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Eco-Driving Scoping Study

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Report prepared for:
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By:
Rebecca Luther (TERNZ)
Peter Baas (TERNZ)

Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

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EXECUTIVE SUMMARY

In February 2011, the AA Research Foundation and the Energy Efficiency and Conservation Authority (EECA) commissioned Transport Engineering Research New Zealand (TERNZ) to undertake a scoping study to explore the potential of eco-driver training as a means to improve fuel efficiency in New Zealand.

During this research information on eco-driving was collected through a literature review, collation of New Zealand driver and vehicle demographic data, and a survey of AA members to determine their views on eco-driving (presented in a separate report). Based on the information collected, the following report discusses:

- The benefits of eco-driving.
- Existing light vehicle eco-driving schemes (New Zealand and internationally).
- The effectiveness of eco-driving schemes.
- Implementing eco-driving in New Zealand.
- A proposed future research plan.

Benefits of Eco-Driving
Eco-driving is promoted as having a wide range of benefits beyond a reduction in fuel use and the consequent greenhouse gas emissions. However, in many cases the evidence for these benefits is relatively limited. What follows is a list of potential benefits of eco-driving for which some evidence was found during this review:

- Reduced use of and demand for non-renewable natural resources (petrol/diesel) through reduced fuel consumption.
- Reduced CO_2 emissions and other pollutants (through reduced fuel consumption).
- Improved vehicle safety, particularly where schemes involve moderation of driver speed, plus observation and anticipation of the situation ahead.
- Reduced ambient noise levels (where advice about rpm is adhered to).

While evidence was not found as part of this review, other potential benefits for eco-driving cited in eco-driving literature include.

- Reduced vehicle running costs (tyre wear and tear, general vehicle maintenance).
- Reduced driver/passenger stress.
- Improved traffic flow.

Existing Light Vehicle Eco-Driving Schemes
The review of existing eco-driving schemes indicated that, internationally, a large number of schemes have been developed. Eco-driving has the longest history in Europe and therefore, the most developed schemes exist in European countries. However, interest in eco-driving is emerging in the United States and other countries such as Australia.

In many countries eco-driving programmes are multi-faceted, including both training and communications components that target one, or several, of the following groups:

- Unlicensed drivers: Typically a combination of embedding eco-driving in the licensing system and public education campaigns.

- Licensed drivers: Typically a combination of voluntary training schemes (sometimes subsidised) and public education campaigns.
- Professional drivers: Typically training schemes (sometimes subsidised) targeted at companies operating fleets.

In most cases countries have made relatively significant financial investments in eco-driving in order to reach these large target populations.

Some schemes, particularly in Europe, have been in place for a number of years and are relatively well developed and evaluated. Therefore, New Zealand can draw on a significant body of knowledge and good practice when developing an eco-driving programme.

Many schemes involve partnerships between government organisations, charities, private organisations and industry bodies. In particular, Ford Europe has partnered with several European countries to develop eco-driving schemes. These relationships appear to be essential to ensure that the scheme is credible and likely to reach its target audience(s).

Several countries have now embedded eco-driver training in their driver licensing system. In these countries most new drivers receive eco-driving training, and in some cases, drivers can fail their driving test if they do not demonstrate eco-driving skills. However, the inclusion of eco-driving in driver licensing is not particularly well embedded in most countries. A new European Union (EU) programme called ECOWILL aims to further embed eco-driver training in driver licensing in participating countries.

A range of eco-driver training schemes for licensed drivers were identified during this review (a number of these were actively promoted to organisations with light vehicle fleets). A wide range of training approaches were identified. However, emerging areas of promise appear to be the shorter 'training snack' approach and the use of driving simulators. Notably, the ECOWILL programme aims to further develop and embed both these approaches in Europe.

In addition to training and communications campaigns, a number of more innovative approaches for promoting eco-driving have been trialled. In particular, most car companies are now introducing eco-driving technology into their vehicles. Other means of encouraging environmentally friendly driving, such as through insurance discounts, are now under discussion.

Effectiveness of Eco-Driving Schemes

A limited number of high quality eco-driving scheme evaluations were identified during this review. While many claims about the effectiveness of eco-driving schemes are made, they are often based on evaluations of driver performance immediately following training in relatively artificial environments such as off-road driving tracks. A number of European eco-driving schemes may have been subject to more rigorous evaluation (particularly the German eco-driving schemes). However, reports in English were not identified during this review. What is clear is that more rigorous evaluations are required to confidently establish estimates of likely medium and long term reductions in fuel consumption resulting from particular types of eco-driving scheme (e.g. communications campaigns vs. one-on-one training).

Despite the lack of agreement about the specific benefits arising from eco-driving, there appears to be a general consensus that some benefit will be realised. Based on this review, it seems likely that a 5% reduction in fuel consumption (approximately) may be a reasonable estimate of the benefits that might be expected from the average eco-driving scheme over the medium term. In-car devices and other on-going feedback may help to improve this result. However, there is currently insufficient evidence to validate this claim. For example, the Fiat study which evaluated real world driver performance using devices that provided on-going driver feedback realised an average 6% reduction in fuel consumption. Where they were available, specific details of the more rigorous eco-driving scheme evaluations are provided in this body of this report.

While early cost-effectiveness data appears to indicate that, in comparison to other fuel reduction measures, eco-driving is a relatively cost-effective approach. Results from established eco-driving schemes in the Netherlands indicate that significant funding is still required to reach a relatively modest number of drivers.

Implementing Eco-Driving in New Zealand

Before the type of eco-driving scheme that may be appropriate for New Zealand is decided upon, a range of factors must be considered. In particular:

- What type of scheme would be most appropriate for New Zealand given the demographic profile of New Zealand drivers and vehicles?
- The views of the New Zealand public on the value of eco-driving?
- The views of industry experts on eco-driving, in particular their knowledge of existing factors that may support or block the implementation of particular types of schemes.

As part of this research, an analysis of New Zealand driver demographics was undertaken and a series of eco-driving scheme options were reviewed with the project steering group. Further information on the views of the New Zealand public on eco-driving (based on the results of a survey of AA members) is provided in a separate report.

Results of the demographic analysis indicated that the New Zealand driver and vehicle profile has some key features that should be considered when reviewing eco-driving options:

- Males in the 25-59 year age group drive a larger number of kilometres than other groups and may therefore be an appropriate target for an eco-driving campaign.
- Learner drivers make up a relatively small part of the driving population (about 1.5% in any year).
- Many learner drivers do not sit the driving test to get their full licence and therefore may be unmotivated to undertake training on peripheral skills such as eco-driving.
- New Zealand has a relatively old light vehicle fleet.

The eco-driving initiatives identified were:

1. Including eco-driving as a formal part of the driving test.
2. Including eco-driving as an educational part of driver licensing.

3. Providing training for licensed fleet drivers.
4. Providing training for licensed drivers.
5. Promoting in-car eco-driving devices.
6. Eco-driving communications campaigns.
7. Eco-driving insurance.

The project steering group supported all seven initiatives in principle. Strengths, weaknesses and opportunities were identified for all initiatives. However, further cost-benefit analysis is required to clearly establish which initiatives may be more appropriate in the New Zealand situation.

Proposed Future Research Plan

Following a review of eco-driving initiatives the steering group proposed that the following actions be taken:

1. Complete a cost-benefit study on including eco-driving as part of the driver licensing requirements, including considering the safety benefits arising from eco-driving.

2. Undertake a market survey to identify what name should be used for eco-driver training.

3. Undertake a review of options for eco-driver training for existing drivers in fleets and as private motorists.

4. Undertake a review of eco-driving devices covering: what devices exist that may be suitable, what devices may soon become available, would these devices suit the NZ vehicle fleet.

5. Develop a marketing plan to support an eco-driving communications campaign. EECA has developed a draft marketing plan which is included at Appendix A.

6. Further research to be undertaken on initiatives involving eco-driving insurance.

In order to develop a coherent eco-driving programme in New Zealand the following issues should also be considered:

- Should an overarching ‘brand’ for eco-driving in New Zealand be developed to ensure that various schemes are recognisably linked?
- How should any programme be linked to national targets for CO_2 reductions?
- Who is the target audience(s)?
- What type of scheme(s) might be feasible in New Zealand (e.g. what is the likelihood of including eco-driving in the driver licensing system)?
- What should the scheme(s) ‘look like’ (e.g. training snacks or longer courses, what messages should be included in a public education campaign)?
- What partnerships can be formed to increase the likelihood of a scheme’s success?

Based on the steering group's proposed actions and the issues listed above the following research plan is suggested:

- Undertake a review of New Zealand environmental and transport policy and identify areas where eco-driving could contribute to achieving policy aims.

- Undertake a review of eco-driving branding and decide how any eco-driving programme should be designed and marketed. Conduct a high-level cost-benefit analysis of all seven initiatives and identify those that are both feasible in the New Zealand context and would form a coherent eco-driving programme Develop a detailed implementation plan for each feasible initiative. The development of the plan would include engaging with key stakeholders, identifying areas where leverage can be providing by existing initiatives, identifying costs/budget for the initiative and specific implementation actions (e.g. target audience). For example, if the eco-driving devices initiative passes the cost/benefit threshold, all of the actions listed in point 4 above would be undertaken.

1 BACKGROUND

In February 2011, the AA Research Foundation and the Energy Efficiency and Conservation Authority (EECA) commissioned Transport Engineering Research New Zealand (TERNZ) to undertake a scoping study to explore the potential of eco-driver training as a means to improve fuel efficiency in New Zealand.

The aim of this study is to provide background information and recommendations on what should be included in a larger scale research programme.

The following set of research questions was agreed by the steering committee and formed the focus of the research:

1. Why encourage eco-driving?
2. What eco-driving schemes exist and what are the costs associated with delivering them?
3. How effective are existing eco-driving schemes?
4. What is the influence of external factors on the cost and benefits of eco-driving schemes?
5. How could eco-driving be best implemented in New Zealand?

In order to explore these questions the following activities were undertaken:

- A literature review summarising readily available information on eco-driver training[1].
- The collation of New Zealand driver demographic data.
- A survey of AA members to determine their current level of knowledge and interest in eco-driving.
- The development of a research plan and preparation of a report.

This report is structured as follows:

Section Two:	Benefits of Eco-Driving.	Overview of the potential benefits of adopting eco-driving practices.
Section Three:	Eco-Driving Schemes.	Brief description of identified light vehicle eco-driving schemes (including costs where available).
Section Four:	Effectiveness of Eco-Driving Schemes.	Summary of the results of identified eco-driving scheme evaluations, including consideration of cost-effectiveness.

[1] Note: because a number of studies highlight the need for an integrated approach to eco-driving, several types of eco-driving scheme, other than training (such as communications campaigns and use of fuel saving technology) were also briefly reviewed as part of this research.

Section Five:	Implementing Eco-Driving in New Zealand.	Discussion of the issues associated with implementing eco-driving in New Zealand. This includes consideration of New Zealand driver demographics, influence of external factors, anticipated uptake of eco-driving practices (based on survey results) and projected benefits of implementing a scheme.
Section Six:	Conclusions and Proposed Research Plan	

2 BENEFITS OF ECO-DRIVING

2.1 Eco-Driving Defined

Barkenbus (2010) provides the following list of driving techniques/behaviours typically associated with eco-driving:

- Accelerating moderately (with shift ups between 2000-2500 revolutions for those with manual transmissions).
- Anticipating traffic flow and signals thereby avoiding sudden starts and stops.
- Maintaining an even driving pace (using cruise control on the highway where appropriate).
- Driving at, or safely below, the speed limit.
- Eliminating excessive idling.
- Vehicle maintenance (such as maintaining optimum tyre pressure and regular changing of air filters).

This list is generally representative of most descriptions of eco-driving, although vehicle selection is sometimes included.

For the purposes of this study, eco-driving was considered to be *driving* behaviours intended to reduce fuel consumption and associated vehicle emissions. As such, vehicle selection and maintenance were not considered.

2.2 Benefits of Eco-Driving

While the eco-driving 'brand' is not currently well recognised by the general public in most countries, road transport policy makers and interest groups have long understood the potential benefits of using a driving style that reduces fuel consumption and associated vehicle emissions. In fact, the first eco-driving scheme was introduced in the United States in the early 1970s (Barkenbus, 2010).

Eco-driving appeals to policy makers because, in contrast with many other environmental initiatives, it requires no new technology, little public funding and offers immediate financial gains to those individuals and organisations who take it up. With many countries poised to enter new regulatory agreements with the aim of reducing greenhouse gas emissions, any cost-effective initiative to reduce transport emissions is highly appealing.

While the potential benefits of eco-driving for reducing vehicle emissions are clear. Eco-driving literature suggests that the advantages go beyond CO_2 emission reductions and include reducing the cost of driving to the motorist, tangible safety benefits, and amenity benefits (such as reduced noise).

The following section summarises evidence of the potential benefits of eco-driving identified during this review. It covers:

- Fuel consumption and vehicle emissions,
- Road safety, and

- Community/population health impacts.

2.2.1 Fuel Consumption and Vehicle Emissions

Inefficient patterns of human behaviour provide a significant opportunity for reducing energy consumption. Ehrhardt-Martinez (2008) cites several studies suggesting that, across the board, gains of up to 25% could be achieved (e.g. Gardener and Stern, 2008, cited in Ehrhardt-Martinez, 2008).

Because private vehicles make up a substantial proportion of personal energy consumption, there is potential for gains in this area to make a significant contribution to overall energy savings. For example, Barkenbus (2010) notes that personal vehicle emissions are the largest single contributor to household/individual emissions in the United States.

In New Zealand, light vehicles (cars and vans) contribute 23% of total consumer energy use, thereby creating 26% of the CO_2 produced in the transport sector[2]. The transport sector as a whole, contributes 19% of New Zealand's total greenhouse gas emissions (Ministry for the Environment, 2011).

A number of researchers have calculated the environmental benefits that might arise from the general adoption of eco-driving techniques. Typically, these are discussed in terms of expected reductions in fuel consumption and/or expected reductions in CO_2 emissions.

The first consideration when calculating the potential benefits of eco-driving is what reductions in individual fuel consumption might be realistically expected following eco-driving interventions. This issue is still the subject of debate and potential savings have been found to range from 25% to less than 5% depending on the nature of the scheme and the type of evaluation undertaken. The effectiveness of individual eco-driving schemes will be discussed in more detail in Section Three of this report. However, for the purposes of projecting the potential benefits of eco-driving, most researchers appear to assume a 5-10% reduction in fuel consumption.

Barkenbus (2010) provides the following worked example of the potential benefits of eco-driving in the United States:

- In 2005, approximately 428 billion litres of fuel was consumed by cars owned by households in the United States. Therefore, a 10% reduction in fuel consumption through eco-driving would amount to 42.8 billion litres saved.

- A litre of gasoline when combusted emits 2.31 kilos of CO_2 to the atmosphere. Therefore a saving of 42.8 billion litres amounts to approximately 100 million metric tons of CO_2 saved. This assumes that no drivers currently use eco-driving and all convert.

- A more realistic estimate of one third of drivers converting to eco-driving would result in a saving of 33 million metric tons of CO_2

[2] http://www.transportco2.org.nz/co2.htm

These savings are equivalent to two thirds of the annual emissions of the aluminium industry in the United States or the equivalent of the emissions of seven large coal-fired electricity plants.

In terms of cost savings, Barkenbus indicates that total societal level savings range from $7.5 to $15 billion per year (calculated by taking a third of 42.8 billion litres, 14.3 billion, and multiplying that by lower and upper limit values for the price of gasoline at $0.53 or $1.06 per litre). Dividing the societal level savings by a third all households (35 million) indicates that the average individual household savings for those adopting eco-driving would be between $214 and $428 per year.

In Europe, projections in 2001 by the EU European Climate Change Programme suggested that the adoption of eco-driving techniques in 15 EU countries had the potential to remove 50 million tons of CO_2 per year from the total road traffic emissions resulting in a cost saving of approximately €20 billion (Eco-Driving Europe, Undated).

A more up-to-date report by Fiat (2010) states that if everyone in Europe was eco-driving (saving approximately 6% of fuel) this would equate to twice the annual production of the world's biggest oil rig, or 50% of Portugal's annual carbon footprint. The cost savings would equate to 40% of the total investment in European renewable energy in 2009.

Using the worked example provided by Barkenbus, the following potential benefits of eco-driving can be calculated for New Zealand:

- In 2007, approximately 2.1 billion litres of fuel (petrol or diesel) was consumed by New Zealand households for transport purposes[3]. Therefore, a 10% reduction in fuel consumption would amount to approximately 210 million litres saved.

- If a litre of gasoline emits 2.36 kilos of CO_2 to the atmosphere, and a litre of diesel emits 2.69 kilos of CO_2 to the atmosphere[4], then a saving of 210 million litres amounts to approximately 0.5 million metric tons of CO_2.

- Or if, as estimated by Barkenbus, one third of drivers convert to eco-driving, the saving would amount to approximately 70 million litres saved and approximately 0.17 million metric tons of CO_2.

These calculations suggest that the adoption of eco-driving by one third of the population has the potential to result in significant reductions to New Zealand's overall greenhouse gas emissions.

2.2.2 Road Safety

While improving road safety is not the primary purpose of specialised eco-driving schemes, the eco-driving style (moderating speed, driving smoothly and anticipating traffic flow) is highly correlated with the driving style promoted to reduce accident risk.

[3] This figure is based on the following data http://www.med.govt.nz/templates/MultipageDocumentPage____40946.aspx Petrol L/hld and Diesel/hld for 2007 were both multiplied by Households (000s).

[4] Figures for the CO_2 equivalent content of petrol and diesel were obtained from "Voluntary Greenhouse Gas Reporting Energy Emission Factors 2009" published by the Ministry of Economic Development and available on their web-site at http://www.med.govt.nz/upload/Voluntary%20Emission%20Factors.pdf. The petrol figure differs slightly from that used by Barkenbus but it is a figure used by government in New Zealand..

A comprehensive study of this issue was undertaken by Haworth and Symmons (2001) who reviewed evidence of the safety benefits of driving in an eco-friendly style (with particular consideration given to driving speed). They considered both specialised eco-driver training and other schemes that, while not focused on eco-driving, encouraged drivers to use an eco-friendly style.

The authors noted that, at the time of their review, limited information was available about the effects of specialised eco-driving schemes on safety. While several studies (e.g. Preben, 1999; and Johannson, 1999, both cited in Haworth and Symmons, 2001) claim a positive safety benefit, little detail was provided in their papers. However, Haworth and Symmons do cite the Cannon Company case study discussed later in this section (Reinhardt, 1999, cited in Haworth and Symmons, 2001).

As part of the review, the authors also identified several examples of safety benefits from schemes that, while not specialised eco-driving schemes, encouraged eco-driving behaviours. These studies are briefly described below:

- van Uden (1997) undertook research that considered the effects of reducing the speed limit for private vehicles in the Netherlands. The author concluded that the maximum enforcement of *current* limits would reduce hospital admissions by 15% and deaths by 21%. Furthermore, the intervention would reduce fuel consumption and carbon dioxide emissions by 11% and nitrogen oxide emissions by 15%. In total, these benefits were projected to lead to savings of $US260 million per year.
- Meers and Roth (2001) undertook an analysis of projected fatality and greenhouse gas savings from major Queensland road safety and environmental programs (e.g. breath testing and speed cameras). They found that the greatest CO_2 savings could be achieved using speed cameras, 400,000 tons of CO_2-e per annum (using 1999 emission data) with the fuel consumption reduction from lower speeds being the primary driver of the benefits. Savings from other initiatives ranged from 33 to 67,000 tonnes per annum.

The studies identified by Haworth and Symmons were undertaken some time ago. However, no more up-to-date information on the safety benefits of eco-driving schemes was identified during this review. One additional paper that highlighted safety benefits of eco-driving was produced by the European EcoDrive programme (Eco-Driving Europe, Undated). Within this document the following case studies are cited:

- Cannon Company in Switzerland provided eco-driver training for 350 of their service drivers. An evaluation of the scheme showed that the drivers reduced fuel consumption by 6.1%, drove 22% more kilometres per accident and had 35% fewer accidents in total.
- A German company, Hamburger Wasserwerke, found that eco-driver training resulted in a 6% reduction in fuel consumption and a 25% reduction in accidents and related costs eleven months after training.

While little specific research on the safety benefits of eco-driving was identified, the studies and case studies described in this section do suggest that significant road safety benefits might arise from adopting an eco-driving style. The primary benefits seem to arise from reduced vehicle speed. In addition, while no supporting evidence was provided, benefits are also likely to arise from a more anticipatory driving style.

