Thought Leadership:
The Interface between Eco-Driving and Safe Driving

Introduction

Many surveys have shown the Australian community is concerned about environmental issues. One survey, of more than 1600 Australian drivers, found 75% of respondents were concerned about the environmental effect of their car, especially air pollution. With an increase in concerns about air pollution and the greenhouse effect, there has been extensive research examining the effects of driving style on the emissions of motor vehicles. There has also been extensive research on the impact of speed on crash severity and likelihood of fatality. But there hasn't yet been much research on the interface between the two phenomenon – the safety and environmental benefits of an improved driving style. This article provides an understanding of key road safety issues that, if solved, also provide environmental benefits.

Drivers are the number one contributor to both safe and environmentally friendly driving practices.

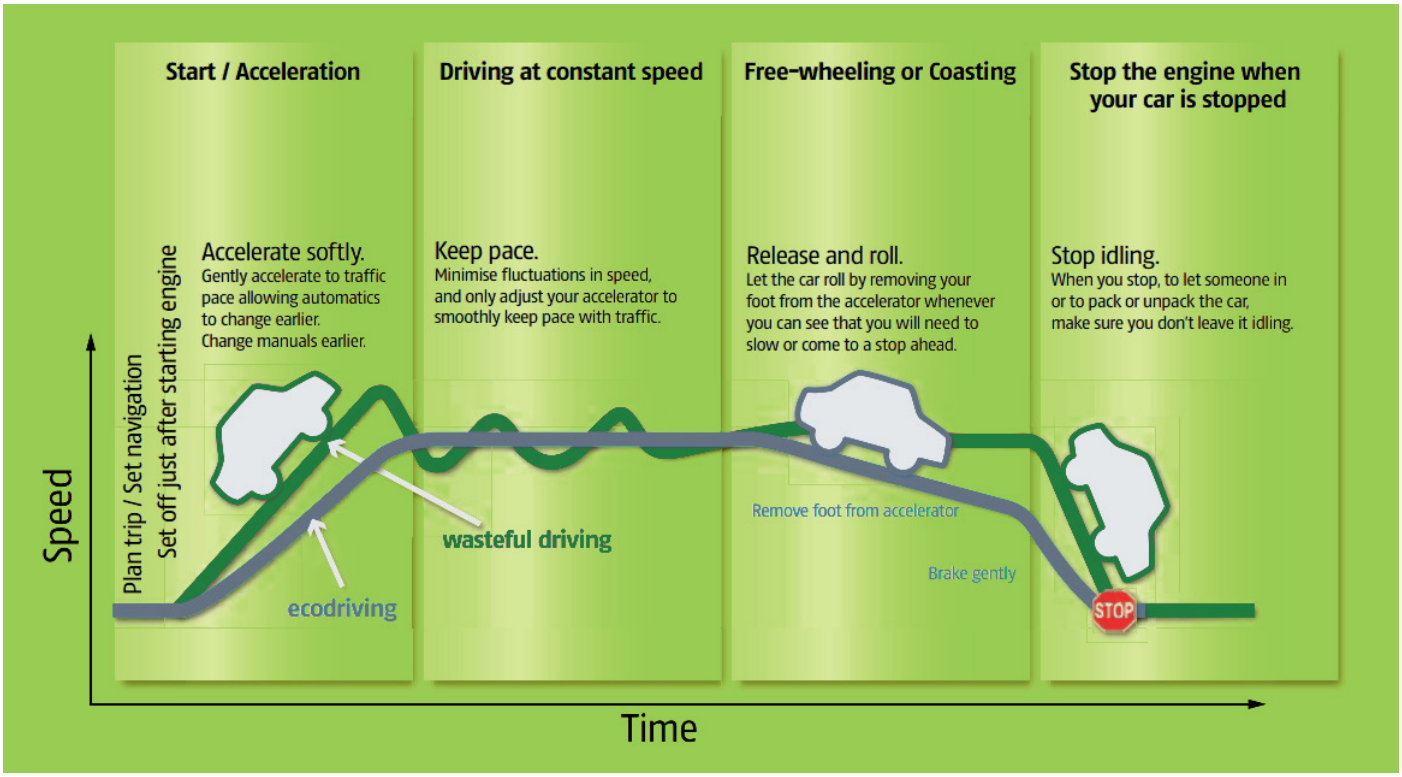
Eco-driving

Eco-driving is a set of steps, techniques and behaviours that drivers can employ in preparing the vehicle before a journey, in planning the journey, in modifying driving style during the journey and in reviewing trip data after the journey. This style of driving can lead to fuel savings, trip cost savings, reduction in Carbon Dioxide (CO_2) emissions and other pollution, and reduction in levels of noise from the vehicle. There is also evidence to show (Case Study: Toyota) that drivers who use eco-driving techniques have less crashes. Eco-driving is beneficial to road safety because drivers have a greater anticipation for risks and exhibit less erratic and unpredictable behaviour.

Seven key principles of eco-driving (as outlined by Toyota)

1. Plan your trip in advance through journey management
2. Remove unnecessary equipment, weight and air resistance from your vehicle
3. Maintain tyre pressure at the recommended level
4. Accelerate and decelerate smoothly
5. Use momentum and speed efficiently
6. Use the air conditioner, and other electrical equipment sparingly
7. Regularly service your vehicle

This flow chart, developed by Toyota, shows how eco-driving is different to regular driving, from acceleration to stopping.



1. Plan your trip in advance through journey management

