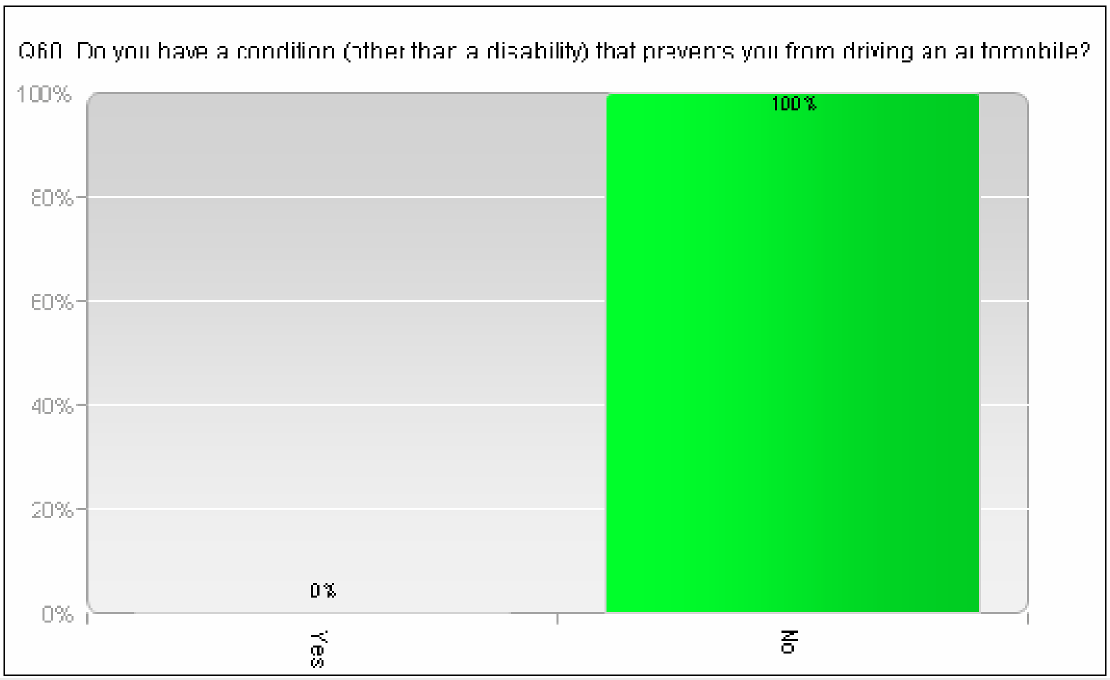

Q55. How many people living in your household work outside the home?
100%
80%
60%
40%
20%
0%
84.48%
5.17%
8.62%
1.72%
0%
0%
Enter text here
0
1
2
3
4+

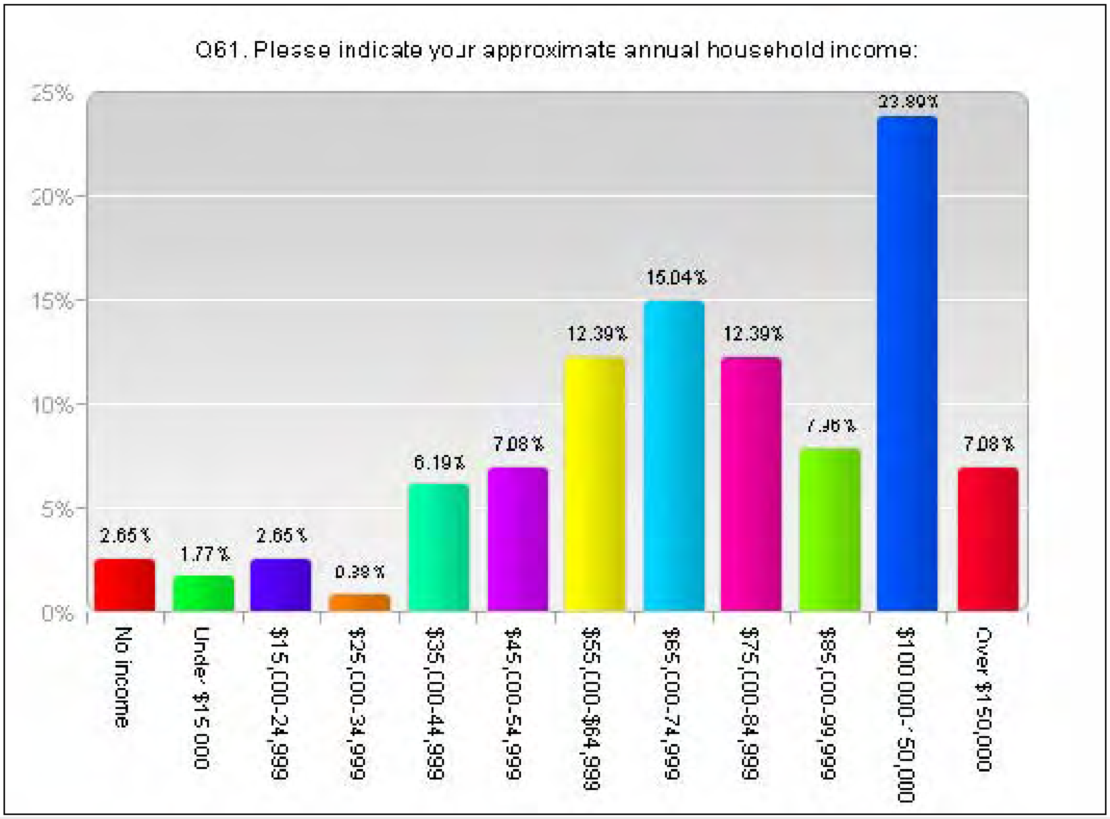

Q56. How many children under age six live in your household?
100%
80%
60%
40%
20%
0%
84.48%
11.21%
2.59%
0.86%
0.86%
0%
Enter text here
0
1
2
3
4+

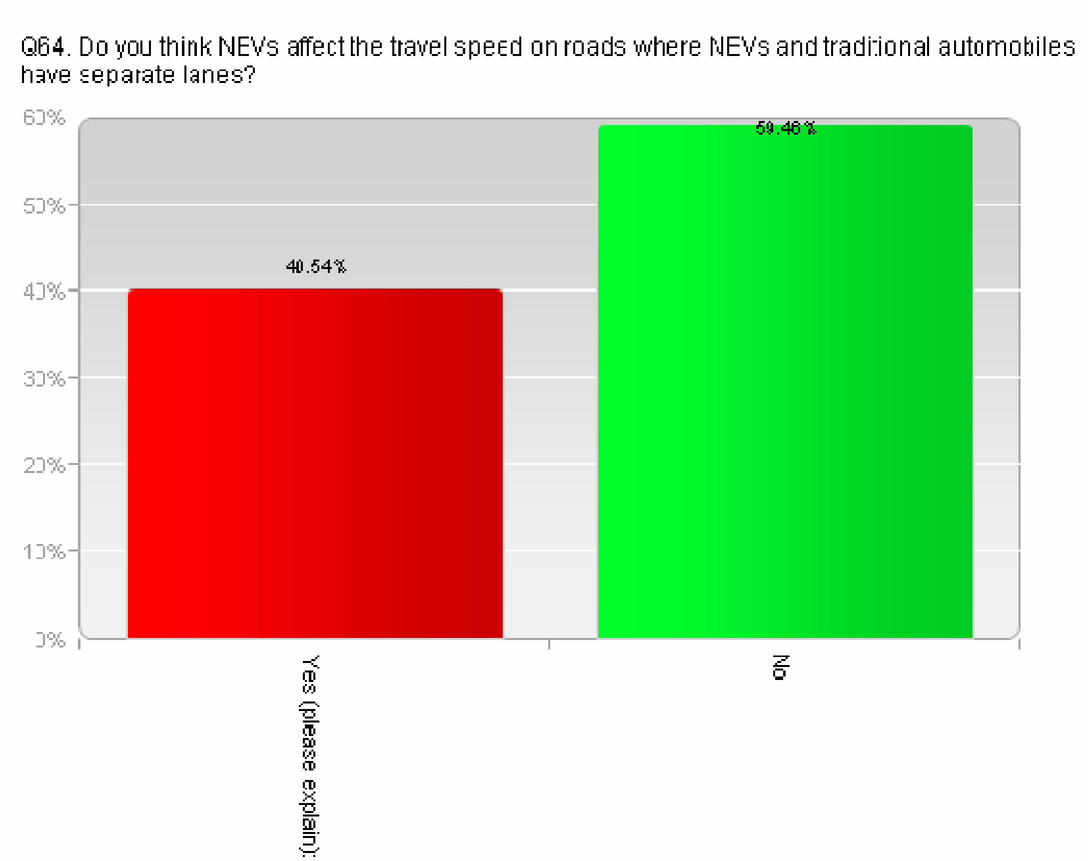

Q57. How many children ages 6-16 live in your household?
100%
80%
60%
40%
20%
0%
84.62 %
13.68 %
0 %
1.71 %
0 %
0 %
Enter text here
0
1
2
3
4+


