ENERGY FLAGSHIP
www.csiro.au

Projecting future road transport revenues 2015-2050

Paul W. Graham and Luke J. Reedman

EP153966
May 2015
Report for the National Transport Commission

Citation

Graham, Paul and Reedman, Luke (2015), *Projecting future road transport revenues 2015-2050*. Report for the National Transport Commission, EPXXXXX, CSIRO, Australia.

Contents

Figures

Tables

Acknowledgments

With thanks to Neil Wong of the National Transport Commission for providing valuable input to the report. The final results presented herein remain the responsibility of the authors.

Glossary

Alternative drive train – a drive train involving a power source in combination or separate from internal combustion to provide power to a vehicle

Alternative fuels – fuels other than petrol or diesel

Articulated vehicle – vehicles constructed primarily for the carriage of goods, consisting of a prime mover (having no significant load-carrying capacity) but linked, via a turntable device, to a trailer

Biodiesel – a diesel fuel substitute made from biomass. Those biodiesels produced using the transesterification process are often called Fatty Acid Methyl Esters (FAME) whilst those biodiesels produced using deoxyhydrogenation or Fischer-Tropsch gasification are call 'renewable biodiesels'. Here we use the term biodiesel to cover both types.

Biomass – trees, crops, stems or other lignocellulosic or woody matters, plant oils or animal fats

Cross-price elasticity of demand – the ratio between the proportional change in demand for a good or service divided by the proportional change in the price of another good or service (at given prices)

Diesel – a petroleum derived fuel suitable for use in compression ignition internal combustion engine vehicles

Drive-trains – the collection of all power transmission components in a vehicle, including the engine, which convert the fuel source into wheel propulsion

Electric vehicle – a vehicle which uses electricity stored in batteries and an electric motor in place of an internal combustion engine and a liquid petroleum fuel tank. Other elements of the conventional drive-train may also be modified or removed

Ethanol – one of several alcohol liquid fuels that can be produced from carbon based primary energy sources

First generation biofuels – Biofuels produced via one of the earlier commercialised technological pathways, including FAME biodiesel from traditional bio-oil crops and ethanol from sugars and starches.

Fischer Tropsch – a process for refining a purified syngas over a catalyst at controlled pressure and temperature into a liquid hydrocarbon. The syngas can be sourced via processing of natural gas or syngases produced from gasification of solid primary carbon fuels such as biomass and coal

Freight sector – the part of the transport sector primarily concerned with delivering non-passenger cargo

Fuel cell vehicle – a vehicle which uses a stored primary fuel such as hydrogen or natural gas, converts it to electricity via a fuel cell which is used to drive an electric motor in place of an internal combustion engine. Other elements of the conventional drive-train may also be modified or removed

Fuel efficiency – the ratio of the vehicle distance travelled per unit of fuel consumed. An alternative measure is distance a tonne is moved per unit of fuel which is more relevant for freight purposes. However, the former is more widely reported and is the preferred measure in this report.

Fuel excise – includes excise on petrol (gasoline), diesel, fuel ethanol, biodiesel, natural gas, liquefied petroleum gas, aviation gasoline, aviation kerosene, fuel oil, heating oil and kerosene. It is imposed at specific rates per unit of product.

Fuel supply chain – the collection of processes beginning from primary energy source extraction or harvesting, through transport of the energy source to a processing, refining or conversion plant, through to transport of the refined fuel the point of sale

Gasification – conversion of solid hydrocarbon fuels such as coal and biomass into a combustible gas rich in hydrogen and carbon monoxide

Greenhouse gas emissions –gaseous materials that have been classified as having a climate changing effect that have been transported into the atmosphere

Heavy duty vehicle – a vehicle with gross mass greater than 3.5 tonnes

Hybrid vehicle – an internal combustion vehicle that has been augmented with batteries and an electric motor which may store electricity generated from the internal combustion engine and then make it available at various times during the drive cycle, particularly when the electric motor is most efficient. The inclusion of an electric motor also allows regenerative breaking and for the internal combustion engine to be completely stopped rather than idled when the vehicle is stationary during a journey.

Internal combustion engine – an engine that uses the combustion of fuels via either spark or compression ignition to create wheel propulsion, usually via pistons.

Light commercial vehicle – light duty vehicle used primarily for business purposes

Light duty vehicle – a vehicle with gross mass less than 3.5 tonnes

Lignocellulosic biomass – the woody, non-food parts of crops, plants and trees

Low carbon fuels – fuels with a lower net lifecycle greenhouse gas emissions profile than petrol or diesel

Modal shift – a change in the use of one transport mode to another to achieve the same journey. For example, from passenger vehicle to bus or from aeroplane to train.

Motorcycles – two and three wheeled motor vehicles constructed primarily for the carriage of one or two persons. Included are two and three wheeled mopeds, scooters, motor tricycles and motorcycles with sidecars.

Non-road transport – aviation, marine and rail transport

Own-price elasticity of demand – the ratio between the proportional change in demand for a good or service divided by the proportional change in the price of the good or service (at a given price).

Partial equilibrium model – a type of economic model which finds the market equilibrium level of demand, supply and prices for a given market sector but not for the whole economy

Passenger kilometres – the number of kilometres travelled by vehicle multiplied by the number of occupants in the vehicle.

Plug-in hybrid electric vehicle – hybrid vehicles that draw electricity from the grid to charge the batteries as the primary source of power, but that also include an on-board internal combustion engine to either supplement or recharge the battery when it becomes depleted in journeys beyond the range of the battery.

Pongamia – an oil seed tree (*Millettia pinnata*) naturalised to Australia

Premium grade petrol – unleaded petrol with an octane rating of 95 or higher

Projection period – the time period from the present to the year 2050

Range anxiety – the aversion some consumers may have to owning a reduced range vehicle.

Regular grade petrol – unleaded petrol with an octane rating of 91

Rigid trucks – motor vehicles exceeding 3.5 tonnes, which do not have a pivot point to assist turning

Second generation/advanced biofuels – biofuels that are produced using non-edible feedstocks of lignocellulose (such as lead, stems, wood) and tree or plant oils which are currently available but not yet used for that purpose

Switching costs – the additional cost to the consumer of purchasing and operating an alternative fuel vehicle

Synthetic fuels – Fuels that mimic the chemical composition of petroleum based fuels such as petrol, diesel and kerosene but are produced from non-petroleum energy sources

Tonne kilometres (tkm) – the number of kilometres travelled by a vehicle (VKT) multiplied by the mass of freight (measured in tonnes) transported.

Transport sector – the aviation, road, rail and marine sectors

Vehicle kilometre – a service unit which represents movement of one vehicle over one kilometre.

Vehicle kilometres travelled (VKT) – the number of kilometres travelled by a vehicle.