While this review focuses on the effects of eco-driving in the light vehicle fleet, the results of studies of eco-driver training for heavy vehicles are worth consideration. A number of case studies have recently been developed on the effectiveness of SAFEDNZ fuel efficient driver training for heavy vehicles (see section 3.4 for further details). Those case studies have consistently shown major reductions in speeding, the amount of braking required and other indicators of safer driving practice. Several of these are outlined below:

- Alexander Petroleum, a nationwide fuel tanker operation, implemented a number of measures, including eco-driving, that resulted in:
  - 17.8% reduction in fuel consumption.
  - More than 50% reduction in the number of safety incidents (from 23 incidents in the first six months of 2005 to 10 incidents in the first six months of 2008).
  - Improved recordable incident rates across all key health, safety and environmental areas.
  - 99% reduction in the occurrences of speeding over 90km/h(.
- During their training nine senior SAFEDNZ driver trainers achieved a:
  - 4.9% reduction in fuel consumption.
  - 6% reduction in trip time.
  - 25.7% reduction in brake use by anticipation and responding more appropriately to the situation ahead.
  - Elimination of all speeding events.
- JPM Holdings, a South Island transport operator with 32 drivers and 16 trucks achieved:
  - 13% improvement in fuel efficiency.
  - 75% fewer speeding events (over 95km/hr).
  - Reduction in significant unscheduled vehicle breakdowns.
  - Much better and more open communication between drivers and managers.
- Westland Milk Products, based in the West Coast region, operates 20 truck and trailer milk tanker combinations and has 57 drivers. In less than three months the following improvements were achieved:
  - 4% improvement in fuel efficiency.
  - 33% improvement in speed management.
  - 13% reduction in harsh braking events.

These studies suggest that, on New Zealand roads, significant safety benefits may be achieved by providing eco-driver training to light vehicle drivers.

Finally, while almost all research on the safety benefits of eco-driving focuses on positive safety benefits, one study undertaken in 2004 by the Turku University in Finland (cited in CIECA, 2007), describes some potential safety issues associated with adopting an eco-driving style. For example:

- A principle of rapid acceleration to target speed could be taken too literally and could cause shorter safety distances in traffic if not combined with proper anticipation.

- Maintaining a constant speed, if misunderstood, can lead to insufficient safety margins because of delayed slowing down.
- Applying engine braking too early may result in a different pattern to that of 'normal traffic' and increase the risk of a rear-end collision.
- The principle of 'avoiding stopping' could cause problems if it is applied near pedestrian crossings or intersections without a clear view 'it is possible that the learner driver's observation skills may be inadequate'.

2.2.3 Community/Population Health Impacts

Literature promoting eco-driving often highlights community/population level benefits resulting from eco-driving such as reduced noise, reduced local air pollution and improved population health. However, little quantified data is available to substantiate these claims.

Eco-Driving Europe (undated) indicates that reduced local traffic noise would result from the reductions in engine revving associated with eco-driving techniques. The paper states that the engine noise of one vehicle revving at 4000 rpm is equivalent to the noise of 32 vehicles revving at 2000 rpm. Therefore, if drivers were to follow eco-driving recommendations, one of the main problems of traffic in urban areas would be significantly reduced.

In terms of reduced local air pollution, while many training programmes and eco-driving schemes highlight benefits in this area, no quantified information about specific reductions in pollutants as a result of eco-driving was identified as part of this review. However, general information about vehicle emissions/pollutants and population health is provided by Haworth and Symmons (2001) who cite data from the United States Environmental Protection Agency.

Haworth and Symmons state that motor vehicles are major contributors to total emissions of CO_2, oxides of nitrogen (NO_x), volatile organic compounds (VOCs, sometimes termed hydrocarbons, HCs) and lead, and are also significant sources of emissions of particles with an aerodynamic diameter greater than 10 and 2.5 micrometres (PM_{10} and $PM_{2.5}$). These compounds have the following potential health effects:

- Exposure to high levels of carbon monoxide may impair alertness and vision in healthy individuals.
- Exposure to nitrogen dioxide can cause coughing, wheezing and shortness of breath in children and adults with respiratory disease. Short-term exposure can also increase the risk of respiratory illness in children.
- Oxides of nitrogen and volatile organic compounds react together in the atmosphere under stable atmospheric conditions and strong solar radiation to form photochemical smog. Ozone in photochemical smog can irritate the respiratory system (causing coughing, irritation and uncomfortable sensations in the chest), reduce lung function, inflame and damage the lining of the lung and aggravate asthma.

Particles with an aerodynamic diameter greater than 10 (coarse particles) and 2.5 micrometres (fine particles) (PM_{10} and $PM_{2.5}$) are a health concern because they can be inhaled into the respiratory tract and deep into the lungs. This information suggests that there are potential population health benefits that might result from the adoption of eco-

driving (resulting in reduced fuel consumption and vehicle emissions). However, more research is needed to project the specific potential benefits of eco-driving schemes.

2.3 Summary

Eco-driving is promoted as having a wide range of benefits, beyond the reduction of greenhouse gases. This review indicates that although some evidence for these benefits can be found, in many cases more research is needed to accurately determine the potential benefits of specific eco-driving schemes. What follows is a list of possible benefits of eco-driving for which some evidence was found during this review:

- Reduced use of and demand for non-renewable natural resources (petrol/diesel) through reduced fuel consumption.
- Reduced CO_2 emissions and other pollutants (through reduced fuel consumption).
- Improved vehicle safety, in some cases, particularly where schemes involve moderation of driver speed.
- Reduced ambient noise levels (where advice about rpm is adhered to).

While evidence was not found as part of this review, other potential benefits for eco-driving cited in eco-driving literature include.

- Reduced vehicle running costs (tyre wear and tear, general vehicle maintenance).
- Reduced driver/passenger stress.
- Improved traffic flow.

3 ECO-DRIVING SCHEMES

One of the earliest fully developed eco-driver training schemes was introduced in the United States in the 1970's by the Department for Energy who developed an energy awareness training programme targeting government fleets and motor pools (Barkenbus, 2010). While this scheme was abandoned in the 1980's, in more recent years many new eco-driving schemes have been developed throughout the world by government departments, charities, private eco-driver training providers and multi-national companies.

The following section provides an overview of eco-driving schemes for light vehicles identified during this review. It should be noted that because a scoping review was undertaken, the list of schemes presented in this section is not exhaustive.

Schemes are grouped by the country in which they were implemented (a section for European Union,EU, schemes is also included). Where schemes are delivered in multiple countries/regions[5], usually because they are provided by multi-nationals such as Ford, they are listed separately in Section 3.2.

While the main focus of the review is eco-driver training (including novice driver training and re-educating licensed drivers), in order to provide a fully developed view of the types of eco-driving schemes undertaken in each country, communications schemes are also described where they were identified. A brief description of some innovative eco-driving technologies and eco-driving incentive schemes based on driver insurance is also provided (Section 3.3).

Finally, a short discussion of eco-driving schemes for heavy vehicles is included (Section 3.4) in order to provide the reader with a fully rounded view of eco-driving activities. This section was included because it is likely that lessons can be learnt from heavy vehicle eco-driving initiatives which will be relevant to the implementation of eco-driving initiatives in New Zealand light vehicle fleets.

3.1 Eco-Driving Schemes by Region

3.1.1 Europe

Eco-driving has been enthusiastically embraced in Europe where schemes have been developed by both individual countries, in particular the Netherlands, and the EU as a regional group.

Within this section, two key EU-level programmes are presented and, following this, schemes implemented in individual countries are described. Some of the 'individual country' schemes are aligned with EU programmes and others have been undertaken on the initiative of the country itself. Where possible an indication of whether schemes are linked to broader EU programmes is provided. However, this is not always clear from the available literature[6].

[5] Other than the European Union.
[6] In some cases key reports on a scheme may not have been translated into English.

EU-Level Eco-Driving Schemes

Most EU-level eco-driving schemes have been developed under the umbrella of Eco-Driving Europe[7]. This initiative was launched in 2001 with the aim of ensuring an integrated approach to eco-driving and accelerating the implementation of eco-driving schemes in Europe (Eco-Driving Europe, Undated). Specifically, the schemes aims were to:

- Build a European network,
- Build a knowledge basis, and
- Make eco-driving a policy issue.

Under this umbrella one eco-driving scheme has been completed and another is ongoing:

- ECODRIVEN (2006-2008) - A European-wide campaign to improve driving behaviour, energy efficiency and traffic safety.
- ECOWILL (2010-2013) - Launched in May 2010, involves the development of short duration eco-driving training programmes for licensed drivers and the promotion of learner driver eco-driving training.

A brief overview of each scheme is provided below. Examples of how they were implemented are provided within the descriptions of eco-driving activities for individual countries.

ECODRIVEN

The ECODRIVEN programme[8] was active between 2006 and 2008 and was undertaken on behalf of Intelligent Energy Europe (EACI). The countries involved were Austria, Finland, the Czech Republic, Belgium, Poland, France, Greece, UK, the Netherlands (Eco-Driving Europe, 2009).

ECODRIVEN was based on a bottom-up approach through European-wide local and regional collaborations of the programme consortium with relevant national and local stakeholders who supported campaign activities and distributed campaign materials (e.g. car dealers, fuel companies, touring clubs, drivers' associations, driving schools, and municipalities).

While a number of countries were already implementing eco-driver training at the time ECODRIVEN was launched, the programme ensured that best practice was shared across all countries involved and enabled already active countries to enhance their eco-driving programmes. For example, SenterNovem (Netherlands) linked ECODRIVEN to their national eco-driving campaign concept, branding and network Het Nieuwe Rijden. Motiva (Finland) used the concept of the previous Finnish marketing campaign of safe and economical driving (2005-2006), but new activities and materials were implemented and produced under the Easy, Rider! logo. Further details of both programmes are provided later in this section (Eco-Driving Europe, 2009).

Campaigns by individual countries included, on-the-road training, simulator training, leaflets, stickers, posters, quizzes, lotteries and competitions, and mass media campaigns (TV, articles, radio). However, many countries appear to have focused on communications

[7] www.ecodrive.org
[8] European Campaign on Improving DRIVing behaviour, ENergy efficiency and traffic behaviour.

campaigns. Key campaign messages adopted by the various participants included, relaxed easy driving, save money and protect the environment.

Under ECODRIVEN, the effectiveness of short-duration or 'snack' training courses was also explored by some countries (in particular the UK). The results of the UK Ecodriven-EST-Ford competition have led to a national programme to provide one-to-one eco-driving snack training for organisational employees[9] (Eco-Driving Europe, 2009)

ECOWILL

The ECODRIVEN programme increased awareness of eco-driving in Europe and laid the foundation for further work through the establishment of a European network and knowledge base. ECOWILL is seen as the next step in implementing eco-driving and involves rolling out short duration eco-driving training programmes for licensed drivers in 13 European countries and promoting the education of learner drivers in eco-driving (Eco-Driving Europe, 2010). The five main objectives of the project are:

- To deploy both the existing infrastructures of driving schools and advanced driver training for the rollout of short duration *eco-driving snack training courses* and *online (e-learning) education* for licensed drivers.
- To *standardise the contents* of snack training courses and to *certify trainers* for providing snack training courses.
- To *train licensed drivers* of passenger cars and vans in *eco-driving* and to involve additional drivers through publicity and media attention.
- To engage governmental and driving school administrations *to incorporate eco-driving in the driving school curriculum.*
- To harmonise and optimise the contents and application of *eco-driving* in the driver test for learner drivers.

In addition, the project has five strategic (long term) objectives**:**

- Setting of defined *standards for eco-driving* snack trainings which can be easily *adopted at pan-European level.*
- Establishing a dense *infrastructure for eco-driving training deployment* which will keep the eco-driving alive after termination of the ECOWILL project.
- Rising *awareness about eco-driving* among drivers, all target groups.
- Incorporation and harmonisation of eco-driving in the driver test and consequently the *incorporation of eco-driving in the driving school curriculums in all EU countries.*
- *Reductions in fuel consumption, GHG emissions*, other *air pollutants emissions* such as NOX, PM, VOC etc. as a result of introducing eco-driving in the markets of the EU 27[10].

As such, there are three main columns to ECOWILL (Lau, 2011):

- Integration and harmonisation of eco-driving in the regulatory framework of driving school education and examination.

[9] For more details see the section on UK eco-driving initiatives.
[10] http://www.ecodrive.org/en/home/ecowill_the_project/objectives/

- Rolling out of eco-driver training for licensed drivers.
- Building up a suitable eco-driving infrastructure of qualified driving instructors.

The ECOWILL programme aims to reduce carbon emissions in Europe by up to 8Mt until 2015 (Eco-Driving Europe, 2010).

A number of EU countries have already integrated eco-driving into their driver licensing system to some degree so it is likely that ECOWILL will, in part, involve transfer of best practice between countries.

In order to reach licensed drivers, ECOWILL will involve developing and rolling out short duration (one hour) training courses to be delivered one-on-one by qualified instructors. In addition, greater use of e-learning and simulators will be explored (Lau, 2011).

TREATISE

Additional work on eco-driving at an EU level has also been undertaken as part of the TREATISE project (2005-2007). The main focus of this project was to encourage organisations (local energy agencies and transport actors) to design and implement new transport initiatives aiming to reduce greenhouse gas emissions. Eco-driving formed part of this work (SenterNovem, 2005). The outputs of the project were three manuals:

- Mobility management,
- Cleaner fuels and vehicles, and
- Eco-driving.

To a greater degree than the Eco-Driving Europe projects, the TREATISE work focuses on encouraging eco-driving at an organisational, rather than individual, level.

Eco-Driving Schemes in Europe (Individual Country Initiatives)

The following section provides information about eco-driving activities undertaken in individual EU countries where they were identified during this review.

It should be noted that this review does not represent an exhaustive list of eco-driving schemes operated in European countries. Many countries other than those listed have some eco-driver education or eco-driving campaigns. Those presented were chosen as a sample of the most developed interventions.

Finland

Finland has had various eco-driving schemes in place since 1995, including integrating eco-driving into novice driver training and testing, licensed driver eco-driving training and communications campaigns (associated with ECODRIVEN).

For novice drivers, eco-driving was first introduced as part of novice driver training in 1995 and became part of the driving test in 1998 (CIECA, 2007). Finland has a graduated driver licensing system and eco-driving is trained and assessed in both the first and second phases of licensing.

During the first phase, eco-driver training is provided in one hour classroom-based training sessions that cover: environmental awareness in the broader sense; the effects of

transport on the environment; choosing a car from an environmental perspective; transport planning (use of alternative transport modes) and trip planning as well as basic techniques for eco-driving (CIECA, 2007). Eco-driving is assessed in the theory test (typically at least 1 question out of 60 is environment related) and during the practical driving test. While drivers cannot fail the driving test because of poor eco-driving they are provided feedback by examiners (CIECA, 2007).

During the second phase of licensing, eco-driving is focused on more intensively during 'before-and-after drives' where the driver's driving style is appraised and a recording of the exact fuel consumption is taken (CIECA, 2007). All driving instructors receive training on economical driving and most driving examiners have received similar training.

Finland is now involved in the ECOWILL project described at the beginning of this section and it is possible that existing eco-driver training and assessment will be updated to align with this project.

For already licensed drivers, Finland promotes eco-driver training through the EcoDriving Centre[11]. The centre provides eco-driver training courses for individual drivers and organisations. Training material is based on research undertaken by Motiva. During a course each participant takes an individual driving style test which is used to identify personal factors affecting fuel consumption. They then receive an eco-driving guide and written report on the economic efficiency of their driving. The EcoDriving Centre is currently exploring how driving simulators might be used to provide eco-driver training more efficiently (Savolainen, 2010).

In addition to driver training, in 2007, as part of the ECODRIVEN campaign, Finland launched an eco-driving communications campaign (Wilbers, 2007).

The campaign was known as 'Easy, Rider!' and the concept was that the driver is like a rider who should treat his vehicle gently. The message was relaxed, comfortable, safe, efficient driving. Target groups were licensed drivers and organisational employees. The campaign was presented in magazines, newspapers, television and on the internet. Several campaign impressions are presented in Figure 1.

[11] ecodriving.com.

Figure 1: Campaign Impressions for 'Easy, Rider!'

Netherlands

Eco-driving has been actively promoted in the Netherlands since 1988 and, as a result, the country has one of the most developed eco-driving programmes in the world. All eco-driving activities are linked to a long-term strategy including the most recent programme, 'Het Nieuwe Rijden' (Van den Berg, 2007). This programme is executed by SenterNovem (a Dutch agency for energy and the environment) on behalf of the Dutch Ministry of Transport and in cooperation with the Ministry of Environment.

Het Nieuwe Rijden focused on creating the necessary conditions and organisational structures to facilitate more energy-efficient vehicle purchase and driving behaviour. It targets individuals and focuses on changing the behaviour of car users and fleet owners, who participate on a voluntary basis. Apart from the targets related to CO_2 emission reduction, the programme emphasises additional advantages of eco-driving such as economic gains, comfort and safety.

In order to achieve its goals a range of consumer and retail organisations were involved in the programme, mainly in the transport and car business such as the Royal Dutch Touring Club (ANWB), the Dutch Consumer Association, the Dutch Bureau for Driver's licenses (CBR), the Dutch branch-organisation for entrepreneurs related to mobility (BOVAG), and the Dutch Association of Car Importers (RAI-Association).

The programme budget for 1999-2005 was €10 million. From 2003-2006 it was raised to €15 million and most recently the third phase of the programme, 2006- 2010 was awarded €15 million. Approximately half of the budget is focused on setting up communication

campaigns; the remaining half is spread over subsidized projects, contracted projects (e.g. for setting up training structures), and overall project execution costs (van der Hoed, Harmelink, & Joosen, 2006).

The programme includes the following activities[12]:

Integrating eco-drive principles into the driving school curriculum: The Netherlands has worked intensively to introduce eco-driver training and assessment into the licensing process (from 2008 onwards). Preparations for the inclusion of eco-driving involved providing free half-day training sessions for instructors and examiners to ensure that they had sufficient skills to provide learners with training and assessment in eco-driving (CIECA, 2007).

Training new drivers in eco-driving: Energy-conscious driving has now been formally added as an appendix to the driver training and testing curriculum and eco-driving is one of 13 criteria that can be used in reaching a pass-fail decision in the practical driving test. The current stance with regard to the relative weight of energy-conscious driving in a pass/fail decision is that candidates will not fail on the basis of poor eco-driving as long as his/her safe driving behaviour is otherwise excellent. However, poor eco-driving can contribute to failure if other (safe driving) aspects of the candidate's performance are found to be lacking. Eco-driving has thus become an important assessment criterion (CIECA, 2007).

Stimulating an eco-drive driving style of (professional) drivers: In order to educate licensed drivers on eco-driving several actions have been taken including training instructors (as described above), providing subsidised training for groups of professional drivers, developing a driving simulator to be used in workshops and conferences and extensive media campaigns (see example described below).

Stimulating the purchase of in-car devices: In order to stimulate the purchase and use of fuel-saving in-car devices (e.g. econometers, cruise control, and other feedback systems), the programme lobbied successfully to achieve tax-incentives for such devices. The tax-exemption was active from 2000-2005. In addition, in-car devices have been brought to the attention of the public through public campaigns and demonstration programs.

Facilitating optimal tyre pressures: In order to increase awareness of the need to frequently check tyre pressure, the programme has organised (or subsidised) demonstration and training projects on tyre checking. In addition, information campaigns (folders, websites) as well as targeted marketing activities (e.g. folders to repair and maintenance shops) have been set up.

Stimulating purchase of more efficient vehicles: No specific programme was set up to promote the purchasing of more environmentally friendly vehicles, given the overlap with an Eco-labelling programme for cars already in place. However, the purchase of more efficient vehicles has been stimulated by raising awareness in driving school curriculum, licensed driver training and communication campaigns.

This review indicated that the Dutch national eco-driving communications campaign developed as part of 'Het Nieuwe Rijden' was also aligned to ECODRIVEN. It involved

[12] This information was sourced from Van den Berg, 2007 and Harmsen, van der Hoed, and Harmelink, 2007.

television and radio commercials, advertisements in newspapers and magazines, internet based promotions (including eco-driving games), workshops, conferences, and the distribution of promotional material (Wilbers, 2007).

The campaign promoted ‘a new way of driving’ and was based on the Dukes of Hazzard. The message was relaxed, comfortable, safe, efficient driving, and modern engine technology. The target groups for the campaign were licensed drivers, fleet owners and intermediaries. When the scheme was evaluated in 2005, the following eco-driving boosting activities and communications had been undertaken (SenterNovem, 2005b):

- 407 television spots.
- 429 radio spots.
- Commercials in movie theatres.
- 400 newspaper/magazine articles.
- Internet, 139,429 hits.
- 20 Conference presentations.
- Promotional material, over 400,000.

Several campaign impressions are presented below.