Q58. How many automobiles (not including NEVs or golf carts) are in your household?
100%
80%
60%
40%
20%
0%
84.62 %
0 %
5.98 %
7.69 %
0.85 %
0.85 %
Enter text here
0
1
2
3
4+


Q59 Do you have a disability that prevents you from driving an automobile?
100%
80%
60%
40%
20%
0%
0.85 %
99.15 %
Yes
No


Q60 Do you have a condition (other than a disability) that prevents you from driving an automobile?
100%
80%
60%
40%
20%
0%
0 %
100 %
Yes
No


Q61. Please indicate your approximate annual household income:
25%
20%
15%
10%
5%
0%
2.65 %
1.77 %
2.65 %
0.88 %
6.19 %
7.08 %
12.39 %
15.04 %
12.39 %
7.96 %
23.89 %
7.08 %
No income
Under $15,000
$15,000-24,999
$25,000-34,999
$35,000-44,999
$45,000-54,999
$55,000-$64,999
$65,000-74,999
$75,000-84,999
$85,000-99,999
$100,000-150,000
Over $150,000


Q64. Do you think NEVs affect the travel speed on roads where NEVs and traditional automobiles have separate lanes?
60%
50%
40%
30%
20%
10%
0%
40.54%
59.46%
Yes (please explain):
No

APPENDIX E. CALIFORNIA ASSEMBLY BILL 2353

Assembly Bill No. 2353

CHAPTER 422

An act to add and repeal Chapter 7 (commencing with Section 1963) of Division 2.5 of the Streets and Highways Code, and to amend Sections 385.5, 21250, 21251, and 21260 of the Vehicle Code, relating to neighborhood electric vehicles.

[Approved by Governor September 9, 2004. Filed with Secretary of State September 9, 2004.]

LEGISLATIVE COUNSEL'S DIGEST

AB 2353, Leslie. Neighborhood Electric Vehicles.

Existing law defines "low-speed vehicle" for purposes of the Vehicle Code as a motor vehicle, other than a motor truck, with 4 wheels on the ground that is capable of a minimum speed of 20 miles per hour and a maximum speed of 25 miles per hour on a paved level surface and that has an unladen weight of 1800 pounds or less. Existing law imposes certain restrictions on the use of low-speed vehicles on public streets and highways, and generally requires an operator of a low-speed vehicle to have a driver's license. A violation of the Vehicle Code is an infraction, unless otherwise specified.

Existing law authorizes a city or county to establish a golf cart transportation plan subject to the review of the appropriate transportation planning agency and traffic law enforcement agency. Existing law provides that operating a golf cart other than on an authorized roadway is an infraction punishable by a fine not exceeding $100.

This bill would authorize, until January 1, 2009, the City of Lincoln and the City of Rocklin in the County of Placer to establish a neighborhood electric vehicle (NEV) transportation plan subject to the same review process established for a golf cart transportation plan. The bill would define "neighborhood electric vehicle" for these purposes to have the same meaning as the above definition of "low-speed vehicle." The bill, among other things, would provide for the plan to authorize the use of state highways by NEVs under certain conditions. The bill would require a report to the Legislature by January 1, 2008. The bill would enact other related provisions. Because the bill would revise the definition of a crime, it would impose a state-mandated local program.

The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state.

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Statutory provisions establish procedures for making that reimbursement.

This bill would provide that no reimbursement is required by this act for a specified reason.

The people of the State of California do enact as follows:

SECTION 1. Chapter 7 (commencing with Section 1963) is added to Division 2.5 of the Streets and Highways Code, to read:

Chapter 7. Neighborhood Electric Vehicle Transportation Plan

1963. It is the intent of the Legislature, in enacting this chapter, to authorize the City of Lincoln and the City of Rocklin in the County of Placer to establish a neighborhood electric vehicle (NEV) transportation plan for a plan area in the city. It is the further intent of the Legislature that this transportation plan be designed and developed to best serve the functional travel needs of the plan area, to have the physical safety of the NEV driver's person and property as a major planning component, and to have the capacity to accommodate NEV drivers of every legal age and range of skills. It is the intent of the Legislature, in enacting this chapter, to encourage discussions between the Legislature, the Department of Motor Vehicles, and the California Highway Patrol regarding the adoption of a new classification for licensing motorists who use neighborhood electric vehicles.

1963.1. The following definitions apply to this chapter:

(a) "Plan area" means that territory under the jurisdiction of the City of Lincoln or the City of Rocklin designated by the city for a NEV transportation plan, including the privately owned land of any owner that consents to its inclusion in the plan.

(b) "Neighborhood electric vehicle" or "NEV" means a low-speed vehicle as defined by Section 385.5 of the Vehicle Code.

(c) "NEV lanes" means all publicly owned facilities that provide for NEV travel including roadways designated by signs or permanent markings which are shared with pedestrians, bicyclists, and other motorists in the plan area.

(d) "Speed-modified golf cart" means a golf cart that is modified to meet the safety requirements of Section 571.500 of Title 49 of the Code of Federal Regulations.

1963.2. (a) The City of Lincoln and the City of Rocklin may, by ordinance or resolution, adopt a NEV transportation plan.

(b) The transportation plan shall have received a prior review and the comments of the appropriate transportation planning agency designated under subdivision (a) or (b) of Section 29532 of the Government Code and any agency having traffic law enforcement responsibilities in the City of Lincoln or the City of Rocklin.

(c) The transportation plan may include the use of a state highway, or any crossing of the highway, subject to the approval of the Department of Transportation.

1963.3. The transportation plan shall include, but is not limited to, all of the following elements:

(a) Route selection, which includes a finding that the route will accommodate NEVs without an adverse impact upon traffic safety, and will consider, among other things, the travel needs of commuters and other users.

(b) Transportation interfacing, which shall include, but not be limited to, coordination with other modes of transportation so that a NEV driver may employ multiple modes of transportation in reaching a destination in the plan area.

(c) Citizens and community involvement in planning.

(d) Flexibility and coordination with long-range transportation planning.

(e) Provision for NEV related facilities including, but not limited to, special access points and NEV crossings.

(f) Provisions for parking facilities, including, but not limited to, community commercial centers, golf courses, public areas, parks, and other destination locations.

(g) Provisions for special paving, road markings, signage and striping for NEV travel lanes, road crossings, parking, and circulation.

(h) Provisions for NEV electrical charging stations.

(i) NEV lanes for the purposes of the transportation plan shall be classified as follows:

(1) Class I NEV routes provide for a completely separate right-of-way for the use of NEVs.

(2) Class II NEV routes provide for a separate striped lane adjacent to roadways with speed limits of 55 miles per hour or less.

(3) Class III NEV routes provide for shared use by NEVs with conventional vehicle traffic on streets with a posted speed limit of 35 miles per hour or less.

1963.4. If the City of Lincoln or the City of Rocklin adopts a NEV transportation plan, it shall do both of the following:

(a) Establish minimum general design criteria for the development, planning, and construction of separated NEV lanes, including, but not limited to, the design speed of the facility, the space requirements of the NEV, and roadway design criteria.

(b) In cooperation with the department, establish uniform specifications and symbols for signs, markers, and traffic control devices to control NEV traffic; to warn of dangerous conditions, obstacles, or hazards; to designate the right-of-way as between NEVs, other vehicles, and bicycles; to state the nature and destination of the NEV lane; and to warn pedestrians, bicyclists, and motorists of the presence of NEV traffic.

1963.5. If the City of Lincoln or the City of Rocklin adopts a NEV transportation plan, each city may do the following:

(a) Acquire, by dedication, purchase, or condemnation, real property, including easements or rights-of-way, to establish NEV lanes.