Executive summary

While there is information about historical road transport revenues, there is a lack of information about future revenue streams from the current road transport taxes, charges and fees. The National Transport Commission has commissioned CSIRO to update its projections of future road transport revenues. CSIRO had previously projected road transport revenues in 2012 (NTC 2014b; Graham, 2012). However since that time many factors have changed.

The scope of the road transport revenues examined in this study is narrower than the full list of road transport revenue sources. The study focuses on only two of the major revenue sources from road transport. These are the fuel excise and vehicle registration fees:

- Light vehicle revenues: fuel excise (Commonwealth) and vehicle registration (states and territories)
- Heavy vehicle road user charges: fuel excise and rebate (Commonwealth) and vehicle registration (states and territories).

The study examines several possible drivers for changes in vehicle registration and fuel excise revenue. The drivers and their expected impacts based on available data and holding all else constant is summarised in Table 1 and Table 2.

Table 1: Summary of fuel excise revenue drivers and their expected impact by 2050

Driver of change	Indicative impact on real fuel excise revenue (holding all else constant)	
	2035	**2050**
Growth in transport demand	51 per cent increase	81 per cent increase
Indexation of excise rates	Neutral	Neutral
Increasing share of rebate eligible heavy vehicles in total fuel consumption	2.6 per cent decrease	4.4 per cent decrease
Improvements in fuel efficiency (excluding impact of EVs)	24 per cent decrease	39 per cent decrease
Uptake of alternative fuels and EVs	22 per cent decrease (12% electricity, 5% biofuel, 5% other)	45 per cent decrease (30% electricity, 5% biofuel, 10% other)

These factors were combined and applied in CSIRO's Energy Sector Model which provides economic projections of transport market outcomes in Australia. Baseline, low and high scenarios are designed to explore the range of plausible outcomes and draw on previous transport modelling in Australia.

The projected road excise and vehicle registration revenues to 2050 for the baseline, low and high scenarios are shown in Figure 1 and Figure 2.

For fuel excise revenue, all scenarios experience a rising trend in the near term but that trend slows and switches to a flat to declining trend from the 2020s. By 2035, relative to 2015, the modelling projects a low scenario outcome of a 17 per cent reduction or a high scenario outcome of a 22 per cent increase in revenue with a baseline or central estimate of a 6 per cent increase. However, by 2050, as the declining trend strengthens, both the baseline and low scenario see further decreases in revenue with 15 and 45 per cent reductions respectively relative to 2015. For the high scenario the increase in revenue, relative to 2015, has eroded slightly to 20 percent by 2050.

Table 2: Summary of vehicle registration revenue drivers and their expected impact by 2050

Driver of change	Impact on real vehicle registration revenue (holding all else constant)	
	2035	**2050**
Vehicle registration rate (proxy) indexation	Neutral	Neutral
Vehicle size preference	0.9 per cent decrease	1.6 per cent decrease
Change in proportion of persons eligible for concessions	1.1-3.2 per cent decrease	1.8-4.2 per cent decrease
Growth in vehicle numbers	51 per cent increase	81 per cent increase

The re-indexation of fuel excise in 2014 has dramatically improved the outlook for road revenue from this source. Without this change the real value of the excise rate would have declined by 60 per cent by 2050 (based on historical rates of inflation and holding all else constant). However, this development has not removed the risk that the real value of fuel excise revenue could decline in the future.

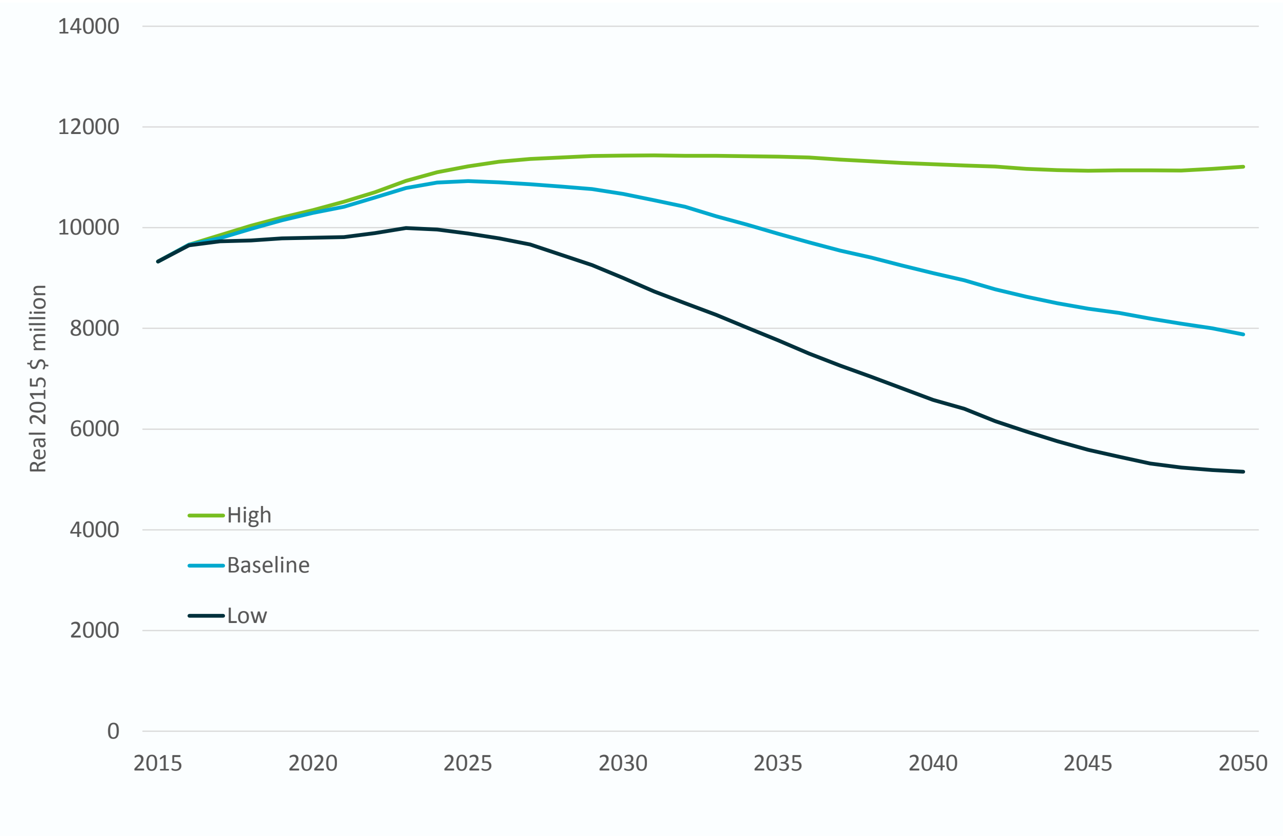

Figure 1: Projected road excise revenue to 2050 for the central, low and high scenarios (real 2015 dollars)

There are two main drivers of declining fuel excise revenue: improvements in fuel efficiency and increased adoption of zero or lower excise rate alternative fuels. The modelling finds that of all alternative fuels adoption of electric vehicles has the strongest revenue reducing factor (both improving vehicle fuel efficiency per kilometre and utilising a fuel source that does not attract road fuel excise). The re-indexation of excise and assumed 80 per cent growth in transport demand is only strong enough to offset these negative factors up until the 2020s, after which further growth is curtailed or reversed.