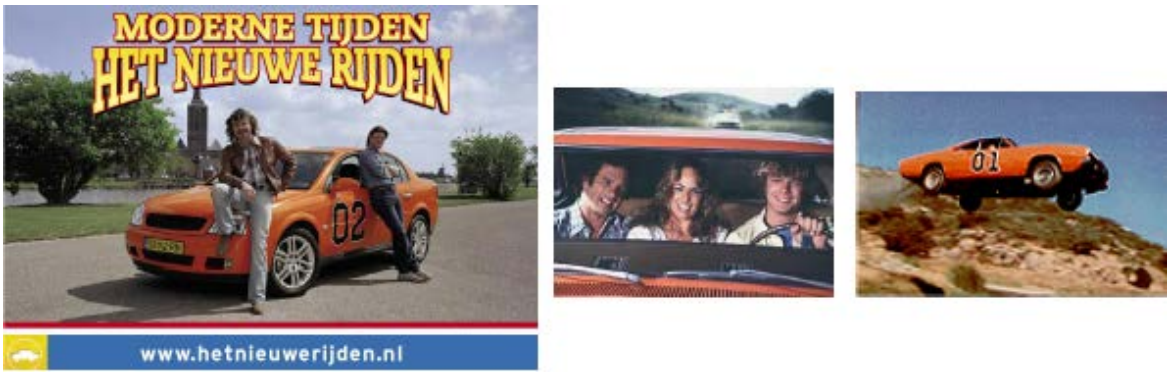

Figure 2: Campaign Impressions for ‘Het Nieuwe Rijden’.

Germany

Like the Netherlands, eco-driving promotion has a relatively long history in Germany. Research on eco-driving has been underway through the German Road Safety Council (DVR) since 2000. Eco-driving programmes in Germany target both novice and licensed drivers.

For novice/learner drivers, eco-driving became part of both the practical and theory driving tests in 1999. In order to ensure that drivers received sufficient eco-driver training, eco-driving principles were incorporated into the ‘Leitfaden’ or scripts that instructors follow for each stage of the learning-to-drive process. For instance, swift ‘changing of gears’ and ‘coasting’ have been integrated into the initial learning stage.

Eco-driving issues are also dealt with in compulsory theory lessons which are split into technical, social and discussion-based components. Licence candidates in Germany can fail the practical test if they make significant eco-driving errors. However, the number of

candidates who fail purely on the basis of eco-driving errors is very low and is estimated to be around 1% (CIECA, 2007). Germany is now one of the countries involved in the ECOWILL programme which will provide further focus on eco-driving in driver licensing.

To provide training to licensed drivers, DVR has partnered with several eco-driver training providers (Lau & Schaarschmidt, 2007). For private organisations, DVR has partnered with BG to develop a series of training programmes including full day training courses for six participants, half day training courses for three participants and training snacks.

For private individuals and fleets, DVR has partnered with Ford Europe to develop training snacks. More details on this scheme are presented in the section on Ford in Section 2.2.1.

A key part of the ECOWILL programme, is the development and roll-out of short course 'training snacks'. A similar concept to the training courses that have already been developed, implemented and evaluated in Germany.

In order to ensure that the eco-driving message reaches a broad audience, in 2006 the German Ministry of Transport approved the contents and budget for a campaign on eco-driving aimed at young drivers, entitled 'cool farhen – sprit sparen' 'drive cool – save fuel' (Lau & Schaarschmidt, 2007).

The campaign included 3500 instructor training sessions combined with the production of a range of campaign materials such as flyers, neckbands for mobile phones and keys, television and newspaper advertising and internet downloads[13].

Switzerland

Like other European countries, eco-driver training is also embedded in the Swiss driver licensing process.

During the first phase of licensing, eco-driving principles are covered in Road Sense classes (the only compulsory element of initial driver training). Where drivers choose to use a driving instructor to learn to drive, they also receive practical eco-driving training. Most driving instructors have undertaken special training on eco-driving. During the driving test eco-driving errors are noted and some could relate to failing the test (e.g. failing to turn the vehicle off at traffic lights).

At least one of the two training days during the second phase driver licensing has a major focus on eco-driving. This includes two on-road feedback drives, where 2-3 novice drivers evaluate each other's eco-driving performance in the presence of a trainer. The first feedback drive focuses on the novice driver's normal driving style. This drive is followed by a group class-based session where the novice drivers work out for themselves what constitutes good environmentally-conscious driving, recalling what they have learned in the initial training phase. A second feedback drive takes place in which the novice drivers are expected to apply eco-driving techniques. As in Finland, fuel consumption is recorded for a before-and-after comparison and to visually illustrate the benefits of eco-driving

[13] http://www.cool-fahren-sprit-sparen.de/

techniques. Driver trainers are required to complete a 10-day further training course which includes these eco-driving elements (CIECA, 2007).

A Swiss organisation (Quality Alliance Eco-Drive) is acting as part of an advisory board for ECOWILL. However, Switzerland does not appear to be explicitly involved in the project.

In Switzerland eco-driver training for licensed drivers is provided by the Eco-Drive Quality Alliance[14] which was formed in 2000. It includes transport associations, training providers, federal agencies and private organisations. The goal of the organisation is to provide passenger and truck drivers with eco-driving education. The organisation provides a wide range of eco-driving courses (for novice and experienced drivers) both on-the-road and in driving simulators.

United Kingdom

Eco-driving as a concept is relatively well established in the United Kingdom. As such it has been partially embedded in the driver licensing process and a number of courses are available for licensed drivers. The United Kingdom has been involved in ECODRIVEN and will take part in ECOWILL.

A CIECA review of eco-driving in driver licensing (2007) indicated that eco-driving does form part of the licensing process in the United Kingdom. However, specific information was not provided. A review of Driving Standards Agency (DSA) information indicates that eco-driving became part of the driving test in 2008 (DSA, 2008) and that the current DSA handbook 'Driving: The Essential Skills' now provides information on eco-safe driving. During licensing, while candidates are provided with feedback on eco-driving, they cannot fail the test because they do not demonstrate eco-safe driving techniques.

To prepare for the addition of eco-driving to the driving test, alterations were made to the Approved Driving Instructor (ADI) Test of Driving Ability in 2005 to ensure that ADIs had the skills necessary to train learner drivers in eco-driving (DSA, 2008).

There are also a number of eco-driving schemes for licensed drivers available in the United Kingdom. Perhaps the largest is provided through the Energy Saving Trust[15]. This scheme and several others are described below.

The Energy Saving Trust provides guidance on eco-driving and has worked with partners to develop an eco-driving short-course for company employees. The course is based on the findings of ECODRIVEN partners, notably Ford of Europe, that short-duration one-to-one lessons can be a very cost-effective way to promote eco-driving.

The courses were developed in 2007 following a joint campaign run by the Energy Saving Trust and Ford Britain (Saynor, 2008). The campaign had four aims:

- Promoting eco-driving to consumers in the UK,
- Testing the effectiveness of short-duration eco-driving lessons,
- Building the case for government funded eco-driving lessons, and
- Leveraging from a relatively small ECODRIVEN budget.

[14] Ecodrive.ch
[15] www.entergysavingtrust.org.uk.

The campaign was branded the "Ford - Energy Saving Trust Smart Driving Challenge", and comprised a national competition to find the UK's most efficient driver. The Challenge was held over thirteen days at the British Motor Show in London and at five regional locations. Drivers competed for a total of £20,000 worth of energy saving products provided by Ford.

In total, 494 drivers participated in the Challenge and achieved an average reduction in fuel consumption of 22.5% after tuition. The results of this trial enabled the Energy Saving Trust to present the Government with solid, United Kingdom based, evidence showing the effectiveness of driving tuition in reducing fuel consumption. This evidence was a key part of a decision made in 2008 by the United Kingdom Department for Transport to fund training for 4000 drivers in 2008/9 and potentially 40,000 in 2009/10.

Energy Saving Trust eco-driver training is organised in partnership with employers, lessons are 50 minutes long and are available to all drivers rather than just company drivers. The cost to the employer/employee is £15 per person (with additional funding provided by government).

Eco-driver training is also provided through Global Action Plan, an environmental charity and one of the leading organisations on environmental behaviour change in the United Kingdom. This organisation has eco-driving simulators which are used to provide training to individuals on eco-driving.[16]. They were developed with support from Toyota Europe and Carbon Connections, in partnership with the University of East Anglia. There are a range of realistic simulations involving urban, extra-urban and motorway driving that enable users to put their new environmental driving techniques into practice. In addition, each simulator provides participants with a breakdown on their fuel efficiency, distance travelled and overall ranking. The eco-driving simulator is accompanied by two trained educators and the simulators are available for short and long-term hire.

Finally, a programme aimed specifically at van fleets has been developed and implemented extensively in the United Kingdom called SAFED[17] for Vans. This programme follows on from the successful development of the SAFED for Heavy Vehicles scheme and is endorsed by the United Kingdom Department for Transport[18].

SAFED for Vans involves comprehensive 'off the job' driver development that combines both theoretical training and practical implementation of safe and fuel efficient driving techniques[19]. This programme has been specifically designed for the Light Commercial Vehicle (LCV) sector.

Following a successful demonstration, the Department for Transport funded the SAFED for Vans programme and established a network of trainers. All SAFED trainers have to be Accredited Driving Instructors and have undertaken SAFED trainer training. Whilst direct government funding for SAFED for Vans ended in April 2010, training remains available on a commercial basis from the established network of experienced SAFED trainers.

[16] http://www.globalactionplan.org.uk/ecodriving-simulator
[17] Safety and Fuel Efficient Driving
[18] Note: a SAFED for Heavy Vehicles programme has also been developed and implemented in NZ and is described later in this section.
[19] The programme can be run in half a day for one driver or several drivers can do a full day of training.

Since its launch in 2006, SAFED has delivered training to over 13,000 van drivers, demonstrating the following benefits:

- A 16% improvement in miles per gallon,
- A 33% reduction in gear changes,
- Negligible impact on journey time, and
- Significant cost savings[20].

As part of the implementation of SAFED for Vans, the Department for Transport produced a series of case studies, including one for Office Depot UK. Office Depot operates a fleet of 300 vans and undertook a pilot study of SAFED for Vans training at their Northampton depot using 16 drivers. The results of the pilot showed that drivers achieved a 12% increase in fuel efficiency following training (Department for Transport, Undated).

In addition to the eco-driver training initiatives described above, several eco-driving communications campaigns have been run in the United Kingdom.

In 2006/2007 as part of the European Union's ECODRIVEN campaign, the Smarter Driving ACT on CO_2 campaign was launched. It used animation to create a link between driving style and fuel usage/emissions with the key message being the financial savings to the driver. The campaign was run in the press, online, by radio and outdoor posters (Wilbers, 2007).

In 2007/2008, Transport for London ran a campaign that included a series of eco-driving messages on the backs of buses. These were specifically designed to be seen by drivers following the buses (Eco-Driving Europe, 2008).

More recently, in 2009, the Energy Saving Trust launched a new £1.5m advertising campaign with Scottish Government funding to encourage eco-driving. The campaign targeted commuters as they were driving to and from work through a combination of filling station, billboard, breakfast and drive-time radio advertising. The idea behind this campaign was to make sure that eco-driving tips are given to commuters when they can actively do something about it (when they are behind the wheel of the car)[21].

3.1.2 United States: Eco-Driving Schemes

While eco-driving has been actively promoted by European agencies for many years, eco-driving schemes are still relatively rare in America. During this review two significant schemes were identified as well as a few locally based eco-driving schemes aimed at light vehicles. One, implemented by the city of Milwaukee, is described below.

The best publicised American eco-driving scheme identified during this review, EcoDrivingUSA, was developed by the Alliance of Automobile Manufacturers[22] in conjunction with Californian Governor Arnold Schwarzenegger and Colorado Governor Bill Ritter in 2008. The goal of the scheme is to 'help spread the word about meaningful

[20] http://vanbestpractice.businesslink.gov.uk/cms/new-drivingholder
[21] http://www.edinburghguide.com/story/transport/car/2855
22 The Alliance of Automobile Manufacturer is a trade association representing 11 automakers: BMW Group, Chrysler LLC, Ford Motor Company, General Motors, Jaguar Land Rover, Mazda, Mercedes-Benz, Mitsubishi Motors, Porsche, Toyota and Volkswagen.

ways to both save money at the pump and reduce carbon dioxide emissions at the same time'.

EcoDrivingUSA takes the form of a public education and awareness initiative and aims to provide consumers with tips on how regular vehicle maintenance combined with simple changes in driving habits can lead to significant improvements in fuel economy and reductions in automobile carbon dioxide emissions. The core of the scheme is a website, ecodrivingusa.com, which provides detailed information about eco-driving and educational/promotional resources such as posters and manuals (Drive Sustainably, 2009)[23].

EcoDrivingUSA has also engaged in promoting eco-driving by forming partnerships with other organisations such as the Network of Employers for Traffic Safety (NETS). NETS run an annual workplace safety campaign to remind all employees of safe driving practices. By partnering with this organisation EcoDrivingUSA were able to promote the message that driving safely and efficiently go hand-in-hand.

Another significant eco-driving public information campaign is run by the Department of Energy Efficiency (DoE) who provide web-based public information on fueleconomy.gov. This website, which was deployed in 1999, includes a wide range of information on vehicle purchasing (including hybrids and alternative fuels), eco-driving and vehicle maintenance. The site also provides calculators to estimate fuel usage.

In order to increase traffic on the website, DoE have actively engaged with media, for example, developing educational segments for public television show, MotorWeek. The site has been mentioned in over 500 television, internet and radio articles and as of April 2007, the site had achieved over 40 million user sessions.

As well as nationwide public education campaigns such as those described above, a number of more local eco-driving schemes have been launched in the United States. Perhaps the most notable, and one of the few that involved active driver training, is the Milwaukee Department of Public Works: Fleet Training on Eco-Driving Project[24].

The project, a two-year initiative, was launched in September 2008 and is promoted as the first eco-driving program of its kind in the United States since DECAT was launched in 1976. The aim of the scheme is to improve air quality through a reduction in vehicle emissions.

The scheme involved fleet drivers working for the City of Milwaukee Department of Public Works and Veolia Water Milwaukee. Drivers in both fleets received eco-driving classroom instruction, behind-the-wheel training, pre- and post-testing, and a Fleet Training Manual. The results of the training were a 10.42% increase in miles per gallon of fuel used[25].

As interest in eco-driving in the United States has increased, several research streams on eco-driving have also emerged. In February 2011 the Journal of Environmental Protection included an article on research being undertaken by University of California, Riverside's College of Engineering Center for Environmental Research and Technology (CE-CERT)

[23] This document was sourced from the following website: http://drivingsustainability.com/
[24] http://www.dnr.state.wi.us/air/pubinfo/airmatters/200906.html
[25] http://city.milwaukee.gov/mpw/general/GreenMilwaukeeEcoDriving.htm

on eco-driving. This research focuses on the use of on-board eco-driving devices that provide instantaneous fuel economy feedback under real-world driving conditions. To date, this research has shown that using the eco-driving device, known as Eco-Way, can result in improved fuel economy by six percent on city streets and one percent on highways. This research appears to be aligned with work being undertaken by a range of vehicle manufacturers on the inclusion of eco-driving tools in new vehicles (Environmental Protection, 2011).

Finally, one organisation providing eco-driver training was identified as part of this review. Eco-Driving Solutions (ecodrivingsolutions.com). The organisation provides both web-based and classroom training, including hands on driver training for drivers and train-the-trainer sessions for fleet trainers in large organisations.

As this review indicates, in the United States eco-driving is a relatively new concept. However, a number of eco-driving schemes have been developed in recent years. Perhaps the most notable differences between these and the identified European schemes is the extent to which private organisations are involved in promoting eco-driving (particularly motor vehicle manufacturers) and the public information/communications nature of campaigns (as opposed to enforcing eco-driver training through the driver licensing process).

3.1.3 Canada: Eco-Driving Schemes

In Canada, eco-driving and other vehicle fuel efficiency initiatives have been in place since the 1970s. These have been developed both to reduce fuel usage generally and as part of wider programs aiming to reduce greenhouse gas emissions[26]. The largest Canadian eco-driving schemes are Auto$mart and Fleet$mart which were developed by Canada's Office of Energy Efficiency[27].

Auto$mart is described in the following section. Because Fleet$mart is primarily aimed at heavy vehicles (placing it outside of the scope of this work), a brief description has been provided in a supplementary section (Section 2.4) at the end of this chapter.

The Auto$mart scheme is part of the second generation of eco-driving schemes in Canada. The first, introduced in the 1970's and 1980's, involved providing the general public with information on vehicle fuel consumption through labelling and fuel guides. The second generation of eco-driving schemes began in the 1990's and involved targeting novice drivers through Auto$mart (ecoEnergy, 2007).

Early phases of Auto$mart involved partnering with stakeholders to develop eco-driver training modules with the theme 'how to buy, drive and maintain vehicles with fuel efficiency in mind'. These training modules are the only national level eco-driving tool available in Canada.

While Auto$mart was well received, in the early phases uptake was limited due to insufficient support/training for driver trainers and an inadequate distribution strategy. As a result, in the early 2000's Auto$mart was relaunched. The latest version of the programme involves:

[26] Personal vehicles contribute over 12% of Canada's greenhouse gas emissions (www.ecoaction.gc.ca).
[27] http://oee.nrcan.gc.ca/english/index.cfm?attr=0

- Extensive collaboration with partners.
- Development of training modules (covering similar areas to the original scheme).
- Training packs including CD-ROMS, videos and handouts.
- Workshop-based training for driver trainers.
- A detailed deployment strategy, including enabling driving schools to brand themselves as Auto$mart registered schools.

While significant progress has been made, there are still a range of issues associated with delivering a national level eco-driving scheme in Canada. Driver education is governed by individual provinces where driver training is not always compulsory and only targets novice drivers. In addition, no national standards exist for driver educators in Canada. In order to manage these issues the developers of Auto$mart work directly with driver educators through train-the-trainer workshops and with the provinces to incorporate Auto$mart into the driver licensing process using the following phased process:

- Phase One: Include fuel efficiency messages in handbooks for new drivers.
- Phase Two: Include questions about fuel efficiency in exams for new drivers.
- Phase Three: Add a mandatory component on fuel efficiency to the driver training curriculum.
- Phase Four: Make Office of Energy Efficiency materials available to the general public at licensing bureaus.
- Phase Five: Provide a link from driver training and licensing websites to Auto$mart.

Auto$mart has recently entered a third generation which will involve developing community-based social marketing and single issue campaigns (e.g. anti-idling, aggressive driving). The goal is for the Office of Energy Efficiency to act as an enabler for other organisations and community groups to promote eco-driving to a wider driving audience, an approach that is considered to be cheaper and more efficient than funding advertising campaigns.

The emphasis on providing eco-driver education as part of driver licensing that forms the basis of the Auto$mart scheme is notably different from the public information campaigns on eco-driving emphasised in the United States. It is, however, closely aligned with the most recent eco-driver training schemes being developed in Europe.

The Auto$mart scheme has now undergone a number of iterations and it appears that its developers have learnt some valuable lessons regarding how to ensure that eco-driver training material is used by the driver training industry. These lessons would be of particular relevance in the New Zealand context, where driver training is also not compulsory if a training, rather than public information, approach is taken to promoting eco-driving.

3.1.4 Japan: Eco-Driving Schemes

The Japanese government has actively worked to promote eco-driving since 2003, when a committee named EcoDriving Promotion Liaison JAPAN was convened. The committee was formed to develop an eco-driving action plan with the aim of popularising eco-driving

habits amongst the general public. The eco-driving plan developed by the committee identified the following actions:

- Review the definition of energy saving driving.
- Develop education activities and a dissemination plan for eco-driving.
- Promote and disseminate an energy saving driving support system.
- Develop an evaluation system for energy saving driving.
- Promote inter-organisational efforts involving municipalities and concerned organisations.
- Survey requirements for promotion and dissemination of energy saving driving.

In order to achieve the actions outlined above, a website outlining eco-driving has been developed, ecodrive.jp. The website provides tips on eco-driving and access to information about promotional events and competitions. For example, in 2007, eco-driving was promoted at the Tokyo Motor Show using an eco-driving simulator (Shinpo, 2007). In 2010, an eco-driving month was announced including a range of promotional events[28].

While Japan's eco-driving programme is not as well developed as other countries, this review also identified an emerging emphasis on supporting technology that is of interest. The Japanese approach to eco-driving emphasises enabling individuals to evaluate their fuel usage and compare it to others using online tools.

In addition, in 2006, Japan implemented government subsidies to service industries that use trucks, buses and taxis in order to assist in the installation of equipment necessary to utilize Eco-driving Management Systems (EMSs). The program provides one-third of the cost of installing equipment for the EMS[29].

3.1.5 Australia: Eco-Driving Schemes

Like the United States, eco-driving is a relatively new concept in Australia. In recent years a number of government and private organisations have considered how eco-driving might be applied in the Australian context. The published documents resulting from this work are briefly outlined below.

Most recently, Symmons, Rose and Van Doorn (2009) undertook a detailed review of eco-driving as a road safety tool for Australian conditions. As part of this review they highlighted a number of existing, and historical, eco-driving schemes or trials in Australia.

The authors indicate that as early as 1991, Australia's Department of Primary Industries and Energy estimated that driver education programs could improve the fuel efficiency of the existing vehicle fleet by up to 15%. However, their suggestions for improving fuel efficiency through training were broader than eco-driving techniques and included, using vehicles less, increasing vehicle occupancies, changing peak hours, and considering parking infrastructure.