(b) Establish a NEV transportation plan as authorized by this chapter.

1963.6. If the City of Lincoln or the City of Rocklin adopts a NEV transportation plan, each city shall also adopt all of the following as part of the plan:

(a) NEVs eligible to use NEV lanes shall meet the safety requirements for low-speed vehicles as set forth in Section 571.500 of Title 49 of the Code of Federal Regulations.

(b) A permit process for golf carts that requires speed-modified golf carts to meet minimum design criteria adopted pursuant to subdivision (a). The permit process may include, but not be limited to, permit posting, permit renewal, operator education, and other related matters.

(c) Minimum safety criteria for NEV operators, including, but not limited to, requirements relating to NEV maintenance and NEV safety. Operators shall be required to possess a valid California driver's license and to comply with the financial responsibility requirements established pursuant to Chapter 1 (commencing with Section 16000) of Division 7.

(d) (1) Restrictions limiting the operation of NEVs to separated NEV lanes on those roadways identified in the transportation plan, and allowing only those NEVs and speed-modified golf carts that meet the safety equipment requirements specified in the plan to be operated on separated NEV lanes of approved roadways in the plan area.

(2) Any person operating a NEV in the plan area in violation of this subdivision is guilty of an infraction punishable by a fine not exceeding one hundred dollars ($100).

1963.7. (a) If the City of Lincoln or the City of Rocklin adopts a NEV transportation plan pursuant to this chapter, the cities shall jointly submit a report to the Legislature on or before January 1, 2008, in consultation with the Department of Transportation, the Department of the California Highway Patrol, and local law enforcement agencies.

(b) The report shall include all of the following:

(1) A description of all NEV transportation plans and their elements that have been authorized up to that time.

(2) An evaluation of the effectiveness of the NEV transportation plans, including their impact on traffic flows and safety.

(3) A recommendation as to whether this chapter should be terminated, continued in existence applicable solely to the City of Lincoln and the City of Rocklin in the County of Placer, or expanded statewide.

1963.8. This chapter shall remain in effect only until January 1, 2009, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2009, deletes or extends that date.

SEC. 2. Section 385.5 of the Vehicle Code is amended to read:

385.5. A "low-speed vehicle" is a motor vehicle, other than a motor truck, having four wheels on the ground and an unladen weight of 1,800 pounds or less, that is capable of propelling itself at a minimum speed of 20 miles per hour and a maximum speed of 25 miles per hour, on a paved level surface. For the purposes of this section, a "low-speed vehicle" is not a golf cart, except when operated pursuant to Section 21115 or 21115.1. A "low-speed vehicle" is also known as a "neighborhood electric vehicle."

SEC. 3. Section 21250 of the Vehicle Code is amended to read:

21250. For the purposes of this article, a low-speed vehicle means a vehicle as defined in Section 385.5. A "low-speed vehicle" is also known as a "neighborhood electric vehicle."

SEC. 4. Section 21251 of the Vehicle Code is amended to read:

21251. Except as provided in Sections 1963 to 1963.8, inclusive, of the Streets and Highways Code, and Sections 4023, 21115, and 21115.1, a low-speed vehicle is subject to all the provisions applicable to a motor vehicle, and the driver of a low-speed vehicle is subject to all the provisions applicable to the driver of a motor vehicle or other vehicle, when applicable, by this code or any other code, with the exception of those provisions which, by their very nature, can have no application.

SEC. 5. Section 21260 of the Vehicle Code is amended to read:

21260. (a) Except as provided in paragraph (1) of subdivision (b), or in an area where a neighborhood electric vehicle transportation plan has been adopted pursuant to Chapter 7 (commencing with Section 1963) of Division 2.5 of the Streets and Highways Code, the operator of a low-speed vehicle shall not operate the vehicle on any roadway with a speed limit in excess of 35 miles per hour.

(b) (1) The operator of a low-speed vehicle may cross a roadway with a speed limit in excess of 35 miles per hour if the crossing begins and ends on a roadway with a speed limit of 35 miles per hour or less and occurs at an intersection of approximately 90 degrees.

(2) Notwithstanding paragraph (1), the operator of a low-speed vehicle shall not traverse an uncontrolled intersection with any state highway unless that intersection has been approved and authorized by the agency having primary traffic enforcement responsibilities for that crossing by a low-speed vehicle.

SEC. 6. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution.

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APPENDIX F. APPROVED CTCDC MEETING MINUTES

MINUTES

CALIFORNIA TRAFFIC CONTROL DEVICES COMMITTEE (CTCDC) MEETING

Sacramento, July 28, 2005

The second CTCDC meeting of year 2005 was held in Sacramento, on July 28, 2005.

Chairman John Fisher opened the meeting at 9:10 a.m. with the introduction of Committee Members and guests. Chairman Fisher thanked Caltrans for hosting the meeting. The following Members, alternates and guests were in attendance:

ATTENDANCE	ORGANIZATION	TELEPHONE
Members (Voting)		
John Fisher Chairman	League of CA Cities City of Los Angeles	(213) 972-8424
Farhad Mansourian Vice Chairman	CA State Association of Counties Marin County	(415) 499-6570
Gerry Meis	Caltrans	(916) 654-4551
Lenley Duncan	CHP	(916) 657-7222
Ed von Borstel	League of CA Cities City of Modesto	(209) 577-5266
Merry Banks	California State Automobile Association	(415) 241-8904
Jacob Babico	CA State Association of Counties San Bernardino County	(909) 387-8186
Hamid Bahadori	Auto Club of Southern California	(714) 885-2326

ALTERNATES	ORGANIZATION	TELEPHONE
Gain Aggarwal	League of CA Cities City of Vacaville	(707) 449-5349

ATTENDEES	ORGANIZATION	TELEPHONE/E-Mail
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05-5 Proposal for Experimentation Use of a Nonstandard Signage for Neighborhood Electric Vehicles (NEV).

Chairman Fisher asked Gerry Meis to introduce item 05-5 experiment with Signage for Neighborhood Electric Vehicle (NEV) requested by the City of Lincoln.

Gerry introduced Carl Walker, City of Lincoln and asked him to present his experiment proposal to the Committee.

Carl Walker, City of Lincoln, stated that the City of Lincoln and City of Rockln are 6 months into a five-year pilot program for NEV travel within the city. The five-year trial is a result of AB2353 which became law as of January 1, 2005. Carl explained about NEVs and how they differ from golf carts. NEV is a compact vehicle, one to four passenger vehicles powered by rechargeable batteries and an electric motor. NEV are classified as a "low speed vehicle" (LSV) under Title 49 C.F.R Part 571.500. Because NEVs are classified as LSVs, they must meet all safety standards such as seat belts, brake lights, rear lights, headlights, mirrors and windshield. NEVs must comply with all the rules and regulations for a motor vehicle as set for in the California Vehicle Code. NEVs must be registered with the State Department of Motor Vehicles and the driver must hold a valid California driver's license and be insured. NEVs may travel on any street with a posted speed limit of 35 miles per hour or less. NEVs may cross state-highways at controlled intersections only. Golf carts are designed to carry golf equipment and not more than two persons, including the driver. Golf carts are not required to possess the safety equipment required of a low speed vehicle and have a top speed 15-mph. State law prohibits use of golf carts on public roadways outside of a "Golf Cart Transportation Plan".

Carl also pointed out a PowerPoint slide containing the specifications of the NEV. Carl added that the benefits of NEV uses are for short distance at low speeds where traffic, parking and air pollution might be of concern. NEV can travel 150 miles per gallon and it supports local businesses. NEV can reduce personal travel cost and provide mobility for people who cannot drive an automobile. A critical element of the NEV Transportation Plan includes the development of special paving, road markings, signage and striping for NEV travel lanes. Carl added that there are currently no State or Federal standards for NEV lane widths. The City of Lincoln's goal is to provide a safe NEV lane width without the lane being so wide that it encourages automobile use.