The real value of revenue from road vehicle registration is projected to increase under all scenarios. For vehicle registration the modelling projects a 40 to 55 per cent increase in revenue by 2035 with a central estimate of 49 per cent. By 2050 the modelling projects a 60 to 94 per cent increase in revenue with a central estimate of 78 per cent

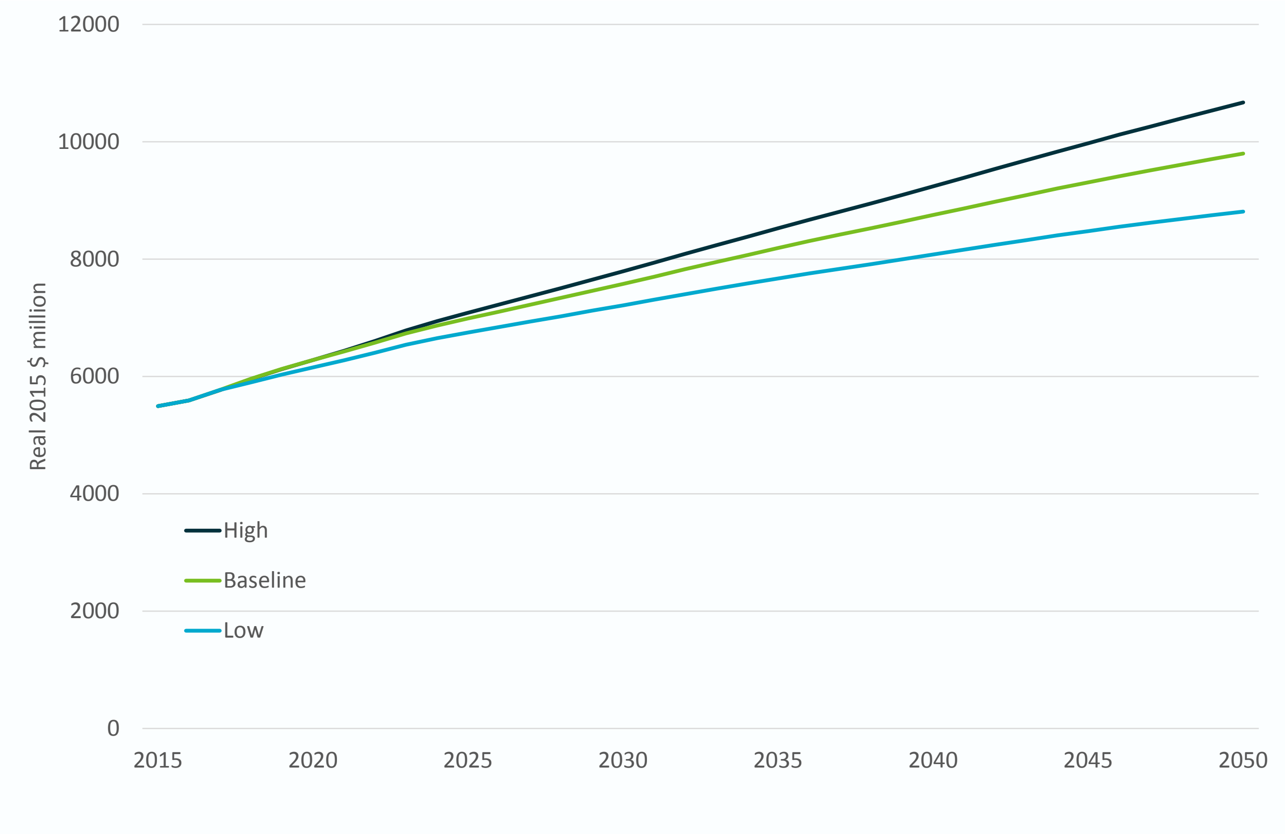

Figure 2: Projected vehicle registration revenue to 2050 for the central, low and high scenarios (real 2015 dollars)

1 Introduction

The National Transport Commission has commissioned CSIRO to update its projections of future road transport revenues. While there is information about historical road transport revenues, there is a lack of information about future revenue streams from the current road transport taxes, charges and fees. CSIRO had previously projected road transport revenues in 2012 (NTC 2014b; Graham, 2012). However since that time many factors have changed.

The scope of the road transport revenues examined in this study is narrower than the full list of road transport revenue sources. The study focuses on only two of the major revenue sources from road transport. These are the fuel excise and vehicle registration fees:

- Light vehicle revenues: fuel excise (Commonwealth) and vehicle registration (states and territories)
- Heavy vehicle road user charges: fuel excise and rebate (Commonwealth) and vehicle registration (states and territories).

Although not exhaustive, the following list indicates fees which have therefore been excluded from analysis in this report but are relevant to any discussion of road transport revenue:

- Stamp duty on transfer of vehicle ownership (states and territories)
- Luxury car tax (Commonwealth)
- Fare box revenues from road-based public transport such as buses
- Revenues from taxi regulation
- Private tollways
- Public tollway revenues (e.g. Sydney Harbour Bridge toll)
- Vehicle import duty (Commonwealth)
- Compulsory third party insurance for motor vehicles
- Levies (e.g. Victoria motorcycle levy for motorcycle safety programs).

We do, however, provide a brief comment on expected future stamp duty revenues given their close relationship to vehicle registration fees.

Figure 3 shows the historical levels of revenue from fuel excise and vehicle registration as published by BITRE (2014a). It shows that fuel excise has declined from its peak in 2004-05 and has stabilised in recent years. The general level of net fuel excise revenue (after available rebates) is $9 billion.

Vehicle registration revenues have had a stronger upward trend, with that trend only being briefly reversed in 2007-08. This decline reflects changes in vehicle purchasing trends (e.g. smaller vehicles) and a general decline in new passenger vehicle sales in 2007, 2008 and 2009 (FCAI, various).

Both fuel excise and road transport revenues have been impacted by the sharp spike in international oil prices that began in 2006 and peaked in 2008 which has led to a general reduction in growth in demand for road transport fuel, travel and vehicle ownership - which continues even though oil prices have now returned to pre-spike levels. Our main purpose here is to understand, based on current knowledge, the direction and extent of future changes in road transport revenues.