There are many options for workplace transport that both benefit the environment and increase worker safety. Before using a motor vehicle for short work-related travel, considering your options can be more economical, more environmental and safer. Short trips in inner-city areas mean engines do not have time to warm up to their most efficient working temperature. This means more fuel is used, as the engine is cold, producing more CO_2 emissions. Active transport options such as walking or cycling are much more beneficial to the environment and the health of workers as well as saving time in traffic congested areas. For longer work-related trips, public transport can be a sensible alternative in inner-city areas, as you don't have to park your car. Public transport is also widely regarded as a more sustainable transport method.

Hint: Journey management

Planning your trip in advance and journey management are very important when it comes to electric vehicles as well (see section on electric vehicles). Drivers need to know the limitations of their vehicles, and journeys need to be planned in accordance with vehicle distance limits so they don't run out of charge before returning to the depot.

If vehicle use is required, some ways to reduce your fuel consumption and therefore emissions include planning your route, so if you need to make multiple stops you don't back track; listening to the traffic report on the radio to avoid highly congested areas; and using freeways as an alternative to city roads to maintain a more constant speed.

2. Remove unnecessary equipment, weight and air resistance from your vehicle

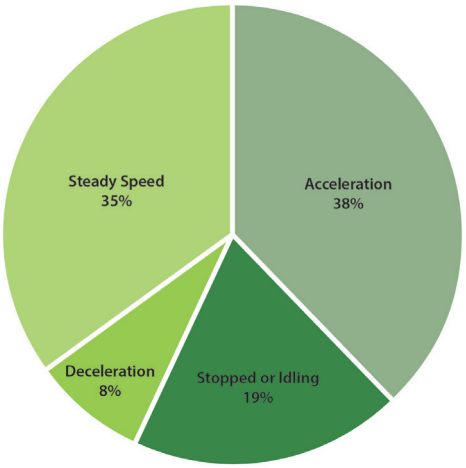
The weight of a vehicle, and it's aerodynamics, are directly related to the amount of work the engine is required to do. The lighter and more aerodynamic your vehicle, the more fuel you save. Reducing the weight of your vehicle can be done through removing unnecessary equipment. Removing attachments on the outside of the vehicle, such as roof racks, increases the aerodynamics of your vehicle. A roof rack can cost as much as 25% extra in vehicle fuel due to the drag it generates.

3. Maintain tyre pressure at the recommended level

Properly inflated tyres can increase fuel efficiency by up to 3.3%.Under-inflated tyres increase the rolling resistance of a vehicle against the road surface, therefore, increasing its fuel use. Remember to maintain your tyre pressure according to your user manual. Properly maintained tyres can save your life, at any given point in time only the size of a hand (per tyre) is touching the road. Lastly, for every % reduction in tyre pressure there is an equivalent % reduction in tyre usage lifetime.