Carl also discussed different alternatives for NEV travel lanes, such as Class I NEV lanes, Class II NEV lanes and Class III NEV routes. Class II NEV lanes would be a portion of public roadways that are designated by signs and pavement markings for NEV travel. Class III NEV routes are mixed with traffic on most streets posted 35 mph or less. Carl also discussed different striping patterns which he shares with the Committee members by a Power Point Presentation. Carl also showed a proposed new symbol for the NEV, however he informed the Committee that the City will approach FHWA for symbol approval. In closing, Carl stated that the State of California would benefit from to the City of Lincoln's experience in implementing an NEV transportation plan. The City will identify the hurdles that will be encountered during the implementation of the NEV plan.

Chairman Fisher stated that the presentation showed marking and striping in addition to the signage. However the proposal in the agenda packet only talked about signs.

Carl responded that the City does not have the complete package for application submittal.

Farhad Mansourian stated that the proposed signage does not cover under Section 1A.3 which was recommended to include in the California Supplement earlier by the Committee.

Gerry Meis responded no, the earlier recommendation allows addition of date, extra timing, not to create a verbal message sign.

Hamid Bahadori stated that a golf cart is allowed on roadways with 25 mph or less speeds, so why is there a need to create new signs and striping.

Carl responded that the NEV could operate on roadways with speeds up to 35 mph. The purpose of a separate lane is that if a roadway has a speed higher than 35 mph, then the NEV will have their own travel lane.

Hamid asked whether the City would collect data to determine if NEVs are acceptable to travel on roadways having speeds over 35 mph as long as they have there own travel lanes.

Carl responded that AB2353 allows NEVs on roadways with speeds over 35 mph as long as there is proper signing, striping and a separate travel lane.

Chairman Fisher asked about the Vehicle Code allowing the establishment of separate bus lanes, bicycle lanes, then does this legislation allow the development of separate NEV lanes.

Carl responded yes.

Jacob Babico asked about the sign specification shown on page 32 0f 60 shows "NEV Lane", in his opinion the sign should be "NEV Route".

Carl responded that is correct, it should be "NEV Route".

Chairman Fisher suggested that "NEV Route" sign should be "White on Green".

Hamid added that the request is also for authorization of new pattern of striping.

Gerry Meis added that he was not aware if there would be a request for a marking and striping approval.

Chairman Fisher asked any other comments from the audience and from Committee members.

Roger Bazeley stated that if the proposal is proven to be successful, then it could be expanded throughout California.

Motion: Moved by Farhad Mansourian, seconded by John Fisher, to authorize experimentation with the signage package with the change of "NEV Lane" to "NEV Route" with the use of existing striping details available. Experiment will be conducted on Class II NEV Routes.

Motion carried 8-0.

Action: Item approved for experimentation.

APPENDIX G. CALIFORNIA SENATE BILL 956

Senate Bill No. 956

CHAPTER 442

An act to add and repeal Chapter 8 (commencing with Section 1965) of Division 2.5 of the Streets and Highways Code, and to amend Sections 21251 and 21260 of the Vehicle Code, relating to neighborhood electric vehicles.

[Approved by Governor October 10, 2007. Filed with Secretary of State October 10, 2007.]

LEGISLATIVE COUNSEL'S DIGEST

SB 956, Correa. Neighborhood electric vehicles.

Existing law defines "low-speed vehicle" for purposes of the Vehicle Code as a motor vehicle, other than a motor truck, with 4 wheels that is capable of a minimum speed of 20 miles per hour and a maximum speed of 25 miles per hour on a paved level surface and that has a gross vehicle weight rating of less than 3,000 pounds. Existing law imposes certain restrictions on the use of low-speed vehicles on public streets and highways, and generally requires an operator of a low-speed vehicle to have a driver's license. A violation of the Vehicle Code is an infraction, unless otherwise specified.

Existing law authorizes a city or county to establish a golf cart transportation plan subject to the review of the appropriate transportation planning agency and traffic law enforcement agency. Existing law provides that operating a golf cart other than on an authorized roadway is an infraction punishable by a fine not exceeding $100. Existing law authorizes, until January 1, 2009, the City of Lincoln and the City of Rocklin in the County of Placer to establish a neighborhood electric vehicle transportation plan subject to the same review process established for a golf cart transportation plan, and defines "neighborhood electric vehicle" for these purposes to have the same meaning as the above definition of low-speed vehicle. A person operating a neighborhood electric vehicle in the plan area in violation of certain provisions is guilty of an infraction punishable by a fine not exceeding $100.

This bill, until January 1, 2013, would enact similar provisions authorizing the County of Orange to establish a neighborhood electric vehicle transportation plan for the Ranch Plan Planned Community in that county, subject to similar penalties. The bill would require a report to the Legislature by November 1, 2011. Because the bill would create a new crime, it would impose a state-mandated local program.

The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

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This bill would provide that no reimbursement is required by this act for a specified reason.

The people of the State of California do enact as follows:

SECTION 1. Chapter 8 (commencing with Section 1965) is added to Division 2.5 of the Streets and Highways Code, to read:

CHAPTER 8. NEIGHBORHOOD ELECTRIC VEHICLE TRANSPORTATION PLAN FOR RANCH PLAN PLANNED COMMUNITY IN ORANGE COUNTY

1965. It is the intent of the Legislature, in enacting this chapter, to authorize the County of Orange to establish a neighborhood electric vehicle (NEV) transportation plan for the Ranch Plan Planned Community in the county. The purpose of this NEV transportation plan is to further the community's vision of creating a sustainable development that reduces gasoline demand and vehicle emissions by offering a cleaner, more economical means of local transportation within the plan area. It is the further intent of the Legislature that this NEV transportation plan be designed and developed to best serve the functional travel needs of the plan area, to have the physical safety of the NEV driver's person and property as a major planning component, and to have the capacity to accommodate NEV drivers of every legal age and range of skills.

1965.1. The following definitions apply to this chapter:

(a) "Plan area" means the Ranch Plan Planned Community project area and all streets located within the project area.

(b) "Neighborhood electric vehicle" or "NEV" means a low-speed vehicle as defined by Section 385.5 of the Vehicle Code.

(c) "NEV lanes" means all publicly or privately owned facilities that provide for NEV travel including roadways designated by signs or permanent markings which are shared with pedestrians, bicyclists, and other motorists in the plan area.

(d) "Ranch Plan Planned Community" means the comprehensive land use, conservation, and development program initially approved by the Orange County Board of Supervisors on November 8, 2004, and covering the remaining 22,815 acres of the historic Rancho Mission Viejo located in southeastern Orange County.

(e) "Transportation planning agency" means the Orange County Transportation Authority.

1965.2. (a) The County of Orange may, by ordinance or resolution, adopt a NEV transportation plan for the Ranch Plan Planned Community.

(b) The transportation plan shall have received a prior review and the comments of the transportation planning agency and any agency having traffic law enforcement responsibilities in the County of Orange.

(c) The transportation plan may include the use of a state highway, or any crossing of the highway, subject to the approval of the Department of Transportation.

1965.3. The transportation plan shall include, but is not limited to, all of the following elements:

(a) Route selection, which includes a finding that the route will accommodate NEVs without an adverse impact upon traffic safety, and will consider, among other things, the travel needs of commuters and other users.

(b) Transportation interfacing, which shall include, but not be limited to, coordination with other modes of transportation so that a NEV driver may employ multiple modes of transportation in reaching a destination in the plan area.

(c) Provision for NEV related facilities including, but not limited to, special access points and NEV crossings.

(d) Provisions for parking facilities, including, but not limited to, community commercial centers, golf courses, public areas, parks, and other destination locations.

(e) Provisions for special paving, road markings, signage and striping for NEV travel lanes, road crossings, parking, and circulation.

(f) Provisions for NEV electrical charging stations.

(g) NEV lanes for the purposes of the transportation plan shall be classified as follows:

(1) Class I NEV routes provide for a completely separate right-of-way for the use of NEVs.

(2) Class II NEV routes provide for a separate striped lane adjacent to roadways with speed limits of 55 miles per hour or less.

(3) Class III NEV routes provide for shared use by NEVs with conventional vehicle traffic on streets with a speed limit of 25 miles per hour or less.

1965.4. If the County of Orange adopts a NEV transportation plan for the Ranch Plan Planned Community, it shall do both of the following:

(a) Establish minimum general design criteria for the development, planning, and construction of separated NEV lanes, including, but not limited to, the design speed of the facility, the space requirements of the NEV, and roadway design criteria.