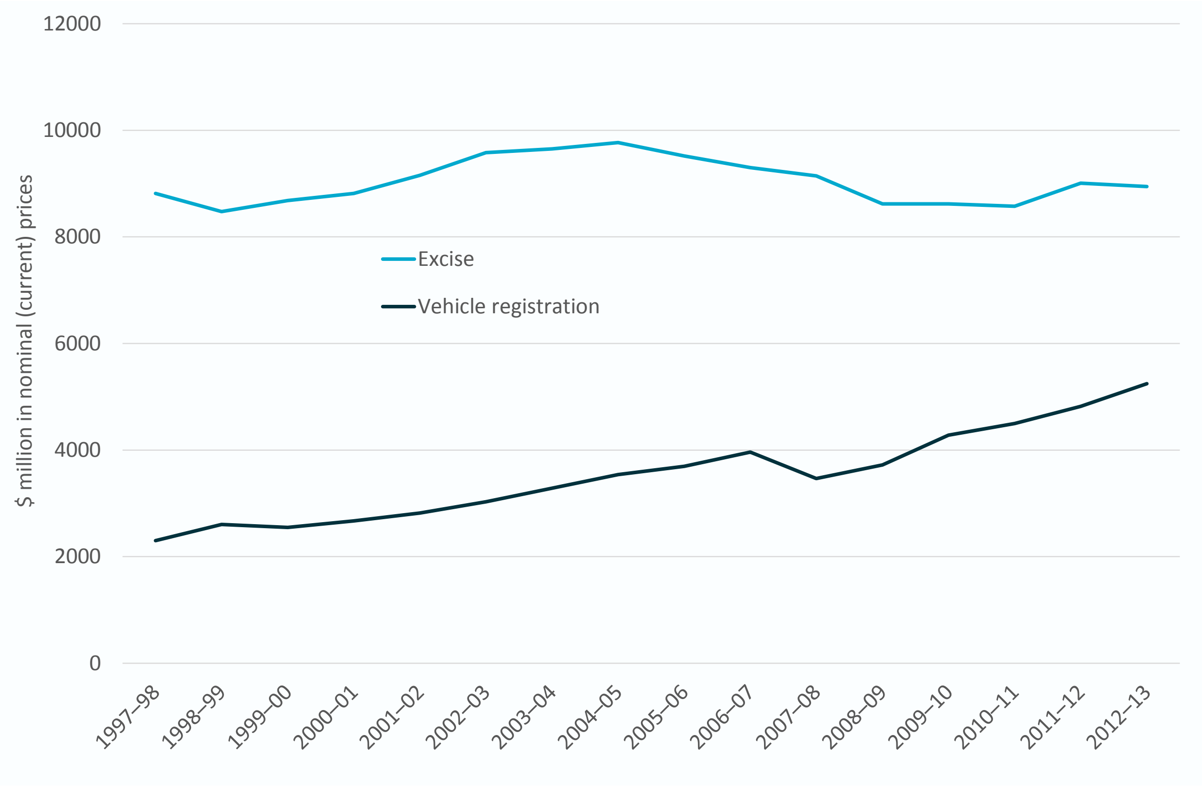

Figure 3: Historical fuel excise and vehicle registration revenues (BITRE, 2014a)

For fuel excise, increasing demand for travel for freight or passenger services (due to economic or population growth) is the main driver for increased fuel demand. However, there are two factors offsetting the positive impact of growing transport demand on fuel excise revenue. Firstly, passenger vehicles are becoming more fuel-efficient in response to the high fuel prices for the period 2006 to 2014 and private vehicle ownership per capita is nearing saturation point. As a consequence fuel consumption may increase more slowly than in the past. The second source of change is the potential use of electric vehicles and other alternative fuels which attract a zero or lower rate of excise than conventional petroleum based fuels such as petrol and diesel.

While the future value of fuel excise revenue is in doubt, vehicle registration fee revenue is more likely to increase. Vehicle registration rates are more closely coupled with population and economic growth which are both expected to increase. Furthermore, state governments have tended to increase vehicle registration fees to keep pace with inflation, if somewhat sporadically. However, one source of risk in vehicle registration revenue is demographic change. All state governments offer concessional vehicle registration rates for those qualifying for the aged pension. Due to high historical birth rates last century following World War II and improved health care, the number of persons eligible for the aged pension is expected to increase as a proportion of the population. Another offsetting factor is changes in vehicle ownership. While not yet evident, new technologies such as automated vehicles and social vehicle sharing services could change attitudes to vehicle ownership in the long run such that the number of people who opt for private vehicle ownership is reduced (Daniels, 2015).

The report is set out in two parts. In the first part we expand on the drivers of change in fuel excise and vehicle registration revenue and how these expected changes have been assumed to apply in the modelling. In the second part we describe the scenarios that were modelled, the resulting projections for road transport revenue and draw conclusions from the projections. The report also includes appendices which provide additional detail about the modelling results and compare the updated 2015 projections to the 2012 projections.

We do not provide an appendix with details of the modelling framework applied, CSIRO's Energy Sector Model (ESM). This model has been described in several other reports which the reader is referred to (see for example, Reedman and Graham, 2013a and 2013b)

1.1 A note on real versus nominal dollar values

Throughout the report we will need to refer to both real and nominal dollar values and so it is important to understand the difference. The level of prices change over time, (typically increasing but not always) and this is called price inflation. Price inflation reduces the purchasing power of each dollar relative to the past. Nominal dollar prices or values reflect the prices that were current for any given historical year and have not been adjusted for price inflation. Real values are units measured in dollars that have been corrected for price inflation. Another term for real values is constant values. The purpose of converting prices or values into real terms is to provide a better measure of relative purchasing power and to determine the extent to which a time series is changing due to factors other than inflation.

To convert a historical time series into real prices requires a measure of inflation such as a consumer price index over the same period. One year in the historical time series is selected as the reference point from which the real value of all the other prices is calculated – hence a real time series will be referred to as being in units of real 2015 dollars, for example. Projections of future prices or values can also be expressed in real terms so long as any nominal terms in the projection are adjusted for price inflation. Two simple examples illustrate the impact of projecting prices and values in real terms: 1) if the projected nominal price of a good increased at exactly the rate of inflation, the price would be constant when expressed in real terms; 2) if the projected nominal price of a good is constant then it will be declining at the rate of inflation in real terms.