4. Accelerate and decelerate smoothly

Slowing down early improves fuel economy. This is because during deceleration most of your inertia is converted to wasted heat, so slowly reducing inertia reduces energy loss. Light use of the accelerator improves fuel economy. This is because during acceleration the engine has to move through many gears, making it less efficient. Toyota developed the following graph which shows that nearly half of all fuel consumption occurs during acceleration and slowing down.



5. Use momentum and speed efficiently

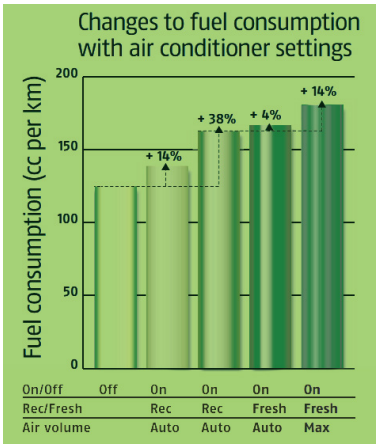
If a vehicle is traveling at a constant speed of 50km/h, the typical engine only required 5% of it's power in order to sustain momentum. Lower speed means shorter stopping distances, increasing fuel economy during deceleration. In addition, lower speeds with shorter stopping distances improves safety. The faster you go, the higher the risk. For example, a 5km/h increase in a 60km/h speed zone, doubles doubles the risk of being in a casualty crash.

By tapping into increasing environmental concerns and awareness of environmental impacts, road safety can also be improved. Drivers can be motivated to reduce emissions by learning of environmental and financial benefits, this in turn will reduce the speed and erratic driving style of drivers on the road, making roads safer.

A study of the costs and benefits of reducing the speed of private vehicles in the Netherlands concluded that the maximum enforcement of current limits alone would reduce hospital emissions by 15% and deaths by 21%. Fuel consumption and CO2 emissions would decline by 11% and nitrogen oxide emissions by 15%. These benefits would lead to a cost saving of about $US260million a year.

6. Use the air conditioner, and other electrical equipment sparingly

The air conditioner in a car can increase the fuel consumption in a car by up to 20%, due to the additional load it is placing on the engine. Toyota developed the following chart which shows how fuel consumtpion increases with different air conditioner settings. At an external temperature of 25°C, using an air conditioner can increase fuel consumption by 14%. At external temperatures of 35°C, air conditioning can increase fuel consumption by 38%.



7. Regularly service your vehicle

Vehicles which are not regularly serviced do not perform as well as vehicles that have been regularly serviced. This is due to the fluids, oils and lubricants in the engine deteriorating. This can be avoided by regularly having your vehicle serviced by a licenced mechanic or car dealership. Regular servicing, if documented, can also increase the re-sale value of your vehicle as potential buyers will be made aware of its well-kept condition.

Increasing fuel efficiency

Driving in a low-risk, safe manner contributes to lower fuel use, and thus a reduction in emissions and pollution. Drivers need to be conscious of how to drive vehicles safely with consideration for the environment. Studies by Toyota and FleetRisk found fuel efficiency could be increased by around 20% by using eco-driving and low-risk driving principles.

Five key factors affecting fuel consumption the most:

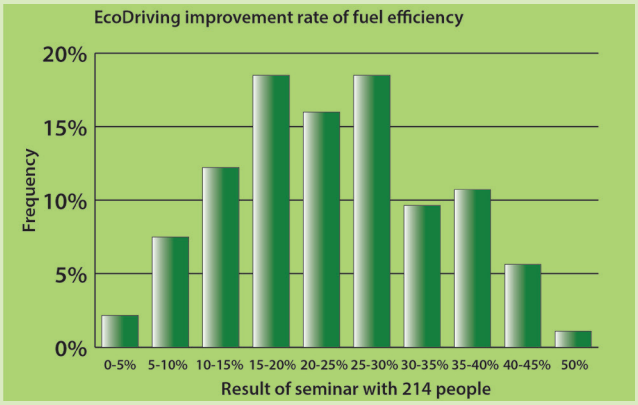
1. How you brake
2. How you accelerate
3. The speed at which you drive
4. The weight and wind resistance of your vehicle
5. The condition of your tyres.