(b) In cooperation with the department, establish uniform specifications and symbols for signs, markers, and traffic control devices to control NEV traffic; to warn of dangerous conditions, obstacles, or hazards; to designate the right-of-way as between NEVs, other vehicles, and bicycles; to state the nature and destination of the NEV lane; and to warn pedestrians, bicyclists, and motorists of the presence of NEV traffic.

1965.5. If the County of Orange adopts a NEV transportation plan for the Ranch Plan Planned Community, it shall also adopt all of the following as part of the plan:

(a) NEVs eligible to use NEV lanes shall meet the safety requirements for low-speed vehicles as set forth in Section 571.500 of Title 49 of the Code of Federal Regulations.

(b) Minimum safety criteria for NEV operators, including, but not limited to, requirements relating to NEV maintenance and NEV safety. Operators shall be required to possess a valid California driver's license and to comply with the financial responsibility requirements established pursuant to Chapter 1 (commencing with Section 16000) of Division 7 of the Vehicle Code.

(c) (1) Restrictions limiting the operation of NEVs to separated NEV lanes on those roadways identified in the transportation plan, and allowing only those NEVs and golf carts that meet the safety equipment requirements specified in the plan to be operated on separated NEV lanes of approved roadways in the plan area.

(2) Any person operating a NEV in the plan area in violation of this subdivision is guilty of an infraction punishable by a fine not exceeding one hundred dollars ($100).

1965.6. (a) If the County of Orange adopts a NEV transportation plan for the Ranch Plan Planned Community pursuant to this chapter, the county shall submit a report to the Legislature on or before November 1, 2011, in consultation with the Department of Transportation, the Department of the California Highway Patrol, and local law enforcement agencies.

(b) The report shall include all of the following:

(1) A description of the NEV transportation plan and its elements that have been authorized up to that time.

(2) An evaluation of the effectiveness of the NEV transportation plan, including its impact on traffic flows and safety.

(3) A recommendation as to whether this chapter should be terminated, continued in existence and applicable solely to the Ranch Plan Planned Community, or expanded statewide.

1965.7. This chapter shall remain in effect only until January 1, 2013, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2013, deletes or extends that date.

SEC. 2. Section 21251 of the Vehicle Code is amended to read:

21251. Except as provided in Chapter 7 (commencing with Section 1963) and Chapter 8 (commencing with Section 1965) of Division 2 of the Streets and Highways Code, and Sections 4023, 21115, and 21115.1, a low-speed vehicle is subject to all the provisions applicable to a motor vehicle, and the driver of a low-speed vehicle is subject to all the provisions applicable to the driver of a motor vehicle or other vehicle, when applicable, by this code or any other code, with the exception of those provisions which, by their very nature, can have no application.

SEC. 3. Section 21260 of the Vehicle Code is amended to read:

21260. (a) Except as provided in paragraph (1) of subdivision (b), or in an area where a neighborhood electric vehicle transportation plan has been adopted pursuant to Chapter 7 (commencing with Section 1963) or Chapter 8 (commencing with Section 1965) of Division 2.5 of the Streets and Highways Code, the operator of a low-speed vehicle shall not operate the vehicle on any roadway with a speed limit in excess of 35 miles per hour.

(b) (1) The operator of a low-speed vehicle may cross a roadway with a speed limit in excess of 35 miles per hour if the crossing begins and ends on a roadway with a speed limit of 35 miles per hour or less and occurs at an intersection of approximately 90 degrees.

(2) Notwithstanding paragraph (1), the operator of a low-speed vehicle shall not traverse an uncontrolled intersection with any state highway unless that intersection has been approved and authorized by the agency having primary traffic enforcement responsibilities for that crossing by a low-speed vehicle.

SEC. 4. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution.

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APPENDICES 3-4

3. UCLA Report into Regulatory Impediments to Neighbourhood Electric Vehicles

4. Pike Research report on NEVs

Regulatory Impediments to Neighborhood Electric Vehicles: Safety Standards and Zero-Emission Vehicle Rules

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UCTC No 458

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The University of California Transportation Center
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Regulatory Impediments to Neighborhood Electric Vehicles: Safety Standards and Zero-Emission Vehicle Rules

TIMOTHY E LIPMAN, KENNETH S KURANI, AND DANIEL SPERLING

The California Air Resources Board mandated the production of zero-emission vehicles (ZEVs) starting in 1998 Other states may follow Among the types of vehicles that may satisfy the requirements of this mandate are small, neighborhood electric vehicles (NEVs) that would be used in urban areas and on collector and arterial streets for a wide range of short trips Although NEVs hold the potential for large energy and environmental benefits, their introduction is hindered by two institutional barriers The first of these is the federal safety standards designed for full-sized, gasoline-powered automobiles The second is the California ZEV regulations that may not award ZEV credits to manufacturers for all vehicles certified as ZEVs, particularly very small NEVs Also there are important inconsistencies in the vehicle definitions used in these and other regulations and vehicle codes This has created confusion with regard to their applicability to various small vehicle designs The history of legislative rule making as it relates to small vehicles is explored, and possible strategies for overcoming these regulatory barriers to the production and sale of NEVs are discussed

Persistent nonattainment of ambient air quality standards in many U S cities and the continued almost 100 percent reliance of the transportation sector on petroleum have prompted new federal, state, and local initiatives to introduce alternative transportation fuels One of the most far reaching of these requirements for new vehicle technology has been enacted by the California Air Resources Board (CARB) Section 1960 1 of Title 13 of the California Code of Regulations requires that 2 percent of new cars delivered for sale by major automakers in California in 1998 be zero-emission vehicles (ZEVs) These proportions increase to 5 percent in 2001 and 10 percent in 2003 On February 1, 1994, 12 states in the Northeast requested permission from the Environmental Protection Agency (EPA) to adopt similar rules

Battery powered electric vehicles (EVs) represent the only available technology that currently meets the ZEV definition Because of their zero tailpipe emissions and flexibility of energy supply, EVs are promising prospects But because of the high cost and relatively poor energy storage characteristics of batteries, many market analyses conclude that few consumers would buy EVs (*1–3*) Although other studies differ in the conclusion (*4,5*), this uncertainty about the market for full-size battery-powered EVs highlights the need to explore other applications and designs for EVs

One new type of vehicle that could help meet environmental and energy goals is the neighborhood electric vehicle (NEV) (see paper by Sperling, this Record) These efficient, clean vehicles could play a valuable role in reducing air pollution, energy consumption, dependence on foreign oil supplies, and greenhouse gas emissions They would be used primarily in urban areas and would not, in general, be intended or designed for freeway travel Their operating environment would be urban and suburban arterials, collector streets, and alleys

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Many of the policy issues confronting the introduction of NEVs can be grouped into the following broad categories

- Modification of regulations and standards to eliminate institutional barriers to the sale and operation of NEVs,
- Development of incentives to stimulate manufacturers to produce NEVs and for consumers to purchase them, and
- Coordination between local, state, and federal agencies to develop the infrastructure and traffic control measures where necessary to provide an appropriate operating environment for NEVs

This paper addresses two underlying institutional barriers in the first category NHTSA federal motor vehicle safety standards (FMVSSs) and language in existing air quality and energy legislation (such as the definitions of ZEV promulgated by CARB), which may not formally recognize these vehicles as "passenger cars " This paper examines the recent history of rule making by NHTSA as it relates to small vehicles The existing procedures under which vehicles that do not conform to the panoply of FMVSSs are sent to market and the potential for obtaining exemptions for or amending problematic standards are described The paper then discusses the potential for the creation of a new vehicle category and proposes a vehicle definition scheme that would accommodate the specialized needs of NEVs Finally the paper explores discrepancies in vehicle definitions in various codes and regulations, including the ZEV mandate, as they affect the regulatory treatment of NEVs

COMPLIANCE WITH FMVSSs

The National Traffic and Motor Vehicle Safety Act of 1966 empowered the U S Department of Transportation to set national safety standards for motor vehicles under the authority of the National Highway Safety Bureau, which later became NHTSA (*6*) NHTSA's primary mandate is to set safety standards that define the minimum level of safety performance for motor vehicles (*7*) The standards promulgated by NHTSA generally fall into three categories crash avoidance (series 100), crashworthiness (series 200), and postcrash (series 300) Automakers are responsible for "self-certifying ' their vehicles A second section of the FMVSSs in 49 CFR addresses the administrative considerations that are relevant to EVs, and this includes NHTSA enforcement (Part 554) and temporary exemption (Part 555) (*8*)