[28] http://www.meti.go.jp/english/press/data/20101029_03.html
[29] http://www.japanfs.org/en/pages/026368.html

The next eco-driving programme identified by Symmons et al was implemented in 2000 and 2001 by the then Victorian Environment Protection Authority (EPA) and Sustainable Energy Authority Victoria (SEAV). These organisations undertook a joint project to develop a driver education program emphasising both eco-driving and road safety. While the course was trialled in 2001[30], the authors were unable to find any further mention of the course or its outcomes during their 2009 review. This education program is the only government-based eco-driving program discussed by Symmons et al (2009). Interestingly, they comment that, because of the limited literature on eco-driving in Australia, industry contacts were used to gather further information. All of the industry based information presented in their report appears to be related to heavy vehicles.

A review by James (2009) also indicated that the development and implementation of eco-driving in Australia is in its infancy. While, James was able to identify several eco-driving pamphlets produced by, for example, the Australian Automobile Association, there was no indication that these were associated with broader eco-driving campaigns. However, he does note that a pamphlet produced in Western Australia was tested as part of a TravelSmart programme (this programme appears to primarily relate to mode choice and trip planning)[31].

Interestingly, Royal Automobile Club of Queensland (RACQ) has recently (January 2011) put a proposal to the Queensland Government to undertake an eco-driving pilot study (RACQ, 2011). The proposed programme would involve eligible drivers completing one of five training options:

- Online learning module.
- Workshop.
- Driving lesson.
- Workshop and driving lesson.
- Half day driving course.

Participants would be compared to a control group and performance measured using surveys and fuel data collected for 12 weeks following the intervention (gathered from fuel cards).

Finally, while limited work on light vehicle eco-driving has been undertaken in Australia, an interesting programme for heavy vehicles has emerged in recent years. This programme is briefly described in Section 3.4.

3.1.6 New Zealand: Eco-Driving Schemes

A brief review of eco-driving schemes in New Zealand was undertaken to identify any recent developments in this area. While only a few eco-driving activities were identified, these are briefly described below.

In New Zealand an Energywise Rally takes place every two years and is jointly organised by the AA, EECA and Gull Petroleum New Zealand (which provides the fuel for all vehicles). The aim of the rally is to raise awareness of fuel efficient vehicles and driving

[30] One of the authors of this paper was involved in this trial.
[31] http://www.transport.wa.gov.au/14890.asp

techniques. It is also used as a means of promoting the AA Make Cars Green brochure containing ten eco-driving tips[32].

Recently, an organisation called EcoDriver specialising in fuel economy training courses has formed.[33] The company provides the following services to organisations of all sizes:

- Ecodriver consulting – advice on vehicle usage, suitability, brands, model types and operational matters.
- Ecodriver Fuel Saver Course - The fuel saver course takes around 1.75 hours and is conducted with two people at a time. Commencing with a 30 minute theory session covering the best techniques and underlying theories for fuel efficient driving, followed with a 1 hour practical in the driver's usual car. The course ends with a 15 minute summary, question session and action plan.

In addition to the eco-driving schemes relevant to light vehicles listed above, the Department for Transport has also supported the development of a SAFED for Heavy Vehicles training scheme in New Zealand. This scheme is described briefly in Section 3.4.

3.2 Eco-Driver Training with Multi National Companies

The information provided in previous sections focuses on country/region specific eco-driving activities. However, a number of multi-national companies (all car companies) have also developed eco-driving schemes. These are briefly described in this section.

Ford

Ford has been heavily involved in eco-driver training for over 10 years (Hennig, 2008). The organisation has engaged with a range of partners to develop fit-for-purpose training programmes for a range of drivers.

In particular, since 1998 Ford in Germany has jointly run a comprehensive test and training programme "Ford Eco-Driving" with the German Federation of Driving Instructor Associations and the German Road Safety Council (DVR). The training programme was tested on over 7,000 participants.Extensive consumer research – including in-depth psychological interviews and questionnaires – revealed excellent learning results and long-term information retention with associated changed behaviour (Ford, 2004).

The fine-tuning of Ford Eco-Driving resulted in three major programmes targeted at: professional drivers/fleets, private drivers, and driving instructors (Ford, 2004).
Ford's portfolio of eco-driving programmes now ranges from 'training snacks' to full day training courses. Hennig (2008) states that, with DVR, Ford have trained over 50,000 drivers and that their 'train-the-trainer' programme has been delivered to German driving instructors.

The 'training snack' approach is particularly innovative. Ford's 'training snacks' are designed for mass training implementation. They last 30 to 60 minutes and focus on key tips, individual intensive coaching and a competitive approach using an eco-rally. The training snacks were successfully trialled at events such as the Leipzip Motor Show in

[32] http://www.aa.co.nz/about/newsroom/Pages/Eco_driving_tips_from_the_AA_Energywise_Rally.aspx
[33] http://www.ecodriver.co.nz/ecodriver/welcome.html

2004 and the Frankfurt Motor Show in 2007 where 765 people were successfully trained using short training modules focused on:

- Low engine speed,
- Anticipatory driving, and
- Using momentum.

Overall, Hennig reports that the 'training snack' approach resulted in 14-26% reductions in fuel consumption at the time of training.

Also in 2008, Ford partnered with the United Kingdom Energy Saving Trust to test the effectiveness of Ford's short duration eco-driving lessons. Results from 500 drivers showed a decrease of 22.5% in fuel consumption. For further details see the description of United Kingdom eco-driving schemes in Section 3.1.1.

Ford is now undertaking eco-driving competitions and events in other countries such as Portugal[34]

In addition to training programmes, Ford also provides web-based information at drivingskillsforlife.com. This website includes an eco-driving training module with the following training objectives:

- Distinguish between ecological and economical benefits of eco-driving.
- Evaluate the ecological and economical effects of driving techniques and behaviours.
- Distinguish the roles of fuel, vehicles and drivers in achieving energy sustainability.

Nissan

While Nissan is not as involved in eco-driver training as Ford, the company has provided eco-driving training sessions at a range of events in Japan and overseas, several of these are listed below[35]:

- Nissan and Yokohama City launched the E1 Grand Prix on September 28, 2009, as part of a five-year collaborative project, Yokohama Mobility "Project Zero." The E1 Grand Prix, which aims to encourage more drivers to adopt eco-driving practices, is a fuel consumption competition open to Yokohama residents. Competitors can register their car details online via the E1 Grand Prix site and report their fuel consumption using a computer or mobile phone. This enables them to see eco-driving rankings by car model and area, as well as graphs and other displays showing improvements made in fuel consumption. There is also an eco-driving diagnosis system that gives points for different driving behaviours, such as starting, cruising, decelerating and stopping.
- Nissan carried out a trial project using Intelligent Transport Systems (ITS) to give support for eco-driving to motorists in the United Kingdom for eight months starting June 27, 2009. Some 100 Nissan car owners took part in the trial. Information relayed to drivers via onboard systems included fuel consumption

[34] http://green.autoblog.com/2009/11/12/ford-launches-eco-driving-campaign-in-portugal/
[35] http://www.nissan-global.com/EN/ENVIRONMENT/SOCIAL/ECODRIVE/

trends to check their eco-driving and rankings to compare their average fuel consumption with that of other drivers from the previous month. Out of the vehicles, the participants received evaluations of their daily eco-driving performance and analyses including a breakdown of fuel consumption trends by distance and road type. The results of the trial will be used in the development of Nissan's next-generation navigation system for the European market.

- Nissan held eco-driving training sessions for customers in China (Beijing, Shanghai and Guangzhou) in 2009.

Toyota

Through the Toyota Fund for Europe, Toyota has developed a series of eco-driver training programmes under the name EcoDriving Europe[36] [37].

This programme has been ongoing since 2007 and involves a range of partners including EcoLife, Global Action Plan (UK), De Accion Global (Spain), EcoLife (Belgium, Flanders), Reseau Eco-Consomation (Belgium, Wallonia), Gronnhverdag (Norway), and Landvernd (Iceland).

The training involves intensive, workshop-based face-to-face instruction on eco-driving methods using driving simulators. During workshops participants are shown the benefits of a new and improved driving style, not only from an environmental point of view but also from a safety and cost perspective. A typical workshop trains 15 people in half a day using five driving simulators.

The training programme was piloted in Belgium in 2007 and has now been rolled out in the UK, Spain, Norway and Iceland, in partnership with the international NGO network Global Action Plan (GAP).

EcoDriving Europe organises events for a broad audience including small to medium sized enterprises, corporations, schools, community organisations and government bodies. Special simulators are used which have been jointly designed and developed for driver education by Ecolife, GAP, Toyota and GreenDino (the simulator supplier).

In 2007, a pilot project in Belgium trained 810 drivers through 54 half-day workshops. Another 10,000 drivers also received information about the principles of eco-driving.

Peugeot

Peugeot has also recently become involved in eco-driver training, in 2010, Peugeot launched the first ever pan-European eco-driving challenge, the Peugeot eco-cup[38]. Competitors sign up at a dedicated website that also contains range of eco-driving tips and an online eco-driving test. They drive one of four different Peugeot cars 1000 kilometres from Paris to Geneva with the winner being the car that arrives in the set time having used the least fuel.

All of the information presented in this section discusses the eco-driver *training* activities undertaken by car companies. The review is not exhaustive and it is likely other car companies also provide some form of eco-driver training. In addition, most car companies

[36] http://www.toyotafund.eu/our_projects/environment/ecodriving.aspx
[37] http://www.ecodriving-online.eu/default.aspx
[38] http://www.thegreencarwebsite.co.uk/blog/index.php/2010/01/25/peugeot-launches-eco-drive-challenge/

are developing in-vehicle eco-drive technology. Technology identified as part of this review is briefly described in Section 3.3.

3.3 Innovative Approaches to Eco-Driving

Eco-Driving Technology

While a detailed review of eco-driving technology is beyond the scope of this work, a brief search was undertaken to identify examples of emerging technology because there are potential links between new technology and the types of eco-driver schemes that may be appropriate for New Zealand. The examples identified are presented briefly below.

Ford EcoMode: EcoMode is available on an increasing number of Ford vehicles and provides a means for drivers to track how economical their driving style is. The software-based system uses algorithms developed from a database of eco-driving techniques to help motorists achieve maximum real world fuel economy. In the instrument panel are three flowers with five petals each, one flower representing gear shifting behaviour, one representing how smoothly the vehicle is being driven and another representing speed. If the vehicle is driven economically the driver is rewarded with illuminated petals on the flowers. Drivers who score more than 75 per cent efficiency are rewarded with an advanced ECO Driver graphic in the cluster. If they achieve 95 per cent they are crowned ECO Champion[39].

Ford Econo Check: Econo Check, launched in 2010 by Ford Europe's Customer Service Division (FCSD). It involves both a vehicle inspection and an extended electronic analysis of driving style to generate a unique report for each driver and provide advice on how to improve fuel economy. During the vehicle check, a Ford technician carries out a series of checks including items such as tyre condition and pressure, and air filter cleanliness. The technician then fits a small data logger to the vehicle, which stores data on driving speed, acceleration, anticipation, braking and gear changes for the next seven days. At the end of the monitoring period, the logger is removed from the vehicle – either by the dealer or the customer – and returned to Ford by post. A dedicated Econo Check personal report is then emailed to the customer, showing the potential annual savings for fuel, CO_2 and money if the report's conclusions and advice are followed.

Ford Adaptive Cruise Control: Ford's Adaptive Cruise Control (ACC) is able to read traffic ahead using radar technology and react accordingly. Once it detects a vehicle ahead travelling at a lower speed, ACC starts to reduce throttle and fuel supply to the engine. If this isn't slowing the equipped vehicle fast enough the brakes are also employed, allowing for a gentle reduction of speed and a safe distance to be kept with the car in front. As the vehicle ahead pulls over ACC then gradually increases speed back up to the set limit, smoothly accelerating to be as efficient as possible.

Fiat eco: Drive: eco: Drive was launched by Fiat in 2008 as a software application that is free to download on the Fiat website. It works by asking drivers to plug a memory stick into a port within their vehicle where it records telemetric data from the vehicle computer. Plugging the memory stick into the user's computer then allows the Fiat servers to analyse trip data. Algorithms measure trip efficiency on four parameters, steady acceleration, steady deceleration, early gear changes and moderate and consistent speed. Drivers receive a rating and overall score. They also receive tailored advice on how to improve their score on each parameter. They can track improvements over time, set targets, and see

[39] http://fordeuropenet.wordpress.com/2011/03/17/ford-combats-rising-fuel-prices-with-smart-technology/

how much CO_2 they are saving. Fiat also has an online community eco: Ville, which shows the latest number of drivers using eco: Drive and the total emissions saved to date. Several screenshots of Fiat's eco-driving website are provided below. As of September 2010, 45,000 drivers had saved a total of 3,300 tons of CO_2 by driving more efficiently using eco: Drive.

Fiat have also launched a version of Eco:Drive for fleets and they aim to launch eco:Drive Live in 2011 which will provide live updates on how efficiently people are driving and reminders on how to improve (Fiat, 2010).

Figure 3: Illustration of Fiat's eco: Drive Index Report

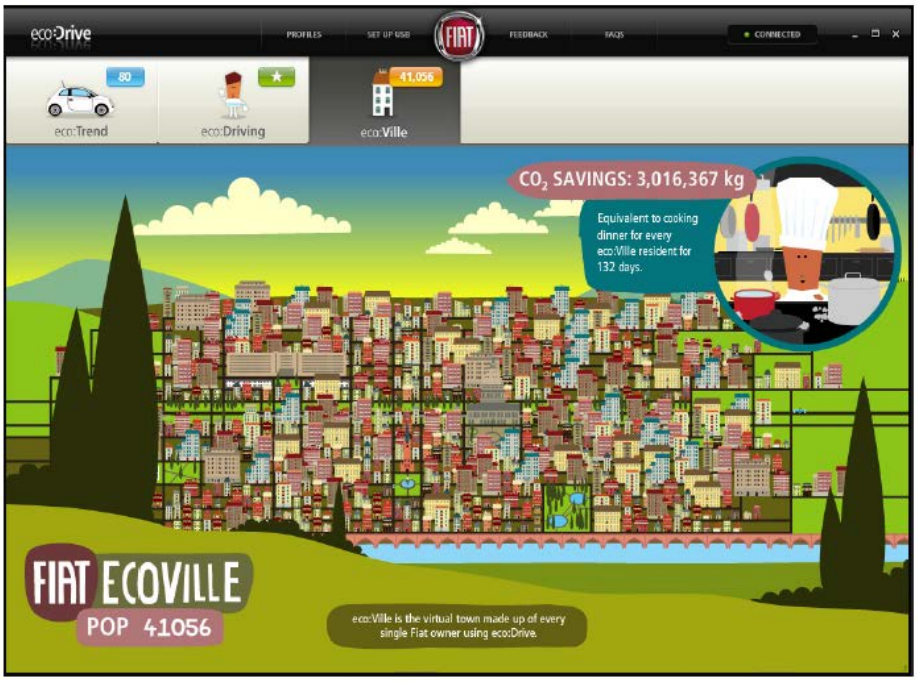

Figure 4: Fiat's Eco: Ville

Nissan ECO Pedal system: As part of its technological development efforts aimed at promoting eco-driving, Nissan creates various systems to help vehicles themselves support drivers' eco-friendly driving habits. The ECO Pedal system monitors pressure on the accelerator, displaying a visual alert on the instrument panel and activating a push-back mechanism on the pedal when the driver presses too hard and burns more fuel than needed. Nissan claims that in many driving situations, this system can improve fuel efficiency by up to 10%[40].

Vehicle Insurance

Research has shown that the pricing structure of vehicle insurance can be used as leverage to alter driving behaviour. In relation to reducing vehicle CO_2 emissions, insurance could be used in a number of ways:

- Reductions in insurance premiums for drivers who use eco-driving techniques.
- Linking insurance with kilometres driven (thus encouraging drivers to reduce vehicle mileage and choose other transport modes).

While no information on linking insurance premiums to eco-driving or eco-driver training was identified during this review, this approach may become increasingly feasible as training becomes more widely available and in-car technology provides a means of assessing whether drivers are using eco-driving techniques.

A number of studies were, however, identified that considered insurance schemes linked to mileage. A recent study, Litman (2011), considered pay-as-you-drive (PAYD) insurance in detail. This type of insurance allows for reduced premiums when motorists reduce their mileage (and thereby exposure to driving risk).

[40] http://www.nissan-global.com/EN/ENVIRONMENT/SOCIAL/ECODRIVE/

PAYD incorporates the number of kilometres driven during the policy term directly into the rate structure in addition to other factors such as driver history, risk categorization, vehicle type, and territory. This converts insurance into a variable cost so motorists save on insurance whenever they reduce mileage.

Litman states that various experts and organisations support PAYD insurance as a way to increase insurance efficiency and equity and help achieve policy objectives including increased traffic safety, consumer affordability, energy conservation, and pollution reduction.

In terms of reduced vehicle emissions, he states that reductions in mileage should provide approximately proportional energy savings and emission reductions. For example, if PAYD pricing reduces total vehicle travel by 10%, this should provide an approximately 10% energy savings and emission reductions. Additional energy savings and emission reduction may be achieved if PAYD allows households to afford a more optimal mix of vehicles, such as a fuel efficient vehicle for general use, and a van, SUV or light truck for special uses, rather than owning a single, less efficient vehicle sized for peak demands. He notes that in a report to Congress by the U.S. Department of Transportation, *Transportation's Role in Reducing U.S. Greenhouse Gas Emissions*, PAYD insurance is ranked as potentially one of the most cost effective emission reduction strategies. This is because a moderate (5-12%) mileage reduction per affected vehicle can be expected from PAYD pricing.

A recent American study estimates the effectiveness of PAYD insurance to be medium to high (compared to other CO_2 emission reduction measures). With estimated direct costs of $30 to $90 per ton of greenhouse gases saved (US Department of Transportation, 2010).

3.4 Schemes for Commercial Fleets

While a detailed discussion of eco-driving schemes for heavy vehicles is beyond the scope of this review, a few key schemes were identified during literature searches. Because these schemes might have some relevance to the development of eco-driving schemes for commercial light vehicle fleets, the key features of several are described below. It should be noted that this review is not exhaustive, a more detailed review of heavy vehicle eco-driver training may be required as part of future work in developing eco-driving schemes for light vehicles.

America: SmartWay Transport

SmartWay Transport is a voluntary public-private partnership launched by the United States Environmental Protection Agency in 2004. The aim of SmartWay Transport is to raise awareness amongst industry about environmentally cleaner and more fuel efficient transport options[41].

The SmartWay website provides guidance on vehicle purchase (including providing a green vehicle mark and a certification mark for superior performers). When transport companies become a SmartWay Transport partner, they receive assistance in calculating their environmental performance, setting improvement goals, and calculating cost savings.

In addition to guidance, the SmartWay programme includes Clean Diesel Finance which aims to accelerate the deployment of energy efficient and emission control technologies by helping vehicle/equipment owners overcome financial obstacles. In 2008, EPA awarded $3.4 million to support three loans programs to help small trucking companies reduce fuel costs and emissions.

[41] http://www.epa.gov/smartwaylogistics/transport/index.htm

Canada: Fleet$mart

In conjunction with Auto$mart (described earlier in this report), the Office of Energy Efficiency have also produced a program called Fleet$mart. Fleet$mart is part of a broader programme called ecoENERGY for fleets offered by Natural Resources Canada[42] [43].

The scheme aims to assist commercial fleets in introducing energy efficient practices. While it is primarily aimed at heavy vehicle fleets, a few training modules have also been produced for some lighter vehicle fleets.

The key source of information for fleets is www.fleetsmart.nrcan.gc.ca. This website provides a range of resources for fleet managers including calculators, case studies and success stories.

The site enables fleet managers to register for sponsored workshops "Fuel Management 101" which covers:

- why you should have an fuel management plan
- how to make a plan
- how to benchmark your fleet
- how to sell your plan to management, implement your plan, analyse the results and chart a future direction

In addition, the scheme also provides SmartDriver training specifically developed for various fleet types (forestry, city, motorcoach, transit, school bus).

Australia: EcoStation

A new pilot scheme, to be known as EcoStation, has been introduced in Australia by a partnership between the Victorian Transport Association and the Victorian Environmental Protection Agency[44].

The scheme was piloted in 2010 and brought together freight owners and transport operators with the objective of improving fuel consumption, reducing emissions and saving money. It is based on the American SmartWay model.

Foundation partners for EcoStation include Linfox, Woolworths, Visy, Glen Cameron Trucking, Toll IPEC, Freestone's Transport, Kalari and Boral Transport. Large consignors and consignees are also represented with companies like Coles, Toyota, Schweppes, National Foods, Myer, Australian Paper, Mars Petcare, Sugar Australia, Australia Post, multimodal operator CRT and Fonterra.

The key objectives of the EcoStation program are to make it as simple as possible for companies to take advantage of the environmental innovations available, measure the efficiencies achieved, and enjoy the benefits that will ensue. As such, through their website, EcoStation provides information about alternative fuels, alternative drivetrains, fuel efficient technology, environmental driving and idle reduction.