Part I Drivers of change in revenue and modelling assumptions

2 Key factors impacting on Australian government fuel excise revenue

2.1 Changes in fuel excise rates

In the 2014-15 budget the government signalled its intent to change the excise treatment of fuels[1]. These changes impact primarily on light duty vehicles and include:

- Indexation of fuel excise other than aviation will be re-introduced in 2014-15 based on consumer price inflation
- The government will reduce grants made under the Cleaner Fuels Grant Scheme to zero and reduce the excise on biodiesel to zero from 1 July 2015[2]. From 1 July 2016, the excise rate for biodiesel will be increased for five years until it reaches 50 per cent of the energy content equivalent tax rate.
- The government will cease the Ethanol Production Grants Programme on 30 June 2015[3]. The fuel excise on domestically produced ethanol will be reduced to zero from 1 July 2015 and then increased by 2.5 cents per litre per year for five years from 1 July 2016 until it reaches 12.5 cents per litre, which represents 50 per cent of the energy content equivalent rate.

The impact of these changes relative to existing excise arrangements is shown in Table 3. In general it will increase the real cost of fuel in 2020 (all else being equal) by 12c/L for petrol and diesel, 4c/L for LPG, 8c/kg for natural gas and 12.5c/L for ethanol and biodiesel.

Table 3: Comparison of real effective fuel excise rates in 2015 and 2020 prior to and after 2014-15 budget changes assuming a 2.7 per cent consumer price index (2015 dollars)

Fuel	Unit	Prior to budget changes		Under 2014-15 budget changes	
		March 2015	March 2020	March 2015	March 2020
Petrol	$/L	0.389	0.33153	0.389	0.389
Diesel	$/L	0.389	0.33153	0.389	0.389
Liquefied petroleum gas	$/L	0.102	0.08693	0.102	0.125
Natural gas	$/Kg	0.213	0.18153	0.213	0.261
Ethanol	$/L	0	0	0	0.125
Biodiesel	$/L	0	0	0	0.125

[1] http://www.budget.gov.au/2014-15/index.htm

[2] Under these previous arrangements the effective excise tax rate was already zero since the Cleaner Fuels Grant was equal to the excise on biodiesel

[3] Under these previous arrangements the effective excise tax rate was already zero since the Ethanol Production Grant was equal to the excise on ethanol unless ethanol was imported

In regard to the biofuels it is interesting to note that, while they are now subject to an effective excise rate, the difference between biofuels and petrol/diesel excise remains at around 26c/L by 2020 under both the existing and new arrangements. However, after 2020 the excise differences among biofuels remain constant under the new arrangements but would be declining in real terms under the previous arrangements. This means biofuels are generally more attractive under the new arrangements. Biodiesel is the most attractive, all else being equal, because it has the same excise but a higher energy content compared to ethanol (depending on the refining process). The light duty sector remains the main target of biofuel production (rather than the heavy duty road sector or any other part of the transport sector) because it provides the largest price-cost differential for biofuel suppliers due to excise arrangements.

The index is applied bi-annually on August 1 and February 1 each year in line with the Consumer Price Index. The post February 2015 fuel excise rate for petrol and diesel was 38.9 cents per litre which has increased from the 38.14 c/L level that it had remained at since automatic indexation was ceased in 2001. Given the fuel excise rate is now indexed to the consumer price index the value of the excise received in the future will be constant in real terms.

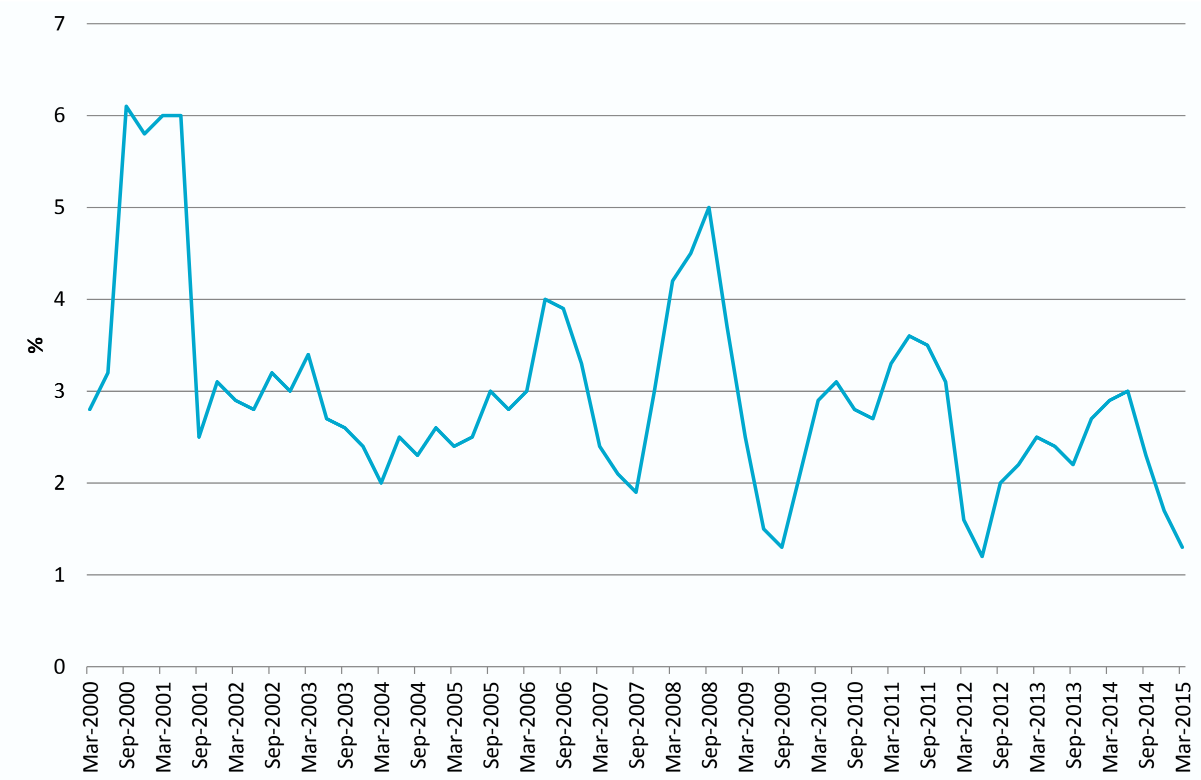

Figure 4: Quarterly Australian consumer price inflation (ABS, 2015)

To project the future level of the consumer price index we have assumed that it will on average be equal to the historical inflation rate from the period March 2005 to March 2015[4]. The average rate of inflation for this period is 2.7 per cent. As can be seen from Figure 4, there is some volatility in the

[4] The 15 year average is also 2.7. The average since 1992 is 2.6 and the recent five year average is 2.5.

rate of inflation, mainly reflecting changes in the rate of economic growth. However, we assume the average historical rate will prevail in the future, regardless of the ongoing volatility.