Top tips for more fuel efficient driving:

- Minimise your vehicle use
- Drive in the right gear
- Drive smoothly
- Minimise fuel wasted in idling
- Don't speed
- Minimise aerodynamic drag
- Look after your vehicle's tyres
- Use air conditioning sparingly
- Travel light
- Keep your vehicle in good condition.

Case study: Toyota

Eco-driving has been tested by many organisations in recent years and has shown reductions in fuel consumption. In a study undertaken in Japan by Toyota, it was found that fuel savings of 20% were achieved by the majority of participants.



This same study found eco-driving reduced the crash rate by 25% because eco-driving also involves a driving style that can be anticipated, maintaining a steady speed, less speeding, less overtaking and less stress/

TOYOTA

Case study: FleetRisk

Conducted over a 10-week period with an Australian state-based government organisation, FleetRisk undertook a case study that aimed to better understand driving behaviours, fuel efficiency based on risk driving, and vehicle utilisation. Several factors were reviewed including speed, acceleration, braking, cornering, fatigue, and late night and peak hour driving to determine the type of risks undertaken, the severity and regularity of the risks, and what opportunities existed to address the risk behaviour.

The study found that on average there was 0.15 risk events per kilometre driven and that there is a 21% difference in fuel efficiency when comparing risk events per kilometre and fuel used per vehicle (like for like). When risk events occurred at a rate greater than 0.15/km, fuel consumption was 8.80L/100km. When risk events occurred at a rate of less than 0.12/km, fuel consumption was 6.98L/100km, illustrating that if drivers can drive safely and conservatively – in a low-risk manner – the fuel saving over a year for a vehicle completing 30,000km, at $1.50 per litre, is more than $800.

FLEETRISK™

Savings in practice

What cost saving can be made for a fleet organiser, operating a fleet of 100 vehicles that each travel 10,000km in a year, by adopting eco-driving principles? It depends on vehicle type and the cost of fuel. The following example is based on the 20% of fuel savings recorded in studies and assumes petrol is $1.30 per/litre.

Vehicle make & model	Regular fuel consumption (L/100km)	Regular cost ($/100km)	Eco-driving fuel consumption (L/100km)	Eco-driving cost ($/100km)	Cost saving for 100 vehicles travelling 10,000km in a year ($)
Ford Falcon	10.7	13.91	8.56	11.128	278.20
Holden Commodore	11.8	15.34	9.44	12.272	306.80
Toyota Camry Altise	7.8	10.14	6.24	8.112	202.80
Toyota Camry Altise Hybrid	5.2	6.76	4.16	5.408	135.20
Nissan Leaf	0	0	0	0	0

Emissions

Generally, the main pollutants of concern when it comes to vehicle emissions are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx), particulate matter (PM10), and carbon dioxide. These pollutants impact the environment in many ways. Greenhouse gas emissions (GHGs), particularly CO2, are causing human induced climate change (visit Climate Change in Australia for more information). Gaseous pollutants from vehicle emissions also have major impacts on human health, with a decrease in air quality leading to several health impacts such as respiratory issues, chest pain, congestion, throat inflammation, cardiovascular disease and lung cancer.

PM10 is particulate matter 10 micrometres or less in diameter. Vehicles will generate particulate matter either from direct emissions from the burning of fuels, especially diesel powered vehicles, from wear of tyres or vehicle-generated air turbulence. Particles may also be generated from the action of wind on the dusty material that the vehicle may be carrying. The specific effect of particles depends on their composition, concentration and the presence of other pollutants, but generally they cause; decreased visibility, harm to vegetation, damage to infrastructure and health impacts such as respiratory issues, fibrosis and cancer.

For more information on these impacts visit the NPI website.

Diesel vs. petrol vehicles

The introduction of catalytic converters, greatly reduced petrol car emissions. Catalytic converters oxidise harmful pollutants, such as CO, into less harmful pollutants such as CO2. Therefore, compared to petrol cars without catalytic converters, cars with catalytic converters have much lower CO, HC and NOx emissions, at the expense of CO2 emissions. However, this means that cars with catalytic converters are less efficient, and use slightly more fuel.