[42] http://www.fleetsmart.nrcan.gc.ca/documents/PDF/Fact%20sheet.pdf..
[43] http://fleetsmart.nrcan.gc.ca/index.cfm?
[44] http://www.ecostation.com.au/

Prior to the introduction of EcoStation, several organisations in Australia had implemented eco-driving programmes. These are briefly described below.

LinFox Logistics: As a major supply chain solution provider in the Asia-Pacific region, Linfox Logistics operates a fleet of nearly 5,000 vehicles across 11 countries. As part of its overall corporate environmental policy, Linfox Logistics has set an initial target to reduce the rate of greenhouse emissions by 15% by 2010 (based on its 2006/07 emissions). Strategies to reduce fuel use explicitly included in the company's three year plan are:

- Trialling a new fleet tracking system to provide dynamic and cumulative fuel use data.
- Moving to hybrid vehicles for company cars (other than utes) and hire cars.
- Developing and delivering an eco-drive training program to all Linfox employees to encourage fuel efficient driving at all times.

Eco-driver driver training is delivered at weekly 20 minute 'toolbox' sessions held with drivers at individual depots. The topics covered include idling, acceleration and gear changing. Prior to rollout of the training, benchmarking of fuel consumption was undertaken to enable the effectiveness of the training to be evaluated. Up to June 2009, 166 drivers had been educated in eco-driving. LinFox sees eco-driving as the single largest opportunity to improve energy use in the road transport sector, baring technological change[45].

Based on the eco-driving curriculum developed within their organisation, LinFox have now developed an e-learning package in partnership with Andromeda and the Australian Logistics Council[46].

Toll-IPEC: In March-May 2008, Toll Magazine included a description of a joint trial undertaken between Toll-IPEC and the Western Australian Government to reduce vehicle idling times (Toll Magazine, 2008).

During the three-month trial, drivers who volunteered were exposed to various behaviour change tools such as posters, feedback meetings, electronic messaging and on-vehicle signage. The joint initiative was so successful that Toll-IPEC has found 79 percent of its drivers have extended environmentally friendly practices by turning off lights as well as reducing idling when driving their cars.

Based on the findings of this trial, the Department of Environment and Conservation (West Australia) calculated that if all light commercial drivers in Western Australia reduce idling times by three hours per week for a whole year this will save $12 million in diesel, eight million litres worth of diesel emissions and slash the amount of CO_2 entering the atmosphere by more than 22,000 tonnes. They have therefore designed a program based on the trial outcomes which is being offered free of charge to transport companies in the Perth metropolitan area.

[45] http://www.linfox.com/News-and-Media/Latest-News/2009/Eco-Drive.aspx
[46] http://www.logisticsmagazine.com.au/news/eco-drive-to-reduce-carbon-emissions

New Zealand: SAFEDNZ (Safe and Fuel Efficient Driving)

SAFED NZ is a driver development course for truck, bus and coach drivers[47]. The course aims to improve the safe and fuel-efficient driving skills of truck and bus drivers through defensive driving and vehicle maintenance. The programme was developed and implemented by the Ministry of Transport and the NZ Transport Agency and is supported by the Bus and Coach Association, Contractors Federation and Road Transport Forum.

SAFEDNZ is based around a successful scheme in the UK (called SAFED), which has been offered on a commercial basis for over six years, and has trained more than 20,000 drivers.

SAFEDNZ course participants are taught to optimise travel speed and gear selection, ensure appropriate engine speeds at which gears are changed, and reduce aggressiveness of accelerator and brake pedal use, and the amount of time the truck is left idling.

The courses are usually run with two drivers assigned to one approved SAFEDNZ instructor. The one-day training programme begins with the instructor assessing the participant's driving on a specific route. This is followed by classroom-based training on best practice in safe and fuel efficient driving techniques. The participant's driving is then reassessed on the same route to record improvements in driving performance and actual fuel consumption. Finally, the participant is assessed on a series of safety check and theory exercises. The final grade is then based on the results from the two practical driving sessions and the exercises. Successful participants receive a certificate of achievement.

Use of safe and fuel-efficient driving techniques learnt through SAFEDNZ can reduce fuel consumption by 10 percent. The SAFEDNZ website indicates that 185 drivers have been trained to date, with an average fuel saving of 6.98%.

3.5 Summary

The review of eco-driving schemes presented in this section indicates that there are a large number of programmes internationally. The most developed schemes are in Europe. However, increasing interest in eco-driving is emerging in the United States and other countries such as Australia.

Many schemes involve partnerships between government organisations, charities, private organisations and industry bodies. These relationships appear to be essential to ensure that the scheme is credible and likely to reach its target audience(s).

In most cases eco-driving programmes are multi-faceted, including both training and communications components. Most schemes target the following groups:

- Unlicensed drivers: A combination of embedding eco-driving in the licensing system and public education campaigns.
- Licensed drivers: A combination of voluntary training schemes (sometimes subsidised) and public education campaigns.
- Professional drivers: Training schemes (sometimes subsidised) targeted at companies operating driver fleets.

In most cases countries have made relatively significant financial investments in eco-driving in order to reach these large target populations.

[47] http://www.transport.govt.nz/ourwork/climatechange/safednz/

The training components of the eco-driving programmes reviewed made use of a broad range of methodologies. Emerging areas of promise appear to be the ‘training snack’ approach and the use of driving simulators. Notably, the ECOWILL programme aims to further develop and embed both these approaches in Europe.

In addition to training and communications campaigns, a number of more innovative approaches to eco-driving have been trialled. In particular, most car companies are now introducing eco-driving technology into their vehicles. Other means of encouraging environmentally friendly driving, such as through insurance, are now under discussion.

4 EFFECTIVENESS OF ECO-DRIVING SCHEMES

The descriptions of eco-driving schemes presented in Section Three of this report show that a broad range of schemes have been implemented internationally. However, a major consideration is the extent to which these schemes have been found to be effective, particularly in terms of reducing fuel consumption and CO_2 emissions in the medium and long term.

The following section provides the results of a review of eco-driving scheme evaluations. It is divided into three parts:

1. Good practice in eco-driving evaluation.
2. A review of evidence of the effectiveness of eco-driving schemes.
3. A detailed description of evaluations of several key eco-driving schemes.

4.1 Good Practice in Eco-Driving Evaluation

A useful overview of the key factors to consider when developing an eco-driving scheme evaluation was provided in a presentation by Lee-Grosselin at the International Transport Forum and International Energy Agency Workshop in 2007. The paper is an interesting baseline against which to assess the eco-driving evaluations presented later in this section.

The presentation outlines issues to consider when designing an evaluation framework (methodology) for eco-driving schemes. While it primarily focuses on how best to measure fuel consumption, some interesting issues related to 'intermediate' measures of scheme effectiveness were also raised.

Lee-Grosselin states that when designing an eco-driving evaluation framework the following factors should be considered:

- In what terms (what are the measures of success),
- With what metrics (how will success be measured),
- Using what instruments (what technology will be used to take measures),
- Who needs to know if the programme works (how will results be communicated).

The key aim of any eco-driving scheme is to reduce CO_2 emissions. Therefore, reductions in fuel consumption and associated vehicle emissions are clearly the ultimate measures of success. However, Lee-Grosselin suggests that a range of intermediate measures may also be appropriate when evaluating eco-driving schemes.

These measures may enable a more fine grained diagnosis of why a scheme is successful, or not, in reducing fuel emissions. For example, if a communications scheme on eco-driving targeted at company fleet drivers fails to achieve reduced fuel consumption, the evaluation might assess driver awareness of the scheme, recall of key messages, whether the scheme affected intentions to drive in a eco-safe manner, and level of skill in eco-driving techniques (e.g. ability to change gears correctly). All of these intermediate measures would help establish why the communications scheme did not achieve reduced fuel consumption.

Intermediate measures may also help to establish whether the eco-driving scheme results in other benefits such as increased road safety, reductions in number of trips or more effective trip planning.

Lee-Grosselin suggests that the following measures might be included in an eco-driving evaluation framework:

- Accident/crash rates.
- Equipment wear and tear.
- Micro decisions about vehicle control (e.g. braking and acceleration).
- Real-time adjustments to routing.
- Congestion avoidance.
- Trip planning.
- Vehicle acquisition.

Other measures might include the number of eco-driving trainers trained, number of drivers trained using the scheme, number of press releases, recall of communications campaigns, and intentions to engage in eco-driving.

Lee-Grosselin suggests that the evaluation design in Figure 5, which includes both intermediate and ultimate measures of success, may be appropriate for evaluating eco-driving schemes.

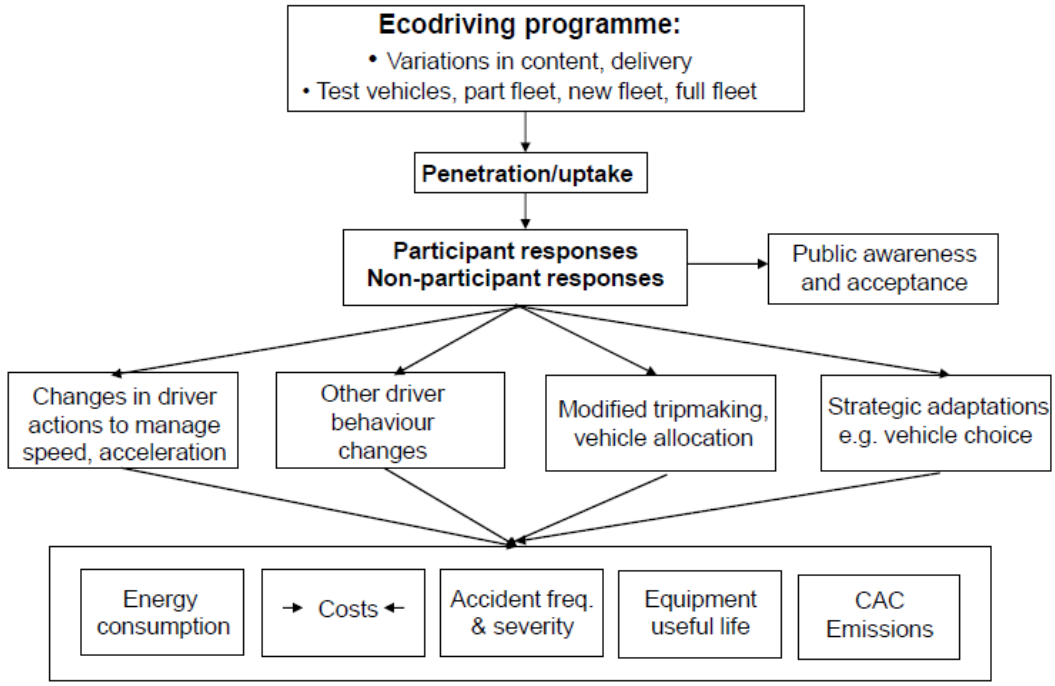

Figure 5: Suggested Evaluation Design (Lee-Grosselin, 2007).

Once measures of success for a particular scheme have been identified, valid evaluation metrics and measurement tools need to be developed.

Careful consideration must be given to how fuel usage will be calculated, for example, will fuel usage be measured by vehicle, passenger or tonne. In terms of measurement technology, while heavy vehicles often have trip computers and associated tools that enable easy access to trip data (including in some cases driving behaviour), most private vehicles do not currently contain this technology. As a result, measurements of fuel consumption are more complex and retro-fitted technology may be required. This issue is currently a significant constraint on the evaluation of light vehicle eco-driving schemes. However, as technology, such as that described in the previous section, is embedded into the driving fleet, evaluating fuel consumption and driver behaviour will become more practical. A study by Fiat, described later in this section, provides an example of what can be achieved with emerging eco-driving technology.

As with any evaluation, it is also important that surveys and other tools designed to capture data on driver behaviours, behavioural intentions and other intermediate measures such as trip planning, campaign awareness and recall of campaign measures must be well designed to ensure that valid data is collected.

Finally, a key issue for eco-driving evaluation, not discussed by Lee-Grosselin, is the measurement of medium/long-term changes in fuel consumption/emissions and driving behaviour. Many eco-driving scheme evaluations only measure changes in driving behaviour shortly after the intervention (e.g. training) has occurred. However, research, described in the following section, shows that early reductions in fuel consumption are not necessarily maintained over time. Therefore, on-going measures must be built into any eco-driving evaluation. Without appropriate technology, this type of evaluation can be time consuming and costly.

4.2 Effectiveness of Eco-Driving Schemes

4.2.1 Reductions in Fuel Consumption and Vehicle Emissions

One of the most notable features of the literature on eco-driving is that, while there is a large body of information reporting success in reducing fuel consumption, relatively little of this data appears to arise from detailed and rigorous evaluations.

Rose and Symmons (2008) concur, noting that while many eco-driving programmes report significant changes in fuel consumption post-intervention, publically available documents provide only limited explanatory information behind the results. These authors quote comments on the Eco-Drive (EU) programme by Wåhlberg (2007b) who stated that:

> *The claims regarding the Eco-drive benefits were mainly made by educators and bureaucrats, and lack scientific backing. More specifically, no literature on Eco-drive was found after a thorough literature search in major academic databases covering transport, energy, and psychology.*

The same authors noted in an earlier paper (Symmons, Rose and van Doorn, 2007) that it seems to be rare for a control group (who do not receive training) to be included, against which the performance of the trained group could be compared – most studies employ a before versus after training comparison. In a more recent review, Smit, Rose and Symmons (2010) drew the following conclusions from their search of eco-driving literature:

- A relatively modest number of separate field trial studies are reported in the English literature though some of them have involved large numbers of drivers.

- European studies clearly dominate the available literature, with Switzerland being disproportionately represented.
- Almost without exception the studies report a positive effect in terms of reductions in fuel consumption.
- Most studies lack scientific rigour, or at least do not report sufficient detail to determine the degree of rigour.

Despite these issues, when the available evidence is taken as a whole, there is little doubt that eco-driving schemes can result in reduced fuel consumption and CO_2 emissions. However, there is some doubt about the extent to which fuel consumption is reduced and how long reductions are maintained. A useful review of the results of a range of eco-driving trials was published by the Intelligent Transport Forum and the International Energy Agency following their 2007 workshop (International Transport Forum, 2007). Figure 6 contains a summary table presented in their publication. It contains the results of a broad range of studies, (including freight in some cases).

Country	Method	Short-term	Mid-term
Netherlands	National programme	10-20%	5-10%
Austria	National programme	10-15%	5-10%
Japan	Smart driving contest	25%	
Japan	Idle stop driving	10%	
Japan	Ecodrive workshop	12%	
Japan	Average mileage workshop	26%	
Sweden	Driver training courses	5-15%	
Austria	ÖBB Post Bus Best Practice training courses, competion, monitoring, feedback	10%	
Austria	Ecodriving competitions for licensed drivers	30-50%	
Austria	Mobility management for company fleets	10-15%	
Germany DVR	- National novice drivers programme		6-10%
	- Professional fleet drivers <7.5t	6-10%	6-8%
	- Driver training courses for passenger cars (evaluation)	10-25%	10-15%
Deutsche Bahn	Training courses, monitoring, feedback, rewards		3-5%
Shell		5-20%	
Ford	Training courses and trip/driving style analysis	25%	10%
FIA – AASA		15%	
FIA – Plan Azul		14%	
FIA – ADAC		25%	
FIA – öAMTC		6%	
FIA – JAF		12-16%	
Nissan		18%	
UK	Freight Best Practice	10%	
UK – Lane Group			4%
UK – Walkers			9 %

Figure 6: Fuel Economy Improvements (International Transport Forum, 2007).

As the table shows, many eco-driving schemes achieve significant short-term reductions in fuel consumption. However, medium-term reductions, where they have been measured, appear to be more modest. The authors of the review suggest that, on average, medium-term reductions of around 5% can be achieved where there is no support beyond initial training increasing to 10% where there is continuous feedback (e.g. using in-cab technology). They also note that there is little evidence on long-term reductions (e.g. over 3 years) because relatively few schemes have been subject to on-going evaluation.

The data presented above largely relates to behaviour following eco-driving interventions. Usually measures are taken on a test track or other artificial environment. It is therefore difficult to assess the extent to which gains following training might translate into real world situations. One useful indication of real world gains is provided by a study undertaken by TNO (cited in Fiat, 2010). This study measured the effects of driving techniques on tailpipe emissions. In order to provide real world estimates, TNO created two reference cycles, urban and non-urban driving, which were representative of Dutch driving conditions. The study concluded that applying eco-driving techniques effectively under real-world conditions led to an average decrease in fuel consumption of 7% with petrol engines and 8-10% with diesel engines.

Taken together, these findings suggest that the average driver should be able to reduce fuel consumption 5-10% using eco-driving techniques in real world driving situations. This result tallies with the results of eco-driving intervention evaluations cited by the International Transport Forum (2007) and appears to indicate that at least some existing interventions are achieving their real world potential in terms of reducing fuel consumption.

In order to provide more detailed information about the results of specific eco-driving trials, the results of several of the more rigorous trials (where sufficient information has been published) are presented in Section 4.3. These include the Netherlands eco-driving programme, and work by Ford the results of which are included in Figure 6.

4.2.2 Cost Effectiveness

While information about the cost effectiveness of specific eco-driving schemes is relatively limited, a number of broader reviews both in Europe and the United States provide useful cost-effectiveness estimates. In 2010, the US Department for Transportation published a comprehensive review of transportations role in reducing greenhouse gas emissions. The paper includes details of European studies of eco-driving and estimates of the potential benefits of eco-driving in the United States.

The paper concludes, based on European experiences, that more comprehensive and sustained efforts to promote eco-driving, including requiring instruction as part of driver education and providing in-vehicle feedback technology, could reduce transportation greenhouse gas emissions by up to 1 to 4 percent. Net included costs (implementation costs and vehicle operating cost savings) were estimated to be between $0- -$230 per tonne of CO_2. Based on this, eco-driving was considered to be of moderate to high benefit compared to other interventions (US Department for Transport, 2010).

The Department for Transport study also cites two European studies that assess the cost-effectiveness of eco-driving schemes. Lucke and Hennig (2007) found cost-effectiveness may range from €17 to -€128 per tonne CO_2-e for eco-driving programs and €5 to -€98 per tonne CO_2-e for optimal tyre pressure measures. This range is mainly a cost savings

because the benefits of reduced fuel usage outweigh the costs of the programs. Another European source (Crist, 2008) concurs with this range and gives a cost savings of €69 per tonne CO_2-e for providing eco-driver training to new drivers and €45 per tonne CO_2-e by providing it to existing drivers (cited in US Department for Transport, 2010).

The Department for Transport study also notes that the Michigan Climate Action Council and Center for Climate Strategies (2008) estimated that an eco-driver training program that reaches about 3 percent of the Michigan driving population per year will cost $93.3 million per year to implement. Including fuel savings they estimate a cost-effectiveness of -$211 per tonne CO_2-e by 2020. A public information campaign to encourage proper tyre inflation that reaches 1.2 percent of the Michigan driving population per year would cost $2.7 million per year to implement, which yields a cost-effectiveness of -$233 per tonne CO_2-e by 2020.

Finally, a study carried out in 2006 by TNO Science and Industry (TNO), the Institute for European Environmental Policy and the Laboratory of Applied Thermodynamics for the European Commission on the reduction potential and costs of technological and other measures to reduce CO_2 emissions from passenger cars concluded that while the initial effect of eco-driving training is relatively well measured and documented, the long-term effect is less well known and expected to be significantly smaller. They therefore note that cost assessments have significant uncertainty margins. However, they do conclude that eco-driving is a very cost effective means of reducing CO_2 emissions when oil prices range from €25/bbl upwards. This estimate covers the full range of eco-driving intervention options, from training to communications campaigns (TNO et al, 2006).

Most of the information presented above relates to either eco-driver training interventions or mixed (multi-method) interventions. Relatively little information is available on the cost effectiveness of eco-driving communications campaigns. However, one study conducted by the International Energy Agency (IEA) (2005) provides some useful information.

The study evaluated the cost effectiveness of various oil saving initiatives including eco-driving. However, it should be noted that the study examines the cost effectiveness for interventions in terms of quickly reducing oil consumption in an emergency situation.

The authors note that an aggressive eco-driving communications campaign, if implemented in all IEA countries, has the potential to result in significant savings of oil, up to 5000 barrels per day for relatively low cost (less than $1 per barrel of oil saved), compared to other measures such as small scale car-pooling programmes and transit fare reductions. Figure 7 provides a summary of the cost-effectiveness analysis for eco-driving presented in the study.

Consensus estimates for comprehensive ecodriving campaigns					
	Japan/ RK	IEA Europe	US/ Canada	Australia/ NZ	Total
Fuel saved per day (million litres)	16.2	43.7	91.3	4.1	155.2
Fuel saved per day (thousand barrels)	102.1	274.9	574.1	25.5	976.6
Road transport fuel saved (%)	5.0%	5.0%	5.0%	5.0%	5.0%
Total fuel saved (%)	2.7%	3.1%	3.7%	3.4%	3.4%

Figure 7: Cost-Effectiveness Analysis of Eco-Driving (International Energy Agency, 2005).