Applying the assumed future inflation rate, Figure 5 shows the projected nominal rate of petrol and diesel excise to 2050. It shows that the nominal excise per litre will be reach just under a dollar per litre by 2050. If there was no offsetting increase in fuel consumption or other factors we would expect total excise revenue from light vehicles to be constant in real terms or increase by 154% per cent in nominal terms by 2050. The potential for fuel consumption increases is discussed below.

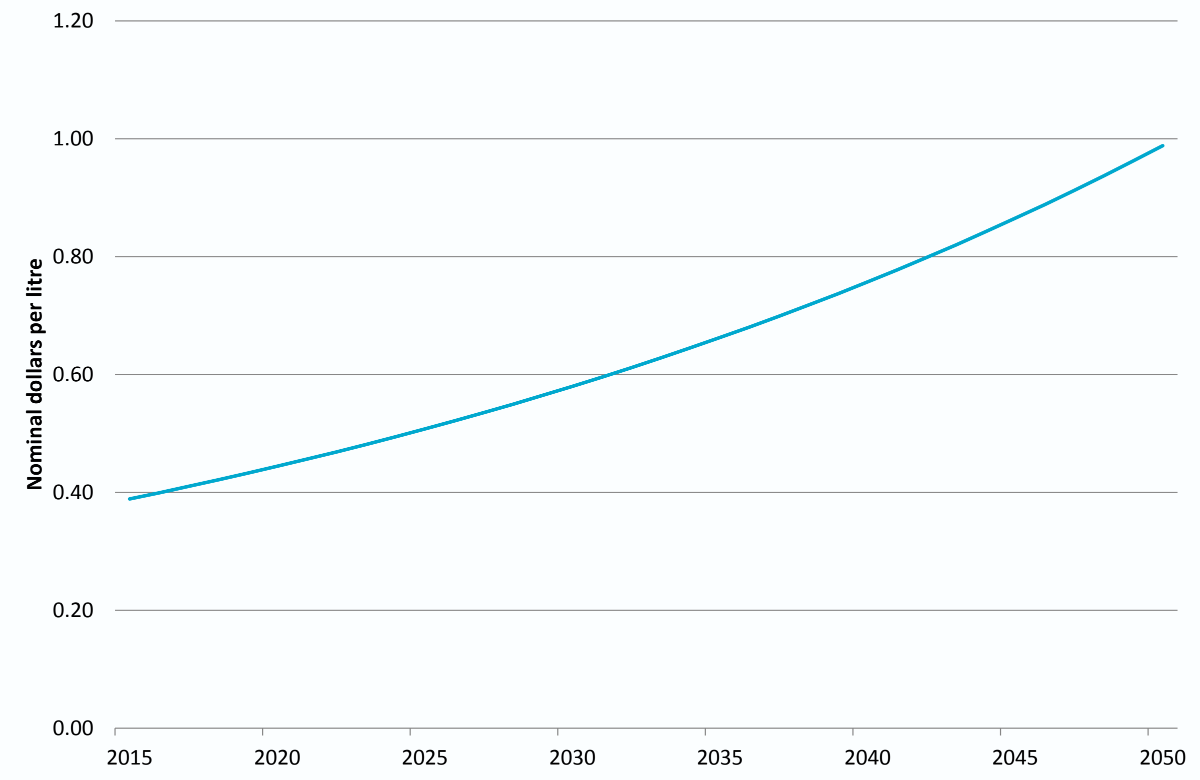

Figure 5: Assumed future levels of the petrol and diesel excise rate in nominal (current) dollars

2.2 Change in heavy road vehicle user charges

Heavy road vehicles use primarily diesel fuel and pay an excise of 38.9 cents on each litre. However, they receive a fuel tax credit of 12.003 cents per litre so that their effective fuel tax rate is 26.897 cents per litre which is roughly equivalent to the road user charge of 26.14 cents per litre (this was the rate set in July 2013 and maintained at that level in 2014). The minor difference is that the excise has been indexed for inflation since the road user charge was set. The road user charge is reviewed each year. While there are a number of considerations for setting the rate of change (which is usually an increase) in the road user charge, the main consideration is the cost of building and maintaining roads. The arrangements for CNG/LNG trucks are different. Given that the road user charge is effectively collected through excise and their fuel excise rate is less than the road user charge, CNG/LNG fuel use receives no tax credit but overall is taxed at a lower effective rate.

For our purposes we need to make an assumption about the future level of the road user charge. Figure 6 shows the historical rate of change in three measures of price inflation. One is the ABS (2015) consumer price index that was already shown in Figure 4 but in this case the data is no longer quarterly but annual. The other two measures are more closely related to road construction costs: the BITRE (2014b) road construction and maintenance measure of price inflation and the Australian Bureau of Statistics measure of roads and bridges measure of price inflation (also reported in BITRE

(2014b)). The average level of price inflation measured during this nine year period to 2013-14 for the ABS consumer series, BITRE road construction and maintenance and ABS roads and bridges series are 2.8, 3.4 and 4.1 respectively.

Figure 6 shows that there has been a lot of volatility in the price indices that directly measure road construction costs. This is likely explained by changes in commodity prices during this period. As a consequence we prefer to apply the ABS consumer price inflation measure as the best estimate of future road user charge increases. In effect, this means the road user charge will remain constant in real terms at 2015 levels since we also apply the inflation rate to convert the nominal road user charge to real terms.