Petrol cars with catalytic converters produce more CO and HC than diesel cars, although exhaust emissions of NOx and particulates are much lower – so low in fact they aren't routinely measured. Diesel fuel has more energy per litre than petrol. In addition, diesel engines are more efficient to run, therefore, diesel cars are more efficient than petrol cars. Diesel fuel contains no lead and emissions of the regulated pollutants (CO, HC and NOx) are lower than petrol cars without a catalytic converter. Although, diesel cars have high particulate matter and NOx emissions, when compared to petrol cars without catalytic converters.

There has been a lot of debate about which type of car is more environmentally friendly. However, comparing the advantages and disadvantages of the two vehicles is difficult. Diesel cars have been promoted as producing less emissions of CO and HC, on average, this coupled with greater fuel economy means that they produce less CO2 per km. However, as mentioned, there are health concerns with regards to particulate matter. Diesel cars also have higher PM10 emissions, creating a health risk for cyclists and pedestrians who may be inhaling these emissions. As a comparison, petrol cars produce virtually no particulate matter, but produce more CO2 per km, on average.

For more information visit air-quality.org.uk.

Emerging technologies

Hybrid vehicles

Hybrid cars are powered by petrol, however, they also have an electric portion to the engine. When sitting idle, or stopped in a traffic jam, a hybrid car will often use its electricity component. When acceleration is required, a hybrid vehicle will convert to its petrol component. In addition, hybrid cars use the energy generated during braking to assist with recharging the electrical batteries. These features allow a hybrid car to be as efficient as possible, reducing petrol use, and reducing emissions. Hybrid cars have been a major move forward in environmentally friendly transport technologies. Pricing for the 2016 Toyota Camry starts at $26,490 plus on-road costs for the base petrol-powered Altise and starts at $30,490 for the hybrid Altise. This means for the same model car including the same features, there is a $4,000 price increase.

Electric vehicles

An electric vehicle (EV) is a vehicle that uses electric motors for momentum. There are two main motors used in electric vehicles, rotary motor, or linear motors (used in tracked vehicles). Electric vehicles differ from traditional fossil-fuel powered vehicles, as they can receive their energy from a number of sources, including renewable energy. These can be fossil fuels, nuclear power, solar power, wind power, or a combination. The introduction of electric vehicles has the potential to dramatically reduce urban air pollution, by negating tail pipe emissions from combustion engine cars. The extent to which emissions are reduce, overall, will depend on the source of electricity used to power the vehicles. With the U.S. energy mix, an electric car could reduce emissions by 30%; predictions in the UK are for a 40% reduction and 19% in China.

Driverless vehicles

There is consensus that driverless vehicles can increase safety, so what would be the overall impact on travel demand, energy use and carbon emissions if driverless cars were readily available?

- The eco-driving style of automated vehicles means smoother acceleration and braking, leading to a 20% energy saving.
- Driverless vehicles can interact with each other so they can travel at a closer following distance. Predictions show that his can reduce total energy consumption of road transport by anywhere from 4% to 25% because vehicles travelling closely behind one another incur less air resistance.
- Driverless vehicles can also interact with traffic infrastructure, predicting traffic signals. This will smooth traffic flow and reduce congestion, providing an energy saving of 4%.
- If a one-person commuter trip is taken by a compact car, and family leisure trips are undertaken in mid-sized sedans, energy demand could reduce by 21-45%.

Although, total carbon emissions produced by vehicles depends on traffic demand, a U.S. study found car travel could increase by as much as 60% with the introduction of driverless vehicles.

Case study: City of Sydney

City of Sydney has employed an eco-driving strategy across the organisation to increase awareness of eco-driving and its benefits, embed a culture of low-emission driving behaviour, improve low-emission driving skills and techniques, and produce a minimal carbon footprint.

A four-year, multi-faceted emission reduction program implemented by the City across its vehicle fleet resulted in a 26% decrease in greenhouse gas emissions between 2010 and 2014. This exceeded the 20% target and was largely supported by the transition to sustainable biodiesel for operational vehicles and the introduction of electric and hybrid passenger vehicles and trucks.