For Australia/New Zealand, consensus estimates of oil saved was 26,000 barrels per day. This translates to 5% of road transport fuel saved, and 3.4% of total petroleum fuel saved. The cost of an intensive communications campaign was estimated to be eleven cents per barrel of oil saved.

While this study provides some encouraging indications about the potential of eco-driving communications campaigns, the estimates were based around reducing oil consumption in an emergency situation. In this case the public are likely to be significantly more motivated to heed the messages in the campaign. Some information about the actual impact of an eco-driving campaign is presented Section 3.3.3.

4.3 Eco-Driving Evaluations

Three more in-depth eco-driving evaluations were identified during this review. These were undertaken by Fiat, Ford Europe and the Netherlands eco-driving programme[48]. The evaluation methodology and results are described within this section.

4.3.1 Fiat eco: Drive study

Fiat's new eco: Drive system (described in Section 2.3.1) provides drivers with a tool for understanding, reviewing and improving their eco-driving performance over time. Drivers can use a USB stick to record data while driving, this data is then uploaded online and analysed by Fiat's eco: Drive computer programme.

Through this process, Fiat has acquired an extensive dataset on Fiat drivers' eco-driving behaviour. This dataset consists of over 9,000,000 journeys from 42,000 drivers (Fiat, 2010). The data provides information about the effectiveness of eco-driving for a large number of drivers over an extended period of time. Fiat claim that it is the closest anyone has come to uncovering the 'real life' effects of eco-driving.

Using part of this dataset, Fiat has recently undertaken a study to establish whether their drivers were successful in reducing fuel consumption. Specifically, the eco: Drive research aimed to answer the following questions:

[48] It is likely that several other in-depth evaluations of European eco-driving programmes have been undertaken, in particular, the German DVR programme. However, reports describing any evaluations were not identified during this review.

1. How effective is eco-driving in real life – can its effects be quantified?
2. Does it last – does it create real, sustained behavioural change?
3. What are the limiting factors that limit its success?

The data used in this study consisted of 428,000 journeys made by 5,697 drivers in 5 countries over 150 days. Drivers were all users of Fiat's eco: Drive system. Therefore, it can be concluded that they were motivated to reduce their fuel consumption and vehicle emissions.

In most cases, driver performance was assessed by comparing their driving performance at the beginning of using the eco: Drive system to their performance after 30 days (the average amount of time drivers remain committed to the system). Performance was assessed on four indices, gear shift, speed, acceleration and deceleration[49]. The eco: Drive system then created an aggregate score taking into account performance on these indices.

The main findings from Fiat's research were:

- Eco-driving (using Fiat's system) brought significant savings in fuel, CO_2 and money. The average reduction in fuel consumption was 6%. The top 10% of drivers saved, on average, 16%.
- Drivers improved most noticeably in the first 15 days of using of eco: Drive. However, they continued to improve steadily beyond this point, suggesting a sustained, gradual improvement.
- A review of the four eco-driving indices showed that drivers had the greatest improvements in their gear change behaviour, followed by acceleration. Less improvement was seen in deceleration and speed. This suggests that, in naturalistic environments, drivers find some aspects of eco-driving easier to implement than others. Results showed that early gear changes and smooth acceleration contributed most to reduced fuel consumption.
- Over the 30 days using eco: Drive results showed an upward trend in average speed of journeys and a downward trend in the time drivers spend stopped during their journeys. This indicates that eco-driving techniques were resulting in real changes in behaviour.
- Results showed no impact of eco: Drive on trip frequency, and type and length of journeys.
- On average, drivers using Eco: Drive saved 133kg of CO_2 over a year and €80 on fuel.

While Fiat's research does show positive results in terms of encouraging eco-driving behaviour, the following issues should be noted:

1. Drivers who were motivated to use Fiat's eco: Drive system are likely to represent a particular sub-set of the driving population. It is, therefore, unlikely that the results of this study could be used to extrapolate likely gains if eco-driving was taken up by the general driving population.

[49] Acceleration is evaluated by measuring how hard the accelerator is pushed; deceleration is measured by how hard the driver decelerates; gear shift is measured by whether the driver shifted up gears as soon as possible; and speed is about maintaining a constant speed as far as possible.

2. Driver behaviour was only assessed for 30 days in most cases (because this was the amount of data available for the average driver). It is not possible to assess whether reductions in fuel consumption were maintained in the medium/long term.

3. The eco: Drive system enables drivers to receive ongoing, personalised, feedback about their driving performance. Therefore, the programme is significantly different to most eco-driving schemes where drivers typically receive a one-off training intervention or a short-term communications campaign.

4.3.2 Ford Eco-Driving Evaluations

Ford Europe has worked with a range of government organisations and charities to develop and implement several eco-driving schemes in Europe (see Section 2.2.1).

As part of the development of these schemes Ford have undertaken or commissioned several evaluations. In particular, they have engaged with the German Road Safety Council (DVR) to undertake an independent evaluation of their schemes in 1999/2000. While the original report describing these evaluations was not located during this review, a number of presentations provide outline information about evaluation activities.

In a 2008 presentation for Energy Efficiency Business Week, Dr Wolfgang Hennig described the results of several evaluations of Ford's eco-driving schemes, presented below.

In 1999/2000 DVR undertook a review of Germany-wide eco-driver training sessions provided by Ford. DVR conducted interviews with 300 randomly selected eco-driver training participants. The results of the evaluation showed that:

- The average fuel saving using eco-driving styles was 25% (immediately following training).
- There was up to a 10% long-term fuel saving (12-18 months following training).
- 99% of participants considered the course to be valuable and would recommend the training to others.
- 98% considered the training tips to be applicable in real world situations.

Following on from the 1999/2000 evaluation, DVR undertook additional analysis of the scheme at the Leipzig Motor Show (2004). Seventy-four drivers (overwhelmingly male) were provided with training. Results showed a 26% reduction in fuel consumption immediately following training (when compared to performance prior to training).

More recently, Ford's 'training snack' approach was trialled at the Frankfurt Motor Show in 2007. A total of 765 drivers received training from DVR certified trainers. The training focused on low engine speed, anticipatory driving and using momentum. The results showed a reduction in fuel consumption of 20.65% immediately following training (when compared to performance prior to training) (Hennig, 2008).

Following on from Ford's success with 'training snacks' in Europe, the Energy Saving Trust (UK) tested the concept at five regional events and for two weeks at the London Motor Show (Saynor, 2008). Drivers received one-on-one training in eco-driving and undertook three drives on a test track (prior to training, under instruction and post-training). Improvements in driving performance were calculated between the first and third lap. In total, 990 drivers were trained and, on average, achieved a 21.23% reduction in fuel consumption.

The evaluations undertaken by Ford have a number of flaws. In particular measures were taken immediately post-training and performance was incentivised through prizes in some cases. However, results achieved are relatively consistent across a number of large scale trials.

4.3.3 Netherlands Eco-Driving Programme

As described in Section 2.1.1, the Dutch eco-drive programme, Het Nieuwe Rijden, has the objective of encouraging more energy efficient vehicle purchasing and driving behaviour (van der Hoed et al, 2006). The eco-driving programme is implemented by SenterNovem, an agency of the Ministry of Economic Affairs, on behalf of the Dutch Ministry of Transport and in co-operation with the Ministry of Environment.

The programme is linked to the Netherlands obligations under the Kyoto agreement and to national policy documents targeting CO_2 emission reductions in traffic and transport. The programme is driven by a long term strategy (1999-2010) that contains objectives for reductions in CO_2 emissions. Specifically, targets have been set for a reduction of 0.8 Mt of CO_2 emissions by 2010 annually (0.5 Mt for in-car devices and driving style changes, and 0.3 Mt via improved tyre pressures). An intermediate goal of 0.4 Mt CO_2 emission reduction was set for 2005 (SenterNovem, 2005, cited in van der Hoed et al, 2006).

The programme covers a wide range of activities which are divided into five streams (Harmsen, van der Hoed & Harmelink, 2007):

- **Stimulating an energy efficient driving style**. This includes training driving instructors in eco-drive principles, subsidising training for professional drivers, development of a driving simulator, and communications campaigns.
- **Integrating eco-drive principles into the driving curriculum.** This includes the training of driving instructors and the integration of eco-driving principles into the driving school curriculum and driving exam.
- **Stimulating in-car devices**. This includes lobbying for tax incentives and public information campaigns.
- **Facilitating optimal tyre pressures**. This includes demonstrations and public information campaigns.
- **Stimulating purchase of more efficient vehicles**. This includes raising awareness during other training activities and communications campaigns.

The effects of the eco-driving programme are evaluated annually. Wardennar (2007) states that annual monitoring of eco-driving projects in the Netherlands consists of:

- Using information from more than 50 specific eco-driving projects.
- Using a telephone survey of 1000 consumers.
- Using research results on the effects of mass media campaigns.
- Using available statistical information on fuel consumption and sales.

In addition, an in-depth ex-post evaluation of the Dutch Eco-Driving Programme was undertaken within the framework of the AID-EE project[50]. This evaluation is described in

[50] Active Implementation of the Directive on End-Use Energy Efficiency and Energy Services.

detail below. This evaluation is a theory based policy evaluation and focuses on the whole policy process (Harmsen et al, 2007). It uses both the results of annual evaluations and additional novel work.

The results of the AID-EE evaluation indicate that:

- **Participation of stakeholders**: The involvement and active participation of stakeholders was assumed to be an important supporting factor for the eco-driving program. The Dutch program was found to be successful in creating a network of representative stakeholders relevant for bringing eco-driving to the attention of the end-user. Among the participating stakeholders were consumer organisations, environmental NGOs, professional organizations (e.g. for drivers, car dealers, logistics companies, driving schools), tyre suppliers, oil companies and car lease companies.
- **Train the trainers**: By 2004, 76% of the 7850 driver trainers in the Netherlands had received eco-driver training.
- **Driving school curriculum**: Eco-driving has been integrated into the driving school curriculum since 2001.
- **New drivers trained**: 92% of instructors plan to include eco-driving into their driver training.
- **Training for existing drivers**: Between 2000 and 2004 more than 100 projects were contracted by SenterNovem to stimulate eco-driving amongst existing drivers. The majority of these projects were training courses. In 2004 approximately 75,000 existing drivers were reached: 26,000 via a multimedia game, 25,000 by tyre pressure training courses and 16,000 by other subsidised projects. In addition, over 8,500 professional drivers such as taxi drivers and other collective transport drivers had been reached as well as 750 truck drivers. Between 1999 and 2004 the Eco-driving program reached more than 150,000 existing drivers. This represents 1.5 % of the total driver population in the Netherlands. A relatively limited number given the large number of projects aimed at this target group.
- **Communication campaign recognition**: Spontaneous recognition of the eco-drive programme increased to 31% in 2004 and supported recognition increased to 50%. Television was the most effective means of reaching the target group with 78% of respondents having learned about eco-driving from television.
- **Familiarity with eco-driving principles**: The typical eco-driving principles are not well known among the respondents: early gear shifting (14 %), anticipating traffic (3 %), driving with constant speed (9 %), rolling out in gears (7 %), lower rpm (revolutions per minute) level (10 %), and steady acceleration (7 %).
- **Changes in driving behaviour**: The level to which eco-driving driving style suggestions are applied by existing drivers has been assessed through annual telephone surveys. In the survey 1100 respondents were asked to rate the extent to which they applied three selected eco-driving principles (constant speed driving, limited revolutions, anticipation behaviour). The results show a gradual increase of the use of all three eco-driving principles (from 10 % of the respondents in 1999 to 22 % in 2004).
- **Checking tyre pressures**: Recent studies show that the number of cars with correct tyre pressure has not significantly increased between 1999 and 2004.

- **In-car devices**: Based on the annual telephone survey an increase in in-car device possession in the c*urrent car stock* can be observed from 13 % in 2000 to 33 % in 2004. Furthermore, integration of in-car devices in *new cars* has increased to over 70 % in 2004.

The information gathered during this evaluation was used to assess the net impact of the eco-driving programme in terms of reductions in CO_2 emissions. Impact was divided between the three policy modules:

- In-car devices,
- Existing drivers/communication, and
- New drivers/driving school curricula.

The net impact of each policy modules was assessed based on annual data collected by SenterNovem. The authors of the report note that in making assessments a large number of assumptions have been made (van Hoed et al 2006). Where they are noted, these assumptions are listed with impact statements below:

- Emissions reductions due to in-car device subsidisation were assessed as 16.024 Kt in 2004. Assumptions made include the number of in-car devices that would have sold without the subsidy and the fuel savings that would result from drivers have access to an in-car device (e.g. the extent to which drivers would use the device and whether they have been trained in the use of the device).

- Emissions reductions due to communications campaigns and training programmes aimed at existing drivers were estimated to result in CO_2 emissions reductions of 34-86 Kt in 2004. The majority of this saving was estimated to be due to the communications campaign, with only 10-20% being due to driver training. In making this estimate, assumptions were made about the number of drivers reached during the communications campaign and the effectiveness of the communication campaign in changing behaviour.

- Emission reductions due to integrating eco-driving into the driving school curricula were estimated at 47-94 Kt in 2004. Assumptions were made about the reach of training programmes for professional drivers and the extent to which behaviour change is maintained over time.

The eco-drive programme was estimated to cost government €9 per tonne of CO_2 saved. This figure is based on the estimates of CO_2 saved described above and a detailed assessment of the cost of eco-drive programmes to government, society and end-users (van Hoed et al, 2006).

In terms of meeting the targets set as part of the programme objectives, van Hoed et al estimate that between 1999 and 2004 energy savings of 0.1-0.2 Mt of CO_2 emissions have been achieved. This amounts to 0.03-0.08% of total fuel used by Dutch transport. Therefore, the authors state that the intermediate target of 0.4 Mt by 2005 will not be reached[51]. However, the authors also note that because of the difficulties with assessing

[51] Interestingly, a presentation by van der Berg (2007) indicates that in an annual evaluation found that 0.3 Mt of CO_2 was saved in 2006 directly related to programme activities and a CO_2 reduction of 0.6 Mt resulted

CO_2 emissions reduced, a focus on intermediate measures (e.g. number of drivers trained) is recommended.

The Netherlands have worked to implement a comprehensive eco-driving programme and the evaluations of this programme are equally comprehensive. They include a range of measures and provide a detailed assessment of the amount of CO_2 saved by key programme elements. What is notable is that, given the large number of eco-driving activities in the Netherlands, at the time of these reports more work was required to meet national targets.

4.4 Summary

In general, the number of readily accessible high quality eco-driving scheme evaluations is limited[52]. Claims regarding the results/effectiveness of many schemes are based on evaluations of driver performance immediately following training and many reports do not provide enough information about the evaluation methodology to assess its scientific rigor. The results of these studies must, therefore, be viewed with some caution.

A number of European eco-driving schemes may have been subject to more rigorous evaluation (particularly the German eco-driving schemes). However, reports in English were not identified during this review. What is clear is that more rigorous evaluations are required to confidently establish estimates of likely medium and long term reductions in fuel consumption resulting from particular types of eco-driving scheme (e.g. communications campaigns vs. one-on-one training).

Despite the lack of agreement about the benefits arising from eco-driving, there appears to be a general consensus that some benefit will be realised. Based on this review, it seems likely that a 5% reduction in fuel consumption (approximately) may be a reasonable estimate of the benefits that might be expected from the average eco-driving scheme over the medium term. In-car devices and other on-going feedback may help to improve this result. However, there is currently insufficient evidence to support this claim. For example, the Fiat study which evaluated real world driver performance using devices that provided on-going drive feedback realised an average 6% reduction in fuel consumption (Fiat, 2010). Finally, early cost-effectiveness data appears to indicate that, in comparison to other fuel reduction measures, eco-driving is a relatively cost effective approach.

The only detailed evaluation that included intermediate measures of an eco-driving programme was undertaken in the Netherlands. The results of the evaluations of this programme indicated that significant funding was required to reach a relatively modest number of Dutch drivers. These results indicate that any eco-driving programme in New Zealand must be carefully designed to ensure maximum brand recognition and that the ‘eco-drive’ message reaches the driving public.

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from all programme elements (e.g. driving style, tyre pressure, in-car devices). With a cost effectiveness of €7 per ton of CO_2 avoided.

[52] For example evaluations that are published in peer-reviewed journals.

5 IMPLEMENTING ECO-DRIVING IN NEW ZEALAND

Sections Three and Four of this report indicate that eco-driving schemes have been implemented with some degree of success in a range of countries. Projections of potential fuel and CO_2 emission savings in New Zealand indicate that an eco-driving scheme may also be of benefit here (see Section 2).

Before the particular initiative(s) that may be appropriate for New Zealand are decided upon, a range of factors must be considered. In particular:

- The type of eco-driving initiative(s) that would best suit New Zealand given the demographic profile of New Zealand drivers and vehicles.
- The views of the New Zealand public on the value of eco-driving.
- The views of industry experts on eco-driving, in particular their knowledge of existing factors that may support or block the implementation of particular eco-driving initiatives.

While a full cost-benefit analysis of each potential initiative is beyond the scope of this study, the information presented in this section provides an early indication of the types of eco-driving initiatives that may be more effective in the New Zealand context. It includes information on New Zealand driver demographics and a review of potential initiatives by industry experts. Further information on the views of the New Zealand public on eco-driving (based on the results of a survey of AA members) is provided in a separate report and the results of the survey are referenced in this section.

5.1 New Zealand Driver Demographics

5.1.1 Drivers

There are approximately 2.8 million drivers of cars and other light vehicles in New Zealand (MOT, 2009).

The number of active drivers (who drive more than 100km per year) varies with age and gender (as shown in Figure 1). Similarly, the distance they drive each year varies (as shown in Figure 2).

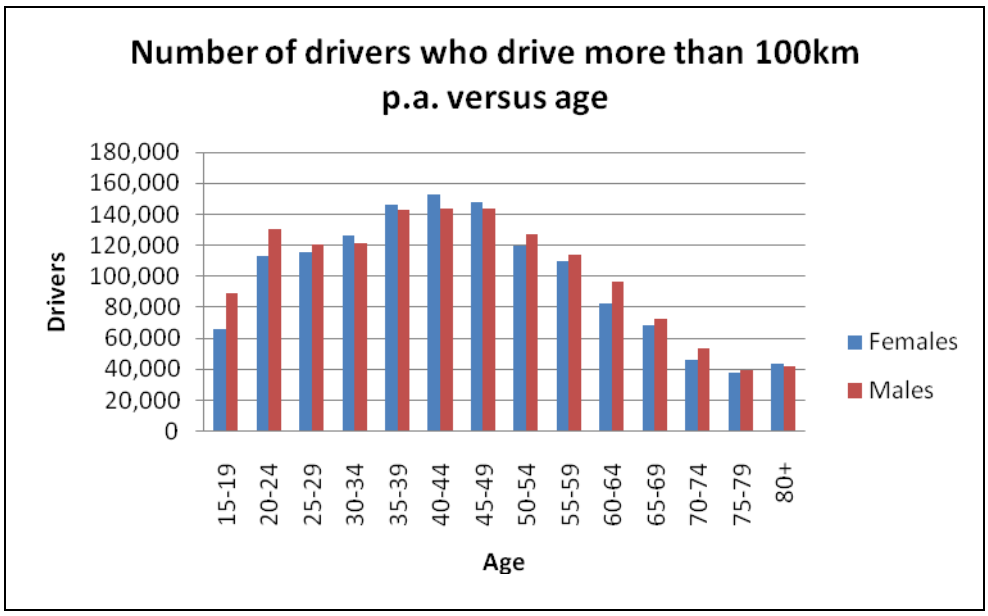

Figure 1: Number of drivers by age and gender

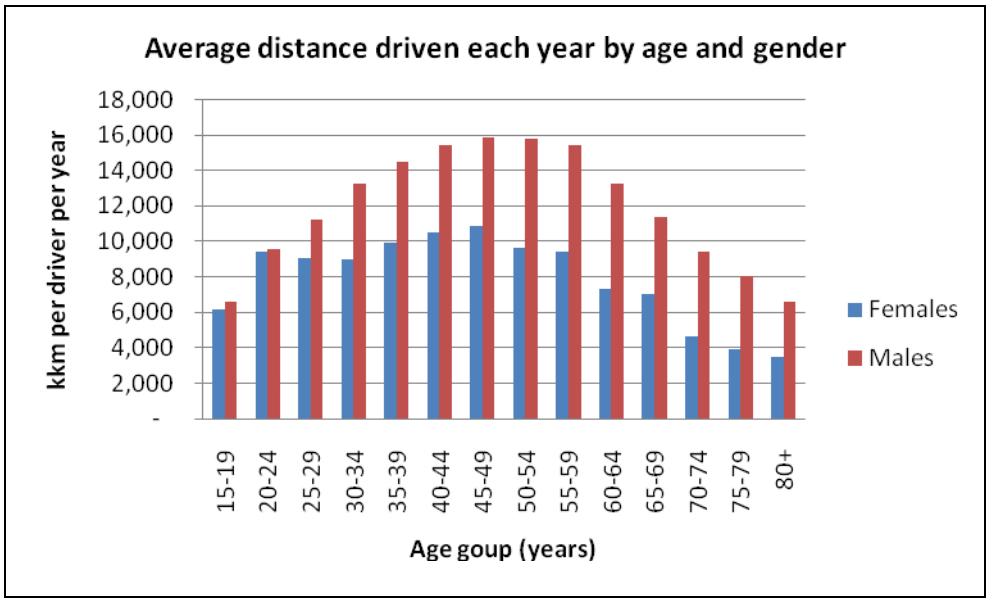

Figure 2: Average distance driven by driver by age and gender.