The FMVSSs were originally written for internal combustion engine vehicles, but the recent resurgence in interest in EVs, coupled with government regulations encouraging or mandating their use, has led NHTSA to reinvestigate the potential need for new or modified standards The willingness of NHTSA to explore the development of specific standards for EVs suggests that there may also be potential for modifications in the rules that would allow NEVs to operate in specific environments An examination of the recent history of NHTSA rule making with regard to both three-wheeled and lightweight vehicles sheds light on the potential to create new rules that would allow the production and use of NEVs

Safety Standards and Vehicle Classifications

To demonstrate the interplay between rule making and vehicle design and to introduce the history of rule making regarding small vehicles, consider the case of three-wheel vehicles Under the current federal vehicle classification system, a small, three-wheel EV would be a "motorcycle," but a small four-wheel EV would be considered a passenger car" As a result three-wheel designs would be subject only to the minimal safety standards that apply to motorcycles, whereas four-wheel designs would face the much more stringent standards applied to full size passenger cars The long history behind these rules, particularly with regard to the motorcycle definition, provides some insight into the future potential of small EV classification strategies

On May 16, 1973, NHTSA published a notice of proposed rule making that examined the vehicle classification system with regard to the apparent inequity in the treatment of lightweight vehicles with similar purposes but with a different number of wheels In that proposal, which sought to revise the motorcycle definition, NHTSA said "Whatever the requirements for lightweight vehicles may be in the future, there is no evidence at this time that a dividing line based on whether they have three or four wheels is rational (*9*) NHTSA went on to propose a motorcycle definition that would exclude enclosed, three-wheel vehicles (*9*) The proposal was subsequently deemed ambiguous and revised several times, but the long history of proposals, comments, and revisions ultimately resulted in no change to the motorcycle definition The clear inequity in the treatment of vehicles with three and four wheels was never resolved, despite NHTSA's original concern that

> the present [May 16 1973] definitional dividing line between three and four wheels would create a major incentive for manufacturers of small vehicles, *such as those that may be developed in the future for urban transportation*, to choose a three-wheeled design and thereby escape the necessity to conform to many safety standards (emphasis added) (*9*)

One dilemma posed by this classification system with regard to the three-wheel EV is the trade-off faced by both potential manufacturers and consumers between the cost of compliance with safety regulations (and thus vehicle price) and consumers' own desire for convenient and safe, but inexpensive vehicles A small three-wheel vehicle that qualifies as a motorcycle offers the lowest cost of compliance because of the relatively few standards that would need to be met But the fact that these vehicles, like motorcycles, may be viewed as unsafe, coupled with the inconvenience to consumers of being required to abide by helmet laws, would likely result in a reduced potential market share, despite the relatively low cost of the vehicle A four-wheel design, classified as a passenger car, would have to meet much more rigorous standards, resulting in much higher costs (*10*)

One solution to the problem of NHTSA compliance for NEVs is to define a new vehicle category that defines standards that small, lightweight vehicles must meet In fact in 1967 the NHTSA safety regulations included a general exemption from motor vehicle safety standards for four-wheel vehicles that weighed under 455 kg (1,000 lbs) The exemption was justified on the premise that it would be impossible for such "lightweight vehicles" to meet the standards imposed on full-size cars The wisdom of this decision was quickly challenged by the Center for Auto Safety, which argued that the exemption should be revoked

> the energy exchange in a collision between two vehicles will result in more disastrous consequences for the lighter of the vehicles Further delay in (lightweight) vehicle compliance may create an unreasonable and intolerable risk of harm to the motoring public (*11*)

On August 16, 1972, NHTSA issued a notice of proposed rule making to remove the general exemption, citing the growing interest in lightweight vehicles and declaring that the potential safety hazard was an issue that needed to be addressed At that time NHTSA conceded that lightweight vehicles might not meet all the safety standards, but emphasized that exemptions from specific standards that could not be met might be possible Standards pertaining to structural strength and crush distance were determined to be potentially problematic for small vehicles, but those pertaining to lighting, braking, and glazing would easily be met Because of the different standards that might and might not be met and because such standard specific exemptions already applied to heavy vehicles, NHTSA concluded

> It thus appears in the public interest to consider the needs and problems of lightweight vehicles on a standard-by-standard basis *as is presently done in the case of heavy vehicles*, which receive differential treatment in several standards, rather than by an across the board exemption (emphasis added) (*12*)

Thus, on May 16, 1973, NHTSA removed the general exemption for lightweight vehicles, but once again emphasized that potential manufacturers could petition for an amendment to any impractical standard or could petition for a temporary exemption on one of several potential bases (*13*) This policy toward lightweight vehicles remained unchallenged until 1979, when NHTSA received a petition for the creation of a lightweight vehicle category NHTSA refused the petition in 1981, stating "As a general matter, cars of all sizes should comply with the same safety standards" (*14*) NHTSA argued that the lightweight vehicle exemption was unnecessary because it had found no evidence that the cost of meeting safety standards was preventing the manufacture of lightweight vehicles Furthermore it argued that the technology was available to build "relatively" light passenger cars that could achieve a high degree of fuel economy while also complying with the standards Finally NHTSA pointed out that although lightweight vehicles were in use in Europe and Japan, the vehicle mix in those countries was different from that in the United States and that the greater average vehicle weight in the United States would result in a greater risk of severe injuries for occupants of lightweight vehicles if these vehicles were not able to meet the full range of safety standards Thus the petition was denied and prospective manufacturers of lightweight vehicles were encouraged to develop designs that would comply with the standards to ensure the safety of the vehicle users (*14*)

This rule-making history suggests that in the short term it would be difficult to reinstate a general exemption for lightweight vehicles A more feasible initial alternative would be to identify those safety standards that cannot be met for a given type of vehicle and to pursue exemptions or amendments for those standards to allow those vehicles to be licensed and operated on public roads

Temporary Exemption from FMVSSs

The design, certification, and testing of vehicle models can be an expensive process For example the cost in 1989 and 1990 for Conceptor/EPRI to test the compliance of the electric G-Van with seven FMVSSs approached $1,000,000 (*8*) Clearly the costs of compliance with all the FMVSSs, as would be required for a new vehicle design, could easily reach millions of dollars, because the procedure would need to include the cost of the test facility, multiple vehicles, damage to test equipment, and redesigning and retesting of prototypes Sensitive to the needs of small companies, NHTSA allows manufacturers of lightweight vehicles to seek temporary exemptions from one or more of the FMVSSs (*8*) Under 49 CFR Part 555, an exemption from one or more standards may be granted for up to 2,500 vehicles per year on one of the following bases facilitation of the development of new low-emission vehicles, substantial economic hardship, or the existence of an equivalent overall level of safety

The exemption procedure is available to any manufacturer selling fewer than 10,000 units per year and might prove very useful to a company interested in marketing NEVs For a small company with low (or no) annual sales, the exemption procedure may be the only way to put vehicles on the market, at least in the short term In fact as of 1994 existing converters and manufacturers of "full-size" EVs were selling their vehicles under one or more of these exemptions The exemption period could be used to facilitate demonstration projects and assessments of vehicle safety, potential markets, requirements for new infrastructure, and the operational feasibility of NEVs If the trial period indicates that NEVs would significantly and positively advance air quality, energy, and mobility goals, manufacturers and regulators may wish to pursue the more challenging option of creating a new vehicle classification Such a classification would remove manufacturers' uncertainty regarding design and operational characteristics, provide consumers with an appropriate standard of safety, and clarify for regulators the role of such vehicles in improving air quality and advancing energy policy

NEVs would likely qualify for the exemption as "low-emission motor vehicles" The primary challenge in obtaining such an exemption would be in convincing NHTSA that the failure of a vehicle to meet one or more standards would not constitute an unreasonable degradation in its safety To the extent that this would require detailed crash test reports demonstrating the safety of the vehicle the cost of this process might become a hindrance to the small manufacturers included in the regulation

In the short term NEVs that are not able to meet all of the FMVSSs could be allowed to operate under temporary, low-emission vehicle exemptions from specific safety standards The high cost of meeting the provisions of the FMVSSs is a strong argument for the temporary exemption procedure, but the ease of obtaining an exemption would likely depend on the type and number of standards that the vehicle does not meet and the perceived safety risk of allowing the vehicles to be licensed without conforming to the standards In the longer term the number of exempted vehicles that could operate in this manner is very limited If NEVs are to be one part of an integrated solution to the problem of improving air quality and energy efficiency, a new vehicle category must be defined along with modified or new standards that apply to the safety concepts employed in small vehicles