The continuous review of vehicle use and promotion of resource sharing has reduced the City's fleet from 600 vehicles in 2006 to 440 vehicles in 2015 without any reduction in service delivery. More than 20 zero-emission electric cars, 40 hybrid cars and 66 diesel electric hybrid trucks have been added to the fleet, reducing greenhouse gas emissions by up to 30% per vehicle. All electric vehicle charging is offset by 100% clean energy generated by the City's own solar PV installations.

CITY OF SYDNEY

Case study: Western Power

Western Australia's electricity utility, Western Power, travels around 30 million kilometres a year across 255,000 km2 to support its one million customers in remote and metropolitan areas of the State.

In conducting an efficiency review of its aging fleet and fleet management arrangements, the business considered the size and age of its fleet, vehicle specifications, fit-for-purpose suitability and whole of life vehicle costs.

The review outcome was a change to fleet management approach, underpinned by an outsourced model and a new leasing arrangement. The approach included replacing its aging fleet with new vehicles with improved safety and environmental efficiency technology.

All new light fleet vehicles will have a five star ANCAP safety rating, through modern safety features such as lane departure warning and autonomous emergency braking. The vehicles support their continuing commitment to provide a safe work environment for all employees. The business has gone a step further and installed state of the art driver emergency call and location technology, to support driver safety.

In May 2017, Western Power introduced 12 plug-in hybrid electric vehicles (PHEV) to its light vehicle fleet. The environment benefit of the PHEV is that shorter trips (less than 50 kilometres) fuel and emissions will be zero, as the vehicle will run on battery power alone. In the case of an extended trip, the vehicles can convert to hybrid technology and regular fuel.

Whilst these vehicles are more expensive to lease than their diesel counterparts, they have a much lower whole of life cost, if run correctly. These vehicles, along with two fully electric vehicles in the fleet, are ideal for day-to-day use for short trips around the city. The business case for introducing the newer vehicles for urban operations is a lot easier, when combined safety and improved efficiency are combined.

Western Power and the State Government will continue to monitor the business costs and environmental benefits of the PHEV, with a goal to increase the number of hybrid/electric vehicles into its fleet.

Mitsubishi Outlander PHEV

Case study: Uniting Communities

Since 2007, Uniting Communities has considered the environmental impacts of vehicles as part of its national tender process and a local review of products on offer. Green ratings are considered from numerous sources, including the Federal Government's Green Vehicle Guide website, and Uniting Communities has been moving towards more fuel efficient vehicles as part of its procurement process – with a notable shift from six cylinder to smaller four cylinder cars as well as a shift to more fuel efficient products in the same cylinder class – reducing emissions and fuel use.

The organisation's purchasing policy also strives for 4 or 5 star green rated vehicles to reduce its carbon footprint. In 2010, Uniting made a commitment to reduce fleet carbon emissions and is now a carbon neutral organisation. Environmental benefits and cost savings drove the decision to switch to hybrid vehicles, and now three quarters of its fleet are hybrid. While the Board made the decision to become carbon neutral, the business case still needed to be made to transition to hybrid vehicles because Uniting is a not-for-profit organisation. So it undertook whole of life costing. The hybrid Camry costs more to purchase than the petrol Camry, for example, but has higher resale. Accompanied with a 33% saving in fuel use and running costs, the hybrids had a lower whole of life cost than their petrol counterpart. By focusing on the environment and reducing emissions, Uniting is saving money. This is all based on energy efficiency and getting more from less, that is using less fuel to drive the same distance.

Another contributing factor in switching to hybrids was the inclusion of more safety features, such as reversing cameras, as standard in base hybrid models, which has helped reduce incident rates. Uniting has also implemented a Drive Green Program, which focuses on eco-driving and smooth driving. Driving smoothly through eco-driving principles conserves fuel while making the driver safer through, for example, increasing stopping distances. Uniting's environmental strategies have had a positive flow on to safety practices, without the two clashing, because a focus on the environment promotes awareness of safety. If an environmental solution is going to impede driver safety, it is no longer beneficial or viable.