The effects of age, gender and average distance travelled is reflected in the total distance driven by each group each year (see Figure 3). As Figure 3 shows, males in the 25-59 years age group drive greater distances than other demographic groups. They make up 32% of drivers but 44% of the total distance driven. These results suggest that targeting this group may be a more effective approach to reducing fuel usage and CO_2 emissions at a population level.

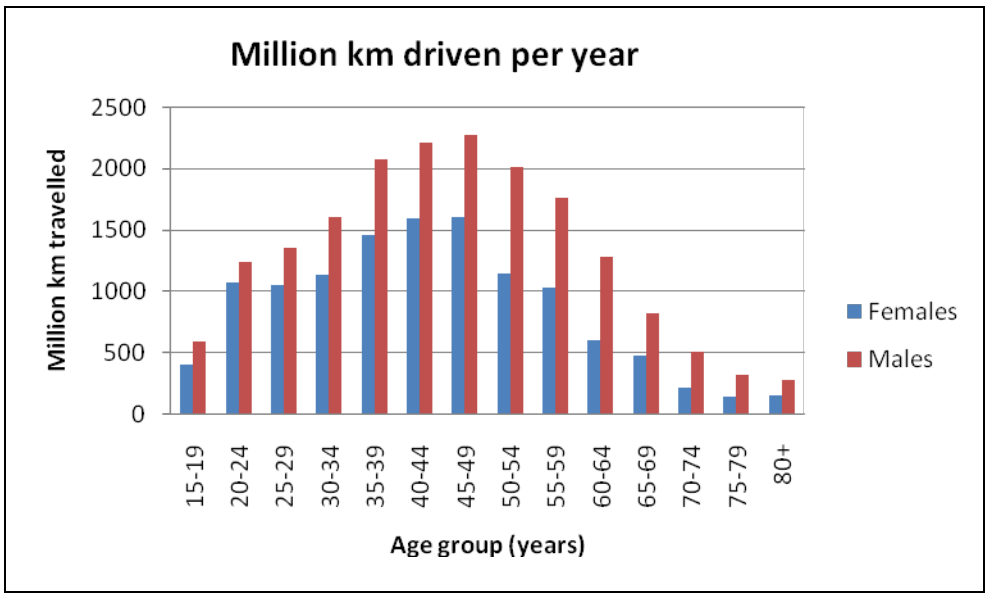

Figure 3: Total distance travelled by each age and gender.

5.1.2 Driver licences

Young drivers who are in the process of obtaining their driver's licence are a potential target group for eco-driving interventions because they are relatively easy to reach.

There were, on average, 44,000 drivers who obtained a learners licence each year between 2003 and 2006 (based on driver licence data extracted by MOT for the AA for this project).

Figure 4 shows the age at which drivers obtained their learner's licence. It is notable that 74% were of school age (15 and 16 years old). This suggests that it may be possible to provide eco-driving instruction at school or as part of the learner licence requirements.

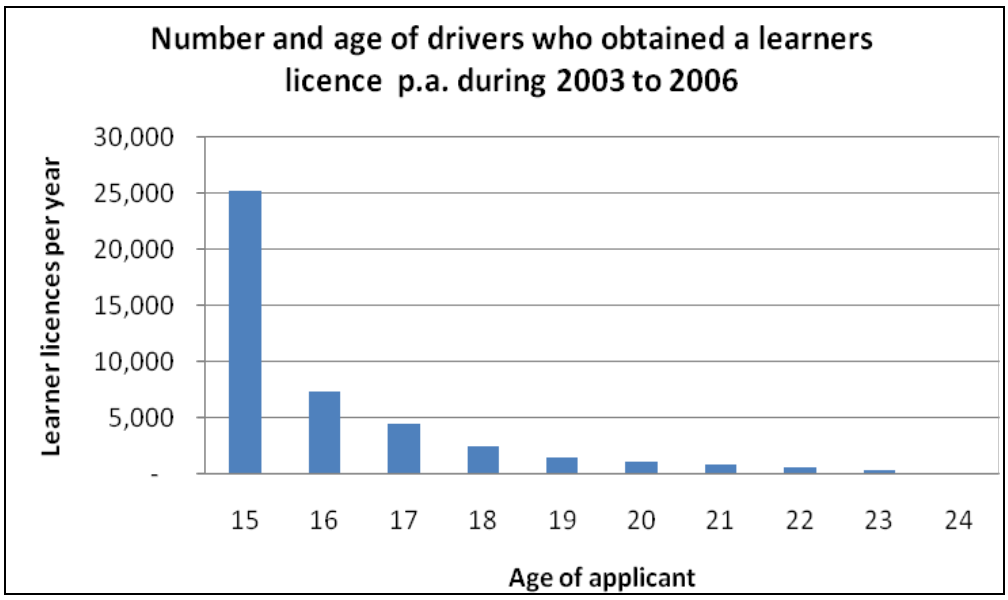

Figure 4: Age of driver (with a restricted licence) when they obtained their learner licence (Years).

Figure 5 shows the length of time drivers held a learner's licence before obtaining their restricted licence.

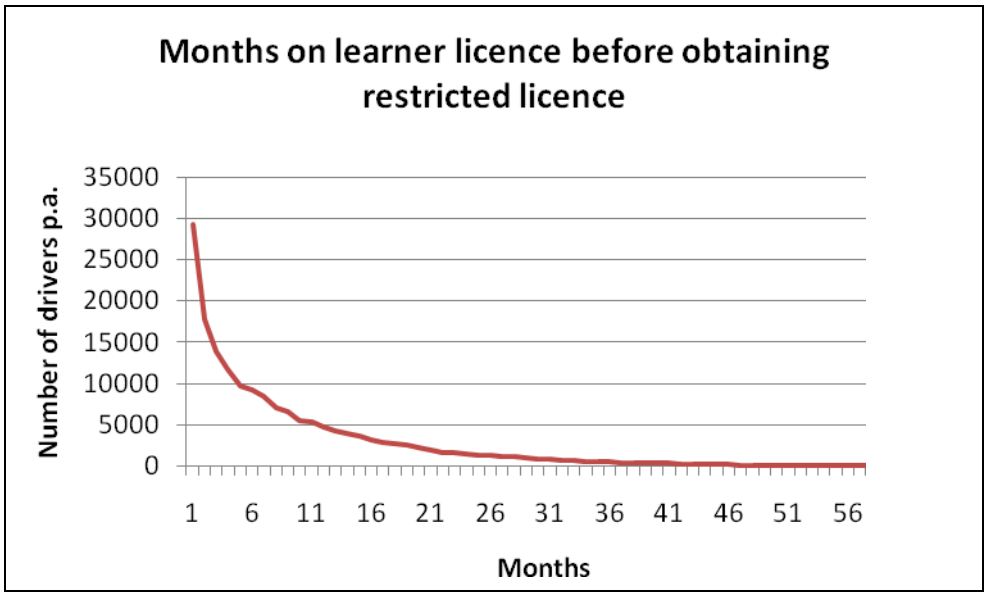

Figure 5: Length of time on a learners licence before obtaining a restricted licence.

Of concern is that 53% (23,400 per annum) of those drivers did not progress to a full licence.

The information presented above indicates that approximately 1.5% of the total driver population of 2.8 million obtain a learner licence each year (44,000). Because the proportion of new drivers entering the driving population each year is very low, targeting this group alone with an eco-driving intervention would result in a very low level of coverage of the total driving population for many years. In addition, the motivation of the large number of drivers failing to progress of a full licence is a concern. If these drivers are not currently completing the full licensing process, it may be unlikely that they will take on eco-driving education.

5.1.3 Light Vehicles

Table 1 provides a breakdown of the number of vehicles on New Zealand roads by type (based on data extracted by the MOT for the AA from the MOT Transport Monitoring Indicator Framework).

Table 1: Road vehicle fleet numbers

	2006	**2007**	**2008**	**2009**	**2010**
Light Passenger	2,536,957	2,580,666	2,584,337	2,574,589	2,599,568
Light Commercial	360,877	371,216	377,014	376,695	379,386
Motorcycle	88,921	99,211	111,566	114,443	112,997
Heavy Truck	110,598	114,010	115,347	113,072	111,654
Bus	7,593	8,018	8,387	8,450	8,315
Vehicles per capita	0.74	0.75	0.75	0.74	0.74

As the table shows, in 2010, approximately 93% of the total fleet are light vehicles (light passenger or light commercial). These figures show that targeting light vehicle drivers with an eco-driving programme would cover a significant proportion of the total vehicle fleet.

The distance travelled by each vehicle type in 2009 is shown in Table 2 (de Pont, 2009). Again, it is clear that the majority of road vehicle kilometres are travelled by light vehicles (passenger or commercial).

Table 2: Total distance travelled by vehicle type

Road vehicle kilometres travelled (VKT) by fuel type (millions)	**2009**
Light passenger petrol travel	27,958
Light passenger diesel travel	3,082
Light commercial petrol travel	1,509
Light commercial diesel travel	4,242
Motorcycle travel	338
Truck petrol travel	11
Truck diesel travel	2,510
Bus petrol travel	2
Bus diesel travel	237
Electric bus travel	1
Petrol travel	**29,818**
Diesel travel	**10,071**

Figure 6 further demonstrates the dominance of the light-vehicle fleet in terms of the proportion of vehicle-kilometres travelled (reproduced from Ministry of Transport data (MOT, 2008)).

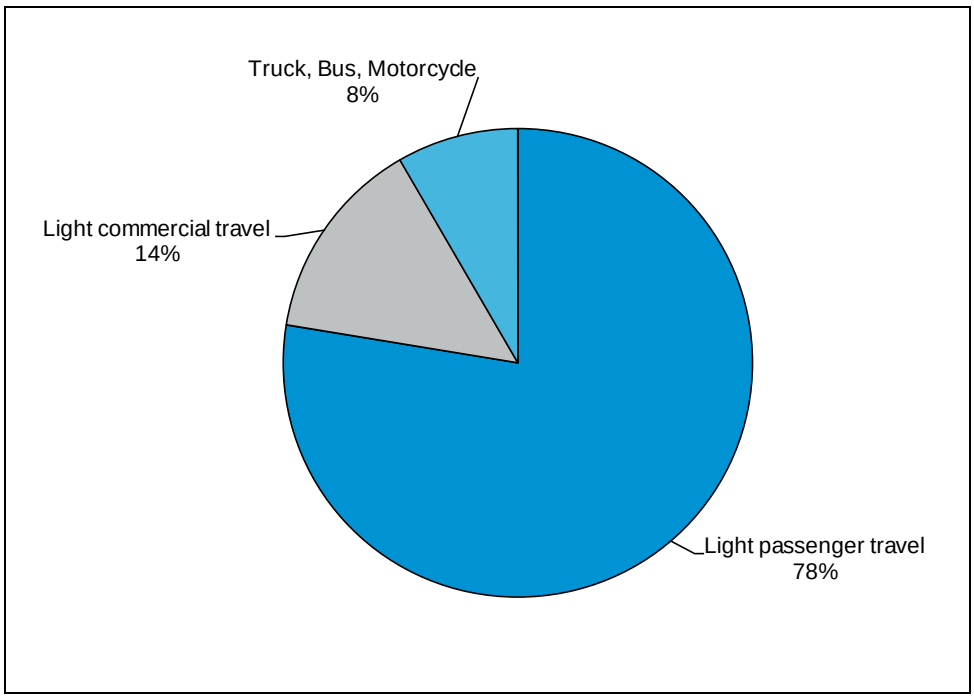

Figure 6: Vehicle-Kilometres Travelled in 2007 by Vehicle Type (MOT, 2008).

Figure 7 shows the age profile of the New Zealand light-vehicle fleet in 2007. The importation of second hand vehicles results in the peak being at 10-year-old vehicles, rather than at new vehicles, which is the case in virtually all other countries and globally. Consequently the New Zealand fleet has a relatively high average age but the proportion of vehicles older than 15 years is comparable to Australia (21.2% in Australia and 22% in New Zealand).

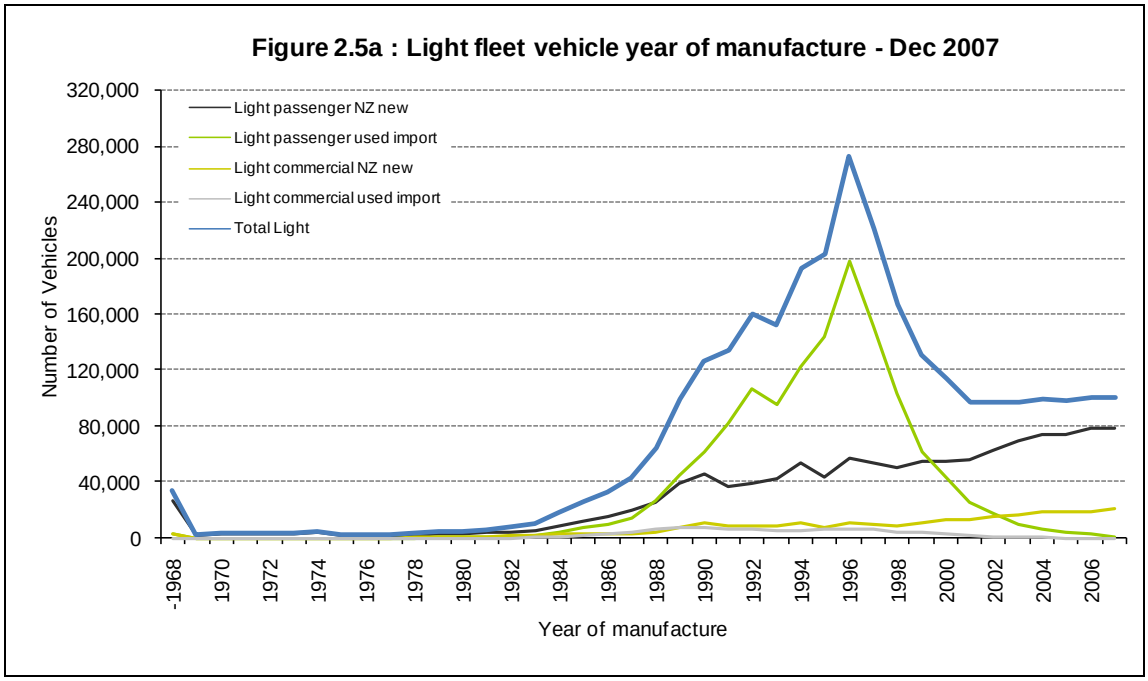

Figure 7: Age distribution of the light-vehicle fleet (adapted from Ministry of Transport 2008d).

5.1.4 Light Vehicle Fleets

There are some advantages in targeting enterprises that have vehicle fleets, especially as the enterprises stand to gain though lower transport costs and could provide eco-driver training as part of the normal staff training efforts.

The four main types of light vehicle fleets are (Baas et al, 2005):

1. Private passenger vehicles such as company and public sector cars. This is the largest group with over 260,000 vehicles in 2005, of which 120,000 in fleets greater than 20 and 60,000 in fleets greater than 100. Vehicles in fleets greater than 20 consume approximately 10PJ of energy. The most cost-effective approach will be to targeting the largest fleets first.

2. Goods service vehicles such as courier and other light delivery vehicles. There were 94,000 goods service vehicles in 2005, many (65,000) in fleets of less than 20 vehicles. A number of these small fleets, especially those involved in courier delivery, work on contract to larger organisations. This sector used approximately 5.9PJ of energy.

3. Rental vehicles. These vehicles are generally in large organisations, with over ½ in fleets greater than 500. The size of the vehicles is smaller on average than that of the whole fleet with over 63% of the rental vehicles having engine sizes less than 2 litres. It is difficult to have much influence over the drivers of rental vehicles especially drivers who may be on holiday from overseas. This sector uses approximately 4.3PJ of energy.

4. Taxis are a relatively small group, consuming less than 0.1PJ of energy per year. There may be some scope to reduce their energy use through driver training using their existing driver training infrastructure. The NZ Taxi Federation and taxi driver training schools may be a good way of gaining access to many taxi fleet owners and drivers.

5.2 Expert Review of Potential Eco-Driving Initiatives for NZ

Based on the results of the international review of eco-driving schemes outlined in this report, the following set of initiatives with potential to promote eco-driving in New Zealand were identified:

1. Including eco-driving as a formal part of the driving test.
2. Including eco-driving as an educational part of driver licensing.
3. Providing training for licensed fleet drivers.
4. Providing training for private motorists.
5. Promoting in-car eco-driving devices.
6. Eco-driving communications campaigns.
7. Eco-driving insurance.

All options, with the exception of eco-driving insurance, have been successfully implemented internationally.

Each eco-driving initiative was reviewed by the project steering group. This group reviewed the findings of the literature review, AA driver survey and driver demographic information and considered:

- What would need to be done to implement the particular initiative?
- What are the strengths and weaknesses of the initiative?
- What, if anything, threatens the chances of the initiative succeeding?
- What, if any, factors may increase the chances of the initiative succeeding?

The results of this analysis are presented in the tables below.

Initiative One: Eco-Driving as a Formal Part of Driver Licensing	
Description	Eco-driving to be included as a formal, assessed part of the driving test either for learner, restricted or full licence. To implement this option the following actions would be required: altering road code and other manuals, training driving instructors and examiners, deciding how skills would be assessed (theory or practical) and altering driving test materials, informing the public of changes.
Overseas Examples	A number of European countries have embedded eco-driving as an assessed part of driver licensing, in particular, the Netherlands, Germany and Switzerland. A new European Union programme called ECOWILL aims to harmonise and optimise the contents and application of eco-driving in the driving test for learner drivers, including engaging governments and driving school administrations to incorporate eco-driving into the driving school curriculum.
Implementation in New Zealand	
Strengths	All learner drivers would be exposed to eco-driving. The scheme targets a group that the AA survey suggests are less likely to be aware of fuel saving tips and techniques. Eco-driving assessments would be consistently delivered and structured feedback could be provided to learner drivers. AA driver survey suggests some support from New Zealand public for this option (51.6% supported). Targeting learner drivers may have ‘spin off’ advantages in terms of educating parents.
Weaknesses	Poor coverage in the short term. Demographic analysis shows that new drivers are a very small percentage of the total driving population. Demographic analysis suggests that many learner drivers currently do not sit full licence tests. These drivers may not be a motivated target group, which may result in poor uptake of eco-driving techniques. Many learner drivers in New Zealand do not have formal driver training, how would eco-driving skills be trained?

Threats and Opportunities	This initiative links in closely with the Government's Safer Journeys action plan for younger drivers. In particular, eco-driver training would increase the educational opportunities for learner drivers.

Initiative Two: Eco-Driving as an Educational Part of Driver Licensing	
Description	Eco-driving to be included as an educational, non-assessed part of the driving test either for learner, restricted or full licence. To implement this option the following actions would be required: altering road code and other manuals, training driving instructors and examiners, deciding how skills would be assessed (theory or practical) and how feedback would be provided, informing the public of changes (including whether eco-driving is linked or not to pass/fail decisions). There may also be opportunities to provide eco-driver training in schools.
Overseas Examples	A number of European countries have embedded eco-driving as an educational part of driver licensing. Finland provides eco-driving training and feedback at both stages of driver licensing. During the second phase of licensing, eco-driving is focused on intensively, including 'before-and-after drives' where the driver's driving style is appraised and a recording of the exact fuel consumption is taken (this approach is also used in Switzerland). The United Kingdom has modified all driver handbooks to include eco-driving tips, driving examiners have been trained in eco-driving and from 2008, eco-driving was included as a non-assessed part of the driving test. In Canada, eco-driver training is a mandatory component of the driving curriculum but does not appear to be currently assessed during driving tests.
Implementation in New Zealand	
Strengths	All learner drivers would be exposed to eco-driving included being provided with detailed feedback from a qualified driving examiner.Validation of eco-driving techniques for inclusion as a formal part of the driving test would not be required. The scheme targets a group that the AA survey suggests are less likely to be aware of fuel saving tips and techniques. Eco-driving assessments would be consistently delivered and structured feedback could be provided. AA driver survey suggests some support from New Zealand public for this option (51.6% supported). Limited additional cost involved.

Weaknesses	The full benefits will take time to achieve because learner drivers are only a small percentage of the total driving population. Demographic analysis suggests that many learner drivers currently do not sit full licence tests. These drivers may not be a motivated target group, which may result in poor uptake of eco-driving techniques. Implementing this option may be relatively time consuming. Many learner drivers in New Zealand do not have formal driver training, how would eco-driving skills be trained?
Threats and Opportunities	This initiative links in closely with the Government's Safer Journeys action plan for younger drivers. In particular, eco-driver training would increase the educational opportunities for learner drivers. Coverage could increase significantly if steps were taken to encourage drivers with restricted licences to progress to a full licence within a reasonable timeframe.