Permanent Amendment to FMVSSs

It is possible that a permanent amendment to one or more of the FMVSSs could be granted for NEVs on a standard-by-standard basis Historically this has been attempted only for vehicles such as the motor-driven cycle and not for passenger vehicles The process by which standards are added or amended is very time-consuming, particularly for those standards concerned with crash protection (T Vinson, Office of Strategic Planning and Evaluation, NHTSA, unpublished information, March 15, 1993) A petition to alter a standard may be discussed and revised for 2 or 3 years before being accepted Because of a lack of precedents, it is unclear exactly what argument would be necessary to convince NHTSA of the need for a standard to be amended, but this option is potentially less difficult than the creation of a completely new vehicle category and should be considered, particularly if only a few of the standards prove to be problematic

Although the degree of difficulty in meeting these standards will differ by vehicle design, several standards were identified by NHTSA in 1978 as being potentially problematic for electric vehicles in general (*15*) Some other standards were not noted by NHTSA but have since been identified as presenting possible difficulties for small vehicles (*16*) A total of 15 standards have been identified to date, primarily in the level 200 (crashworthiness) category, which suggests that attempting to obtain separate amendments to each standard would be difficult and time consuming

A careful examination of these standards suggests that gaining NHTSA approval for the operation of NEVs may be one of the greatest challenges facing those who wish to introduce these vehicles into the U S market In its 1978 study NHTSA concluded that the CitiCar, a small EV that weighed less than 591 kg (1,300 lbs), would "no doubt have difficulty meeting existing safety standards (*15*) Given the number of standards with which compliance of NEVs is likely to be problematic or that are simply not applicable to the characteristics of the vehicles, potential manufacturers currently have few options apply for temporary exemptions or attempt to operate under loopholes in the law, such as those that exist for three-wheel vehicles Examples of vehicles that use each approach include two Danish designs the Kewet El-Jet, a four-wheel vehicle that is operating under a temporary exemption, and the City-Com City-El, a three-wheel design that is classified as a motorcycle

Creating a New Vehicle Category

A final alternative is to develop a new category of vehicle with an accompanying set of fully relevant standards At the time of the 1978 NHTSA study the CitiCar was determined to be so dissimilar from conventional vehicles that the agency considered developing rules for "a special class of vehicles with restrictions on weight, operational performance, passenger capacity, and use" (8) This option was subsequently deemed infeasible, but perhaps it will be reexplored if a sizable market for small vehicles develops

There are two primary justifications for the creation of a new lightweight vehicle category with an accompanying set of crashworthiness standards The first of these is that safety concepts designed to minimize the hazards of vehicle collisions (i e , composite materials, air bags, and rigid passenger compartments) have improved much in the past 20 years, making it potentially easier for lightweight vehicles to provide a level of safety comparable to that provided by heavier passenger vehicles The current FMVSSs in some cases are highly prescriptive, specifying the means by which standards are to be met (i e , crush zone distance, etc), and this approach excludes other safety concepts that may be more appropriate for small vehicles The second justification for a new category is that NEVs are the only small vehicles that will require substantially different standards Not only will they operate in low-speed environments that will not be as hazardous as those of freeway-capable vehicles but their safety can be enhanced through specialized traffic control measures and infrastructure design concepts These measures can be employed to restrict the commingling of NEVs with heavier, faster vehicles when necessary (see paper by Stein et al , this Record) In a larger sense safety must be considered in context In the case of NEVs the context is slow-moving traffic, a restricted operating environment, and tailored traffic controls

The development of a new vehicle category will require that consensus be reached among manufacturers and regulators as to the description of this new class of vehicle This may be somewhat difficult, but in the long term it seems unavoidable given that the characteristics of NEVs essentially preclude them from complying (at a reasonable cost) with all of the safety standards currently imposed on passenger vehicles The following new definitions are suggested as a starting point for discussion

Minivehicle (MV) a motor vehicle having three or more wheels in contact with the ground, a fully enclosed passenger compartment, a vehicle curb weight of less than 910 kg (2,000 lbs), and a top operating speed of over 65 km/hr (40 mph) and that is designed and used for the transportation of people

Mini-electric vehicle (MEV) a minivehicle that is powered by electrical energy

Neighborhood electric vehicle (NEV) a motor vehicle having three or more wheels in contact with the ground, a fully enclosed passenger compartment, a vehicle curb weight of less than 910 kg (2,000 lbs), and a top operating speed of 65 km/hr (40 mph) or less and that is powered by electrical energy

This scheme can be represented as shown in Figure 1

This classification system is useful because it accomplishes three important tasks First, it makes the basic distinction between small vehicles, with a vehicle curb weight of under 910 kg (2,000 lbs), and larger vehicles This distinction is necessary because the current set of FMVSSs has been designed for full-size vehicles, and all small vehicles, regardless of their propulsion system, may benefit from standards specifically designed for them Second, a useful distinction is made between the vehicles that employ elec-

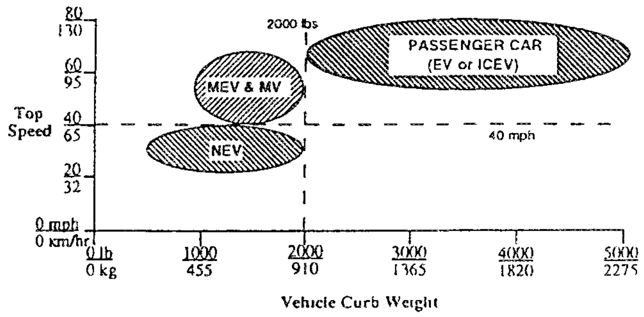

FIGURE 1 Proposed vehicle classification scheme

tric propulsion (i e , NEV, MEV, and EV) and those that do not This is the most basic division needed for the purpose of applying different propulsion-related standards to various vehicle types and for accommodating current and future incentive policies that lower the price and increase the convenience of EVs to encourage their socially desirable emission and energy use characteristics Other refinements can be added to this basic framework for full size and small hybrid vehicles and for other alternate-fuel vehicles Third, this classification scheme distinguishes between MEVs, which will likely be freeway capable and should meet the intent of the FMVSSs (although possibly employing new safety concepts), and the slower and generally smaller NEVs, which are not freeway capable and thus have clearly distinct requirements for safety standards

Thus a new classification scheme would provide a simple framework that could be used for the dual purposes of developing incentive policies for the use of clean, efficient vehicles and of developing safety standards that address the specific needs of different vehicle types and sizes It is important to note that the majority of the standards will be met without difficulty by small vehicles, but in the long term standards that are based on vehicle speed and size will need to be modified, particularly for NEVs, for these vehicles to be brought to market at a reasonable cost

INCONSISTENT REGULATIONS AND ZEV MANDATE

The primary motivation for manufacturers to introduce EVs in California is the ZEV mandate promulgated by CARB in Section 1960 1 of Title 13 of the California Code of Regulations But the applicability of that mandate to NEVs is unclear because of the inconsistent and vague vehicle definitions in regulations and codes The ZEV mandate applies only to passenger cars and light-duty trucks Although the definition of a "passenger car" used by CARB is "any motor vehicle designed primarily for transportation of persons and having a design capacity of 12 persons or less," at this time some vehicles, particularly NEVs with three wheels that would be certified as ZEVs (for purposes of tax credits and other incentives) would not be awarded ZEV credits (California Code of Regulations, Title 13, Section 1900) Manufacturers of four-wheel NEVs apparently would receive ZEV credits, but CARB has yet to make an official determination on the inclusion of various types of NEVs in the credit scheme The fate of NEVs with regard to this critical mandate is therefore unclear