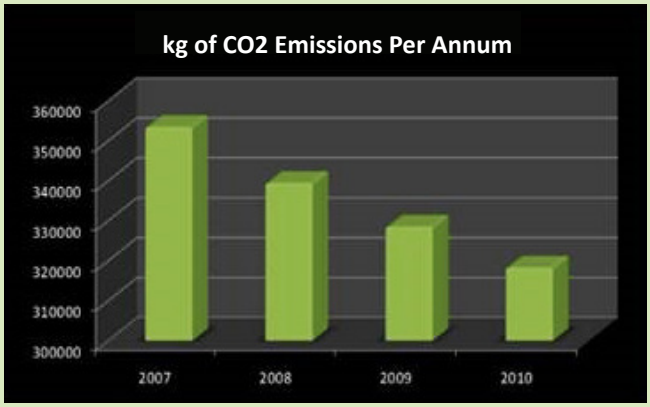
For every mid-sized petrol vehicle converted to hybrid, we save more than $1,000 in fuel costs and reduce our CO2 emissions by 1,860kg each year.

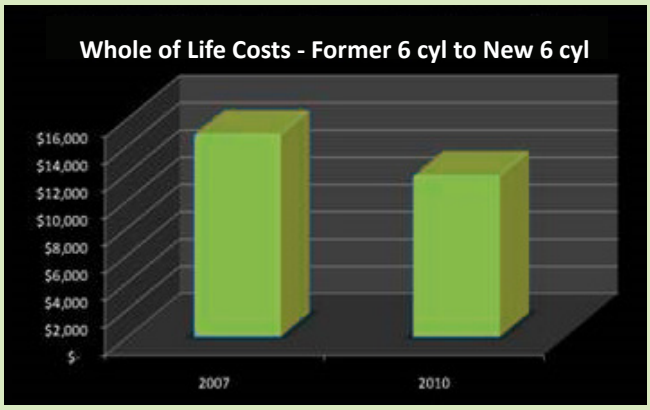
UNITING COMMUNITIES

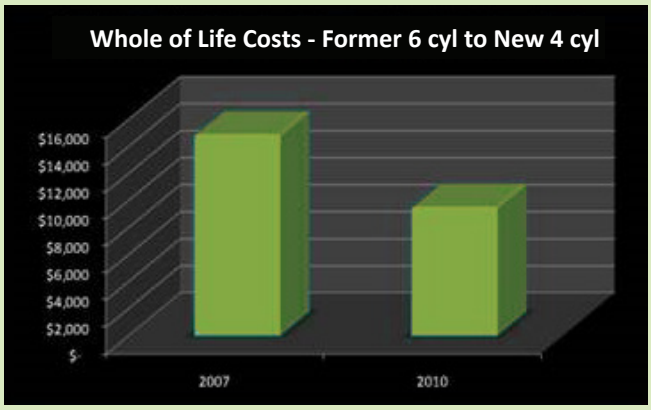
Outcomes of Uniting Communities' Eco-driving Program

By implementing various eco-driving strategies, before the introduction of hybrid vehicles, Uniting Communities saw a 9% reduction in CO2 emissions from its fleet – 30,000kg of CO2 a year – which is the equivalent of taking 7 cars out of its 125 car fleet. Another benefit is that Uniting Communities is now running a more reliable product in its fleet.

This means less down time, fewer repairs and maintenance as well as deferral of capital expenditure. Annual maintenance costs have halved. Another cost saving is the decrease in whole of life costs, with whole of life costs for the same class product dropping by 20% and whole of life costs for switching to smaller vehicles reducing by up to 36%.







For more information

- Uniting Care – Drive Green Program
- Toyota EcoDriving Guide
- City of Sydney – Low-Risk Eco-Driving Handbook
- Road Driver – Does Eco-Driving Improve Road Safety?
- The Conversation Article - Driverless Vehicles
- NRSPP Quick Fact: Why Tyres Save Your Life
- Natural Resources Canada - Vehicle Air Conditioning
- Monash University Accident Research Centre – Driving to Reduce Fuel Consumption and Improve Safety
- The Simple Explanation of How Hybrid Vehicles Work
- Electric Vehicles Definition
- Motor Vehicle Emissions Control and Fuel Types
- NRSPP Quick Fact: Why Speed Matters?
- NRSPP Quick Fact: Stopping Distance
- Roof racks a drag on fuel economy