Initiative Three: Eco-Driver Training for Licensed Fleet Drivers	
Description	Eco-driver training to be provided to licensed fleet drivers through their companies. This training is likely to be developed and promoted by NZ driving organisations such as AA and FleetSafe NZ. Ideally, the training is will be accompanied by a monitoring and/or incentive scheme to help embed eco-driving practices. It is possible that this type of training could follow the Ford 'training snack' model and could possibly include on-line or simulator based training. Training courses would be accredited to ensure they are of a high standard and driver trainers audited. The model used for the SAFEDNZ driver training for trucks may be appropriate.
Overseas Examples	The review of international eco-driving schemes identified a number of schemes targeted at fleet drivers. For example: Subsidised eco-driver training for fleet drivers is provided in the Netherlands. In Germany, DVR has partnered with BG to develop eco-driving training programmes to be delivered in private organisations. They include full day training courses for six participants, half day training courses for three participants and training snacks. In the United Kingdom, the Energy Saving Trust has partnered with Ford to develop eco-driver training. Training is organised in partnership with employers, lessons are 50 minutes and available to all drivers rather than just company drivers. The cost to the employer/employee is £15 per person (with additional funding provided by government).
Implementation in New Zealand	
Strengths	If larger organisations can be encouraged to take up the training, a relatively large number of drivers can be trained at relatively low cost. Organisations can incentivise drivers to make use of the techniques through monitoring fuel consumption. Organisations have a financial incentive to take part in the training,

	significant cost savings could be achieved for larger companies.
Weaknesses	Demographic analysis suggests that light vehicle fleet drivers are a relatively small part of the total driving population (this group makes up 14% of the total vehicle kilometres travelled). Engaging companies in training of this type can be difficult and time consuming. Some of the larger fleets could be hard to influence because driving is only a means of staff getting to appointments (e.g. nurses in DHBs). Expert group felt that the cost of letting a staff member go for a day for training can be too high for some companies as no-one is there to cover the absence.
Threats and Opportunities	AA has already worked with Peugeot to develop an eco-driving programme that may be of use. Expert group felt the government would support this option The expert group suggested that the results of the ACC Road Safety Discount Programme be used to determine whether it is worth promoting to light vehicle operators.

Initiative Four: Eco-Driver Training for Licensed Drivers	
Description	Eco-driver training to be provided to licensed drivers through a wide range of schemes. This training is likely to be developed and promoted by NZ driving organisations and would leverage off the work of driver education providers in New Zealand. It could involve a wide range of delivery mechanisms – for example providing training to drivers in AA centres waiting to renew licences, and training at the point of vehicle purchase. The training might be multi-faceted and include use of the Ford 'training snack' model, in-car training and possibly on-line or simulator based training.
Overseas Examples	Many countries provide subsidies for eco-driver training for licensed drivers. The most notable is the Netherlands, who subsidised more than 100 projects through SenterNovem between 2000 and 2004. These included multimedia games, tyre pressure training and other projects. Ford Europe also provides training to licensed drivers through their 'training snack' approach at motor shows and during vehicle purchase in the United Kingdom and other European countries.
Implementation in New Zealand	
Strengths	Drivers are more likely to take up eco-driving techniques following a training intervention than through a communications campaign.
Weaknesses	Overseas examples suggest that significant investment is required to reach a relatively small number of drivers compared to other approaches. Most drivers are not willing to cover the cost of a full training course at realistic levels (see AA eco-driving survey)

Threats and Opportunities	Opportunity to leverage off the expertise, contacts and networks of existing driver training organisations such as AA.

Initiative Five: Promoting Eco-Driving Devices	
Description	There are a number of ways of promoting the installation and use of eco-driving devices, for example by: providing independent consumer information, promoting their uptake through a public information campaign, encouraging or requiring vehicle manufacturers to include these devices as part of new vehicles, providing special offers on purchase targeted to AA members, tying their use with lower insurance premiums.
Overseas Examples	The only example of a scheme subsidising eco-driving devices was identified in Japan. In 2006, Japan implemented government subsidies to service industries that use trucks, buses and taxis in order to assist in the installation of equipment necessary to utilize Eco-Driving Management Systems (EMSs). The program provided one-third of the cost of implementing equipment for the EMS.
Implementation in New Zealand	
Strengths	Installing eco-driving devices provides drivers with the ability to self monitor and regulate their driving. Fiat have proven this approach (see Section 4.3.1).
Weaknesses	New Zealand has a relatively old vehicle fleet and many cars may not be able to take eco-driving monitoring devices. It is likely that many newer vehicles are driven by the group the AA survey found are mostly likely to already know and follow eco-driving tips (older men). This may limit the benefits that may be gained. The scheme is likely to be more expensive that other approaches, particularly because an extensive communications campaign would likely be required. Expert group noted that New Zealand has a high number of Japanese imports and that these cars do not have eco-driving monitoring devices (unlike Europe).
Threats and Opportunities	The expert group felt that it may be possible to work with Z-energy or BP to provide feedback at gas stations. The expert group felt that car auctioneers could be persuaded to hold sales specifically for fuel efficient cars. The expert group suggests that a cost-effective idea could be to put a sticker on the green part of the speedometer.

Initiative Six: Eco-Driving Communications Campaign	
Description	Communications campaign(s) targeted at various driver groups using a range of media from print to television and internet with the goal of embedding knowledge about eco-driving techniques in the New Zealand population.
Overseas Examples	A range of countries have used eco-driving public information campaigns. The core component of the ECODRIVEN programme run by the EU was the development of communications campaigns. In addition, in the United States a large scale communications campaign called EcoDriving USA was developed by the Alliance of Automobile Manufacturers in conjunction with Californian Governor Arnold Schwarzenegger and Colorado Governor Bill Ritter. EcoDrivingUSA takes the form of a public education and awareness initiative. The core of the scheme is a website, ecodrivingusa.com, which provides detailed information about eco-driving and educational/promotional resources such as posters and manuals.
Implementation in New Zealand	
Strengths	Eco-driving messages can be targeted at specific driver groups through choice of message, media, and campaign design (e.g. fuel wasting). The expert group noted that communications campaigns can achieve very broad coverage for lower cost than training interventions. The expert group felt that a communications campaign could be seen as a move away from a punishment model and towards an empowerment/encouragement model. Results of the AA driver survey suggest that there was little support amongst respondents for paying for eco-driving training at realistic cost levels. A communications campaign may be a more effective way at reaching drivers.
Weaknesses	Canada has identified that communications campaigns can be expensive and have therefore opted for alternative approaches. It is difficult to evaluate the effectiveness of communications campaigns.
Threats and Opportunities	The expert group noted that dialogue with NZTA would be required for action on this initiative. There is currently a mandate for achieving this initiative, the Minister and Road Safety Committee wish to raise the profile of eco-safety and fuel efficiency issues. The expert group suggested targeting young parents through Plunket because they are typically safety conscious and trying to save money. ECCA has found television advertisements to be successful and has

	budget available for further Energy Spot one minute clips.

Initiative Seven: Eco-Driving Insurance	
Description	Drivers to receive a discount on insurance premiums if they have undertaken an eco-driving course (justified by research linking eco-driving styles and safety outcomes).
Overseas Examples	None identified.
Implementation in New Zealand	
Strengths	The expert group felt that this approach was potentially more appealing to ministers.
Weaknesses	The expert group felt that this initiative could be hard to implement for private drivers, particularly families, because it is difficult to know who is driving the car. It may be more feasible for fleets.
Threats and Opportunities	The expert group felt that partnerships were important for this initiative. If it is to be pursed at the next stage of research then the steering group membership may need to be broadened.

5.3 Summary

The review of New Zealand driver and vehicle demographics indicated that the New Zealand profile has some key features that should be considered when reviewing eco-driving options:

- Males in the 25-59 year age group drive a larger number of kilometres than other groups and therefore may be an appropriate target for an eco-driving campaign.
- Learner drivers make up a relatively small part of the driving population (about 1.5% in any year).
- Many drivers on restricted licences do not sit a driving test to get their full licence and therefore may be unmotivated to undertake training on peripheral skills such as eco-driving.
- New Zealand has a relatively old light vehicle fleet.

The review of seven eco-driving initiatives undertaken with the project steering group showed that the group supported all initiatives in principle. Strengths, weaknesses and opportunities were identified for each initiative and further cost-benefit analysis is required to clearly establish which may be more appropriate in the New Zealand situation.

6 CONCLUSIONS AND PROPOSED RESEARCH PLAN

6.1 Conclusions

The aim of this project was to explore the potential of eco-driver training as a means to improve fuel efficiency in New Zealand by providing background information and recommendations on what should be included in a larger research programme.

The following conclusions can be drawn from this review:

1. Research literature and promotional materials discuss a wide range of potential benefits of eco-driving. However, in many cases the evidence for these benefits is relatively limited. Some evidence was found for the following benefits during this review:
    - Reduced use of and demand for non-renewable natural resources (petrol/diesel) through reduced fuel consumption.
    - Reduced CO_2 emissions and other pollutants (through reduced fuel consumption).
    - Improved vehicle safety, particularly where schemes involve moderation of driver speed plus observation and anticipation of the situation ahead. Reduced ambient noise levels (where advice about engine speed is adhered to).

2. A wide range of eco-driving schemes have been implemented internationally. Some of these schemes, particularly in Europe, have been in place for a number of years and are relatively well developed and evaluated. Therefore, New Zealand can draw on a significant body of knowledge and good practice when developing a set of eco-driving initiatives.

3. Most countries engaged in eco-driving have developed a suite of schemes aimed at different target groups (e.g. embedding eco-driving in driver training, providing training for fleet drivers and communications campaigns). As a result they have invested significant funds.

4. Many eco-driving schemes involve a partnership between government, charities, private organisations and motoring groups. These partnerships help to ‘get the message out there’ and increase the credibility of the scheme.

5. A number of interesting approaches to eco-driver training have emerged in recent years. In particular, shorter ‘training snack’ courses and the use of training simulators. Both of these innovations may be relevant when designing an eco-driving scheme for New Zealand.

6. Despite the lack of rigorous evaluations of eco-driving schemes, a sufficiently large number of evaluations have been undertaken to conclude with reasonable confidence that a fuel saving of approximately 5% could be expected in the medium term. While this may be increased with ongoing training or other interventions, there is relatively little data available to validate this claim.

7. In terms of cost-effectiveness, evaluations suggest that eco-driver training and other eco-driving schemes are relatively cost-effective when compared to other options for reducing fuel consumption and vehicle emissions.

8. The review of New Zealand driver and vehicle demographics indicated that a range of factors specific to New Zealand should be taken into account when designing an eco-driving scheme. In particular, the age of the light vehicle fleet.

9. The project steering group indicated that a broad range of eco-driving initiatives may be appropriate for New Zealand (supporting all seven initiatives presented). Strengths, weaknesses and opportunities were identified for all initiatives and further cost-benefit analysis is required to clearly establish which may be more appropriate in the New Zealand situation.

6.2 Proposed Research Plan

Following a review of eco-driving initiatives the steering group proposed that the following actions be taken:

7. Complete a cost-benefit study on including eco-driving as part of the driver licensing requirements, including considering the safety benefits arising from eco-driving.

8. Undertake a market survey to identify what name should be used for eco-driver training.

9. Undertake a review of options for eco-driver training for existing drivers in fleets and as private motorists.

10. Undertake a review of eco-driving devices covering: what devices exist that may be suitable, what devices may soon become available, would these devices suit the NZ vehicle fleet.

11. Develop a marketing plan to support an eco-driving communications campaign. EECA has developed a draft marketing plan which is included at Appendix A.

12. Further research to be undertaken on initiatives involving eco-driving insurance.

In order to develop a coherent eco-driving programme in New Zealand the following issues should also be considered:

- Should an overarching ‘brand’ for eco-driving in New Zealand be developed to ensure that various schemes are recognisably linked?
- How should any programme be linked to national targets for CO_2 reductions?
- Who is the target audience(s)?
- What type of scheme(s) might be feasible in New Zealand (e.g. what is the likelihood of including eco-driving in the driver licensing system)?
- What should the scheme(s) ‘look like’ (e.g. training snacks or longer courses, what messages should be included in a public education campaign)?

- What partnerships can be formed to increase the likelihood of a scheme’s success?

Based on the steering group's proposed actions and the issues listed above the following research plan is suggested:

- Undertake a review of New Zealand environmental and transport policy and identify areas where eco-driving could contribute to achieving policy aims.

- Undertake a review of eco-driving branding and decide how any eco-driving programme should be designed and marketed. Conduct a high-level cost-benefit analysis of all seven initiatives and identify those that are both feasible in the New Zealand context and would form a coherent eco-driving programme Develop a detailed implementation plan for each feasible initiative. The development of the plan would include engaging with key stakeholders, identifying areas where leverage can be providing by existing initiatives, identifying costs/budget for the initiative and specific implementation actions (e.g. target audience). For example, if the eco-driving devices initiative passes the cost/benefit threshold, all of the actions listed in point 4 above would be undertaken.

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8 APPENDIX A: Strategy for Eco-Driving Communications and Marketing Campaign and Research

Introduction

"Eco-driving" can have benefits not only for the environment but for safety as well. A joint steering group made up of the AA, the AA Research Foundation, EECA, MOT and TERNZ is interested in achieving these benefits through various interventions.

Two of these strands consider making eco-driving part of driver licensing (thereby targeting new drivers). Another strand is designed for licensed fleet drivers supported by technological intervention and incentives through reduced insurance premiums.

The fourth is a communications campaign. This document is a draft strategy for a marketing and communication campaign based on existing research, and including recommendations for further research.

This campaign would be aimed at the general motorist (with some skewing towards the younger male, as discussed below). By raising awareness and acceptance of eco-driving in the shorter term, a marketing and communications campaign could lay the groundwork for the other suggested strands which will take more work and lobbying to achieve (such as driver licensing changes). In other words, these other strands should be considered as part of a long-term staged approach, which will leverage off the awareness and messages of the initial marketing and communications.

Background: Survey results and discussion

The AA Research Foundation carried out a survey of members in 2011 to determine interest in "eco driving", their ability to do it, and the attitudes which might shape their ability to successfully maintain fuel efficient driving methods.

Its findings and the implications for the marketing and communications campaign are discussed below.

The survey found that the concept of eco-driving is popular, with 88% supportive of promoting this practice in NZ.

People were more interested in learning defensive driving than eco-driving – but given the overlap, it would make sense to combine these. This may indicate however that the emphasis should be on safety rather than economy, to appeal to the greatest number of drivers. Whatever the wording though – be it efficient driving/eco driving – there appears to be a level of acceptance for the concept. The exact wording can be tested to get a better understanding.

Many respondents associated fuel efficient driving with open road driving styles. The idea of fuel efficient urban driving was not as well established. This indicates an opportunity for education and room for results.

When asked what likely response they would take if they wanted to cut back on fuel use, the survey found that the most popular responses were:

- combine trips
- drive more efficiently
- don't drive as much.

Female groups were more likely to combine trips (multi-task), carpool, and not drive as much. The male groups were more likely to 'drive more fuel efficiently'.

Males aged 25-64 do 47% of the kilometres driven on New Zealand roads. Women the same age do 32%. The recommendation from the survey is that if eco-driving gains acceptance with men, it will therefore have greater effect. It notes that given most accidents are caused by men this will also have a greater safety benefit.

While the campaign should still be general in nature this indicates that greater gains are to be had from targeting men more than women.

The survey comments that men are more interested in knowing how to get more out of their machines than women and may acquire status from this sort of competition.

This indicates that a campaign targeted at men may be more successful if it focuses on mechanical/performance factors (air con, tyre pressure, smooth driving) than those not associated with the car itself (car-pooling, combining trips). It also suggests that introducing an element of competition may be a good incentive. That said, any campaign should not be limited to a single sex in its messages and should have flexibility to be relevant to males and females. (NB. The NZTA's 'man driving' campaign is a campaign that was solely focused on males.)

When asked if they drove in a style that would give better fuel consumption, around 50% of drivers 25-44 said they did 'always' or 'usually', compared to around 70% for those in the older age bracket. This indicates that there is room for improvement (and therefore benefits) particularly by targeting drivers aged 25-44.

How to get the biggest impact

According to the analysis above, the audience to target to deliver the greatest benefits is:

- men, because they do more driving than women
- 'younger' drivers (25-44) because they are less likely to drive efficiently already.

If we focus on men, then a technical/mechanical/performance messages is most likely to appeal, particularly with a competition element.

According to AA Technical, the driving tips with the greatest efficiency value are:

- light acceleration and braking (20%)
- weight reduction (11%)
- aircon and internal energy reduction (9%)
- drag reduction (8%)

- tyre inflation and maintenance (5%)

Given the campaign is also designed to deliver a safety benefit, it seems clear that the main message should be around light acceleration and braking, which is a skill-based measure with appeal to males who are more interested in getting the greatest performance out of a vehicle. It also has a potential competitive element.
The campaign could include complementary elements of defensive driving which have an economy benefit (looking ahead, anticipating).

Suitable channels

The survey revealed that men cited radio and print higher than women as a source of tips, while TV was high on everyone's list as a source.

Internet advertising is less expensive and is an appropriate channel for the 25-44 age group.

Further market research can assist with this (see below).

Aims of the communications campaign

The aim of the campaign will be to:

- raise awareness of the benefits (safety and economy) of smooth driving technique
- educate drivers on how to drive smoothly in order to save fuel and be safer on the road. This should go into some detail, as many drivers are already aware of the concept of light braking etc, but probably less aware of the detail.
- Introduce an element of incentive or fun to the campaign – for example, an online car driving game or rewards (discounts/flybuys) for verified savings/learnings.
- Measure the results and feedback from the campaign, to inform future campaigns and reinforce the message
- Provide a direction for people to go to for further information (i.e. more tips) on eco driving that can be used by the agencies involved outside of the initial campaign period

Approach

The detail of the communications and marketing campaign will depend mainly on budget. The following elements could be included:

- Energy Spot "special" on driving technique
- Online game / competition to test (and illustrate areas for improvement) for smooth driving technique and other features of eco driving in the urban environment, which also demonstrates it doesn't make the journey longer time-wise
- competition to win a course on defensive driving
- real life video case study of someone learning to eco drive - could also be used for advertising. Measure before and after fuel consumption.
- Free online educational course using video and a quiz, showing driving techniques being employed. (NB. An online defensive/efficient driving course has recently

been launched (http://www.sharpdrive.co/). Unless we think our offering is significantly different we probably shouldn't compete with a private operator.
- Billboards or other advertising aimed at motorists
- Partnership opportunities to help educate and raise awareness – i.e. at service stations or VTNZ station
- PR on eco-driving benefits / research results
- A 'university challenge' – winner featured on Energy Spot

The ability to develop this approach will depend on the budget available for such a marketing and communications campaign. This is something that needs to be agreed upon as soon as possible.

Market research

In order to develop an approach and strategy fully, there are a number of issues that should be explored first through market research. These include:

- Getting an understanding of consumer responses to names and messages (see below for more detail)
- Understanding existing driving habits of the target audience (25-44 year old males)
- Attitudes to advertising channels – i.e. what types of print, online will work for the target audience
- Consumers' motivations for eco driving

This is something that EECA's research agency Synovate could do.

Game and social media

EECA is interested in the concept of a game with links to social media, which would encourage better driving technique. There is a possibility of hosting this on EECA's ENERGYWISE website, if it goes ahead.

Existing campaigns in the market place

We should consider if our messages will 'clash' or compete with other speed/safety transport messages already out there. Ideally they will be complementary.

Target audience

General public / average motorist (not business / fleet) but focusing on 'younger' males (25-44).

Timing

To coincide with holiday driving period – December 2011–January/February 2012

Further research possibilities

Savings from eco-driving are usually derived from overseas studies. A New Zealand study would give greater credibility to statements made about the savings available. Such

a study could involve measuring the savings made by a representative group of drivers (male / female, old / young, urban / rural) after being coached on eco-driving techniques.

This study could also look at the most effective way to get the information to drivers – written vs. video vs. real life coaching and could be used as an online resource. It should also incorporate market research modelling done for EECA on commitment to using energy wisely, which examines the incentives that drive different segments of the market. And it could consider how lasting the effects are – and how the message could be reinforced.

Decisions and actions required

- Decide whether to go ahead with a marketing and communications campaign as a priority, and to lay the groundwork for other strands/interventions
- Agree goals with regard to target audience and outcome
- Decide on budget available for this year, which will help define the scope of planning for this campaign
- Involve an advertising agency to help with strategy and messaging for an effective campaign to achieve agreed goals
- Agree on and commence market research to get a better understanding of issues with consumers
- Agree staging for overall campaign in the long term (ie, over several years and including other options)
- Agree messaging for the overall campaign to ensure consistency