In addition to the uncertainties surrounding the CARB ZEV regulations, NEVs face the problem of a lack of consistency among the vehicle definitions used by various regulations and vehicle codes The EPA Clean Air Act Amendments (CAAA), the Corporate Average Fuel Economy (CAFE) standards, the federal Uniform Vehicle Code (UVC), and the California Vehicle Code (CVC) all use different motor vehicle definitions, adding greatly to the confusion surrounding policy and regulatory issues related to NEVs To choose a particularly bewildering example, a three-wheel EV capable of 50-mph travel (an early prototype made by the Horlacher company would meet these criteria) would be considered a "passenger vehicle" by CVC, a "motorcycle" by UVC, a "passenger car" by CARB, a "light-duty vehicle" under CAAA, and possibly a "passenger automobile" and possibly not (depending on a determination by the Secretary of Transportation) for purposes of inclusion under the CAFE standards

The definitions used in promulgating the CAFE standards and the regulations of CAAA are confusing in that the terms *passenger car*, *passenger automobile*, and *light-duty vehicle* are all used to mean essentially the same thing, but subtle differences do exist A *passenger automobile* is defined, for the purposes of CAFE standards, as a vehicle designed to carry "no more than 10 individuals," and a *light-duty vehicle* is defined, for the purposes of CAAA, as being "capable of seating 12 passengers or less " Thus a vehicle seating 11 passengers is a "light-duty vehicle" but not a "passenger automobile" (40 CFR §600 002-85 and 40 CFR §86 082-2) Of greater relevance to the NEV is the language of the CAFE regulation defining an *automobile* as a "four-wheel vehicle " The exclusion of vehicles with fewer than four wheels would hold barring a determination by the Secretary of Transportation that such vehicles would be "substantially used for the same purposes" (40 CFR §600 002-85)

A first and obvious recommendation would be to combine the terms *passenger car*, *passenger automobile*, and *passenger vehicle* and give the resulting term a clear and consistent definition throughout the various codes and regulations The authors suggest using the term *passenger car*, as used in UVC, because it is the most widely used and thus the easiest to standardize and also because it has a simple definition that clearly excludes motorcycles and could easily be modified to exclude other vehicle categories Another recommendation would be to define the terms *light-duty vehicle*, *medium-duty vehicle*, and *heavy-duty vehicle* primarily in terms of the weight of the vehicle and to restrict the usage of these terms to situations in which the weight of the vehicle is important In cases in which weight is not an issue, more general terminology should be used (i e , *passenger car*, *neighborhood electric vehicle*, etc)

In summary simplifying and reconciling the terms used to define vehicles would remove a considerable amount of confusion that currently exists A consistent and precise definition scheme would allow manufacturers to know with certainty how various vehicle designs would be affected by laws and regulations and would aid them in their strategic planning in bringing their vehicles to market and in meeting the ZEV mandate Given the potential importance of the mandate in California and elsewhere in promoting the sale of EVs, the success of the NEV concept may depend on it being included in the provisions of the rule Such inclusion would likely have to be supported by analyses of how much pollution and gasoline vehicle use is reduced as a result of each NEV purchase If analysis shows that NEVs are used much less than gasoline-powered vehicles (and full-sized EVs), fractional ZEV credits could be awarded

CONCLUSIONS

The introduction of small, limited-performance NEVs to consumers and cities confronts a rule-making system tied to full-size, gasoline-powered cars Standards and rules need to be made more flexible to accommodate differences A first step is to define appropriate classifications, definitions, and standards for NEVs and other small vehicles Specifically the development of NHTSA safety regulations that are appropriate for small vehicles operating in restricted environments and the inclusion of all NEV designs in the credit scheme of the ZEV mandate are critically important for the success of the NEV concept The second issue, qualification for ZEV credits, is of especially great importance because it creates a potential market for NEVs

A research agenda designed to address the issues raised in this paper must include safety, emissions, and vehicle use studies Development and testing of new safety concepts, new materials, and the interaction between vehicles in low-speed operating environments will clarify how safety standards can be modified to allow for the safe operation of NEVs The potential for these vehicles to substitute for short, low-speed, urban trips suggests that their emissions reductions may be far greater than indicated by the number of trips or number of miles they travel Thus the ability of NEVs to complement, rather than replace, gasoline-powered vehicles within a household stock of vehicles must be assessed

With the cooperation of vehicle manufacturers and federal and state agencies, procedures and policies that will allow NEVs to meet the requirements of ZEV regulations in California and other states and to provide safe transportation can be implemented If this is done the viability of the ZEV mandate will be strengthened and a new mode of safe, efficient and environmentally benign transportation will become available

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http://www.pikeresearch.com/newsroom/695000-neighborhood-electric-vehicles-to-be-on-the-road-by-2017

695,000 Neighborhood Electric Vehicles to be on the Road by 2017

June 16, 2011

Neighborhood electric vehicles (NEVs), also known as low-speed electric vehicles, were one of the original “electric vehicle” categories and have been on the market for a number of years. NEVs are street legal with a top speed of 25 miles per hour. Originally conceived as a way to fulfill the California Air Resources Board zero emissions requirements in the late 1990s, the vehicles have found a niche with fleets that can use inexpensive vehicles on public roads, and consumers who live in communities that often have designated paths and parking for the vehicles.

According to a new report from Pike Research, the total number of NEVs on the world’s roadways will grow from 479,000 in 2011 to 695,000 by 2017, a 45% increase. During that period, the cleantech market intelligence firm forecasts that annual NEV sales will rise from 37,000 vehicles to nearly 55,000 units by 2017, and North America will account for 45% of annual sales.

“Neighborhood electric vehicles are proof that EVs will take many forms in different parts of the world,” says senior analyst Dave Hurst. “And while moderate in terms of sales volumes compared to other emerging vehicle markets, the growth rate for NEVs will double that of the total light duty vehicle market during the same period.”

Hurst adds that NEVs remain competitive and relevant in today’s market by utilizing lead acid battery technology, allowing them to compete at less than half the cost of light duty electric vehicles. At $100 to $200 per kilowatt hour (kWh), these lead acid batteries are the most inexpensive batteries available. Batteries used in NEVs include flooded, gelled, and absorbed glass mat (AGM) lead acid batteries.

Pike Research’s report, “Neighborhood Electric Vehicles”, provides a comprehensive examination of the market forces, technology issues, government incentives and regulations, and key drivers of the growth of neighborhood electric vehicles. The report includes sales, revenue, and battery forecasts through 2017, as well as profiles of key industry players. An Executive Summary of the report is available for free download on the firm’s website.

Pike Research is a market research and consulting firm that provides in-depth analysis of global clean technology markets. The company’s research methodology combines supply-side industry analysis, end-user primary research and demand assessment, and deep examination of technology trends to provide a comprehensive view of the Smart Energy, Smart Grid, Smart Transportation, Smart Industry, and Smart Buildings sectors.

Neighborhood Electric Vehicles

Low-Speed Electric Vehicles for Consumer and Fleet Markets: Demand Drivers and Barriers, Technology Issues, Key Industry Players, and Market Forecasts

Neighborhood electric vehicles (NEVs) were one of the original “electric vehicle” categories and have been on the market for a number of years. NEVs are street legal with a top speed of 25 miles per hour. Originally conceived as a way to fulfill the California Air Resources Board zero emissions requirements in the late 1990s, the vehicles have found a niche with fleets that can use inexpensive vehicles on public roads, and consumers who live in communities that often have designated paths and parking for the vehicles.

NEVs remain competitive and relevant in today’s market by utilizing lead acid battery technology, allowing them to compete at less than half the cost of light duty electric vehicles. Pike Research’s analysis indicates that the global market for NEVs is currently small, but will grow at a healthy pace over the next several years.

This Pike Research report provides a comprehensive examination of the market forces, technology issues, governmental incentives and regulations, and key drivers of the growth of neighborhood electric vehicles. The report includes sales, revenue, and battery forecasts through 2017, as well as profiles of key industry players.

Key Questions Addressed:

- How are neighborhood electric vehicles (NEVs) defined?
- How do NEVs differ from golf carts and light duty vehicles?
- Who are the typical customers of neighborhood electric vehicles?
- How large is the fleet market for NEVs?
- How important are urban planning issues to the NEV market?
- What are typical prices of NEVs?
- How important are government purchase incentives for the NEV market?
- What types of batteries are used in the vehicles?
- What the cost breakdowns for major components in NEVs?
- Who are the major manufacturers of these vehicles?
- How large is the NEV market?
- Where are the biggest opportunities for NEV sales?

Who needs this report?

- OEM marketing managers
- OEM product planners
- Battery manufacturers
- Electric motor manufacturers
- Government agencies
- Industry associations
- Fleet managers
- Utilities

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