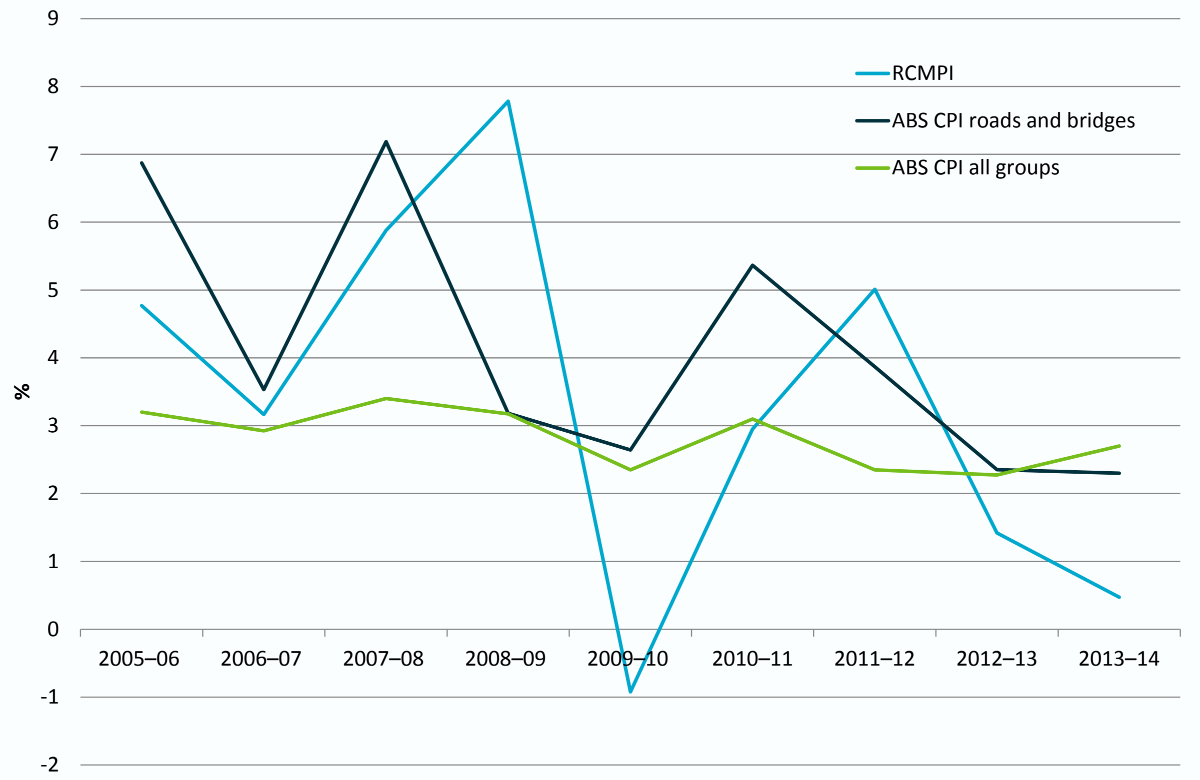

Figure 6: Comparison of three annual price inflation measures (BITRE, 2014b; ABS, 2015)

2.3 Change in light duty vehicle fuel efficiency

The more fuel efficient (in kilometres per litre) road vehicles become the less fuel excise revenue that can be expected to be collected. This is because fuel excise is charged on the consumption level of fuels rather than transport activity (in kilometres).

The higher oil prices of 2006 to 2014 has sparked a change in consumer preferences (and a response by manufacturers to meet those preferences) towards smaller, more fuel efficient vehicles (Figure 14). This has only recently started to significantly change fleet fuel consumption as it takes time for the weight of new more fuel efficient vehicles to reduce the average rate of fuel use in the fleet (Figure 9). It has also been observed that the trend towards lighter vehicles has been offset somewhat by increasing weight, power and 4WD capability of those vehicles.

The ABS (2012) Survey of Motor Vehicle Use (the most recent available) calculated only a modest 1.8 per cent reduction in the average passenger vehicle fuel consumption rate from 11.3 litres per 100 kilometres in 2010 to 11.1 litres per 100 kilometres in 2012. However, more recent data on new vehicles by the NTC (2014b) indicates that fuel efficiency improvement is accelerating.

To explore this topic further we provide an index of historical and projected average fuel efficiency changes in both new vehicles and the fleet as a whole. Changes in the efficiency of new light vehicles indicate current vehicle improvements while changes in the fleet average also reflect changes that occurred in the previous two decades as new vehicles are progressively adopted into the fleet and older vehicles are forced out through retirement. The average age of retirement for cars is around 20 years.

During the 1990s new light vehicle fuel efficiency did not improve (reflecting that this was a period of very stable world oil prices) but average fleet vehicle fuel efficiency continued to improve due to efficiency improvements in the 1980s gradually filtering through the fleet. From the mid 2000s new vehicle fuel efficiency again started to improve as oil prices substantially increased, peaking in 2008.[5]

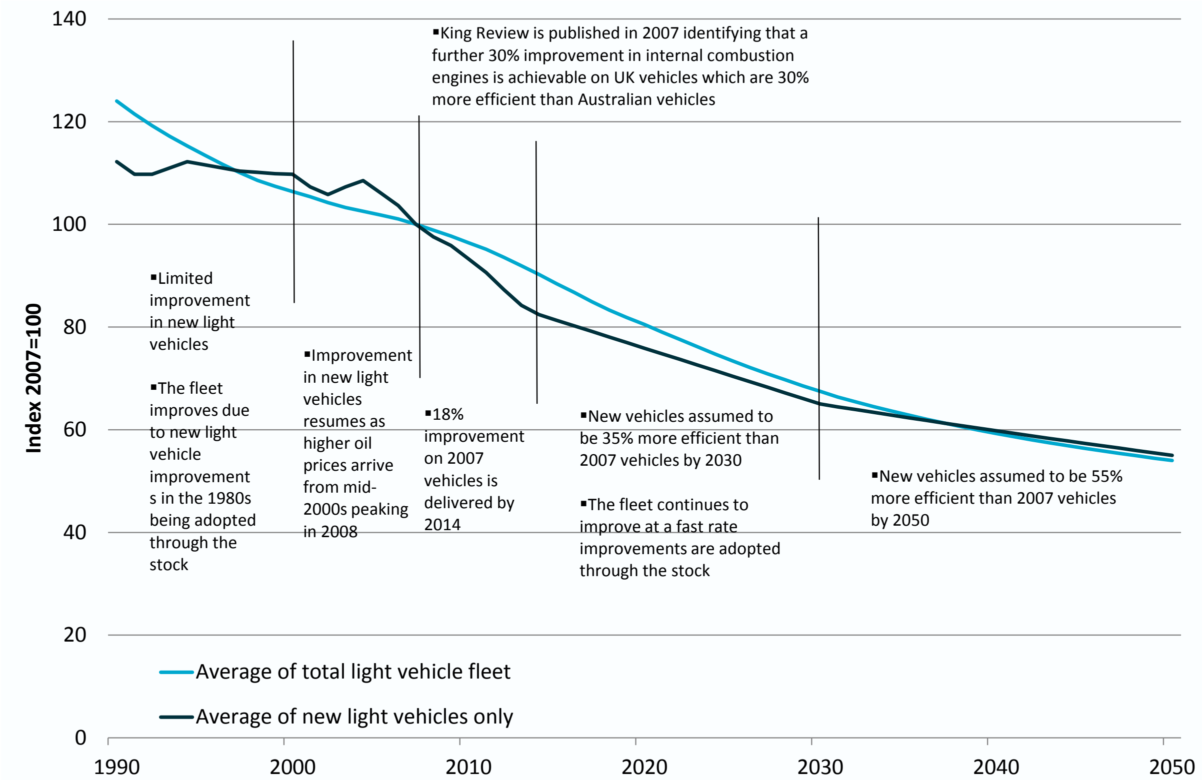

Figure 7: Average fuel consumption of internal combustion engine passenger vehicles (ABS, 2012 and various past editions)

Although the latest oil price peak has passed, new light vehicles have continued their rapid fuel efficiency improvement up to the present reflecting several drivers – the lag in manufacturing more efficient vehicles is around 5 years from design through to delivery to market; adoption of consistent fuel standards across Europe has provided greater access to vehicles from that region which are generally more fuel efficient; the spill over to Australia of emission standards introduced in Europe and elsewhere in the world in our imported vehicles (which are around 90 per cent of new sales) and perhaps an expectation by consumers that recent low oil prices will not be sustained indefinitely.

[5] Note, this largely reflects improvement in petrol engines given petrol dominates the light vehicle market.

To develop our assumptions for the future rate of fuel efficiency improvements we employ three steps. The first step is to identify the remaining cost-effective technical potential for fuel efficiency improvement of internal combustion engines. The total technical potential was identified as 30 per cent in the King Review (2007). However, that relates to United Kingdom vehicles which were already 30 per cent more efficient than Australian vehicles, making the total Australian potential improvement up to around 50-60 per cent. By 2014, 18 percentage points of the available fuel efficiency improvement has already been delivered. We assume new vehicles will be 35 and 55 per cent more efficient than 2007 vehicles 2030 and 2050 respectively. Figure 9 shows the consequences of these assumptions. New vehicle fuel efficiency of internal combustion engines improves in two distinct stages, the first between 2014 and 2030 and the second after 2030. However, the average fleet fuel efficiency does not improve at the same rate, because the cumulative effect of improvements from previous decades take time to influence a greater share of the fleet.

These fuel efficiency improvements mainly relate to an equivalent size internal combustion engine vehicle. However, we could also achieve further efficiency improvements by reducing vehicle size and utilising more efficient electric drive trains. We deal with these separately below.

2.4 Change in heavy duty vehicle fuel efficiency

Between 2005 and 2012, rigid and articulated trucks combined moved 30 percent extra tonnes per year using only 21.5 percent additional fuel (ABS, 2012). The increased load per trip, particularly for articulated trucks, is the reasons why, in contrast to light duty vehicles, heavy duty vehicles have not significantly reduced their fuel use per kilometre in the last decade. Carrying greater loads (e.g. the increasing number of B-doubles in the truck fleet) increases the workload per kilometre, offsetting fuel efficiency improvements (measured in energy per vehicle kilometres).

A consistent fuel efficiency time series for new heavy duty vehicles is not readily available. However the ABS (2002, 2012) report average fleet efficiencies which are shown in Table 4 and demonstrate the flat to declining fuel efficiency in the heavy road vehicle fleet.

Table 4: Average Australian heavy duty vehicle fleet fuel efficiencies in litres per 100 kilometres, 2002 and 2012

	2002	2012
Rigid trucks	28.8	28.7
Articulated trucks	53.9	57.7
Buses	28.0	29.0

New heavy duty road vehicle fuel efficiency could improve from their current levels. TA Engineering (2012) outline the potential of the *DOE SuperTruck Program* in the United States. Against a baseline projection of a 0.1 per cent per annum improvement in new truck efficiency between 2020 and 2050, it considers a low and high range for the rate of deployment of advanced conventional and hybrid electric trucks, resulting in total improvements of between 0.2 and 0.4 per cent per annum.

Here we adopt the lower end of this range across new heavy duty vehicles and allow the model to endogenously choose to take up more electrification technology where economically and technically feasible to do so. Note that, because the historical fleet efficiency has not been improving it may still take a decade or more before the impact of improved new vehicle efficiency begins to result in a decline in average fleet efficiency.

2.5 Potential for alternative fuel uptake

If the share of alternative fuels consumed in the total road transport fuel mix in Australia increases, this reduces potential fuel excise revenue because, as outlined above, most alternative fuels have a lower effective excise rate.

While cost competitiveness is the most important factor, the rate at which alternative fuels can increase their share of the overall fuel mix is also limited by infrastructure constraints. Each fuel has its own particular vehicle and fuel distribution infrastructure requirements. The time required to deploy this new infrastructure is the main source of delay in incorporating new fuels into the fuel mix.

The expected rate of deployment of alternative fuels is largely a function of investor confidence. Even where a project appears profitable on current trends, investors will consider the level of uncertainty and not invest if it is too large. To partially account for investment uncertainty, we assume alternative fuels only expand significantly after they are economically viable. Other specific fuel assumptions are explained below.

2.5.1 Liquefied petroleum gas (LPG) and natural gas (LNG/CNG)

LPG vehicles are already established in Australia but their attractiveness is waning because of competition from hybrids as a platform for taxi services and a poorer outlook for the cost of LPG vehicles. The LPG Vehicle Scheme which provided subsidies for purchase of new or conversion to LPG vehicles closed on 30 June 2014. Furthermore, owing to the expected closure of vehicle manufacturing in Australia and to a recent change in preferences of taxis for non-LPG vehicles, it is expected all new LPG vehicles will be achieved only through conversions rather than from supply of a dedicated LPG vehicle, which was generally lower cost. The rate of improvement in fuel efficiency of LPG vehicles is also expected to be lower as a result.

While there are thousands of public LPG refuelling facilities and vehicles, the existing fleet of LNG/CNG vehicles is negligible and available refuelling infrastructure is limited and user owned or contracted. However, this situation could change. Australia does have an existing natural gas pipeline network, and the technology for compressing or liquefying natural gas is well developed. Home natural gas compression appliances could be purchased and larger scale LNG processing and fuelling stations could be developed at freight hubs.

Economics is perhaps the strongest issue holding back LNG/CNG vehicles at present. Since the oil price declined rapidly at the end of 2014 the gap between oil and gas prices is no longer sufficient to support a supply chain that can compete with diesel or petrol. Even if the oil-gas price differential increased, we would expect some delay before greater adoption proceeded. Graham et al (2014) calculated the impact of uncertainty on natural gas vehicle supply chain adoption, using real option analysis. That analysis indicated that, even though some LNG vehicles appear to offer financial benefits at current oil prices, if the market is left to determine the timing, significant uptake could be delayed until the 2030s.

2.5.2 Biofuels

Current volumes of biofuel uptake are strongly driven by the New South Wales biofuels mandate (which is 6 per cent for ethanol and 2 per cent for biodiesel) and local support for ethanol use in Queensland which at various times has considered its own mandate. The NSW Office of Biofuels reports[6] that the ethanol share of petrol peaked at around 4 per cent in the third quarter of 2012 and was just over 3 per cent in quarter one of 2015 implying an annualised volume of around 165 ML (Figure 8). Biodiesel has increased its share of diesel from around 1 per cent in 2010 to around 1.6 per cent in quarter one of 2015 implying an annualised volume of around 80 ML (Figure 9).

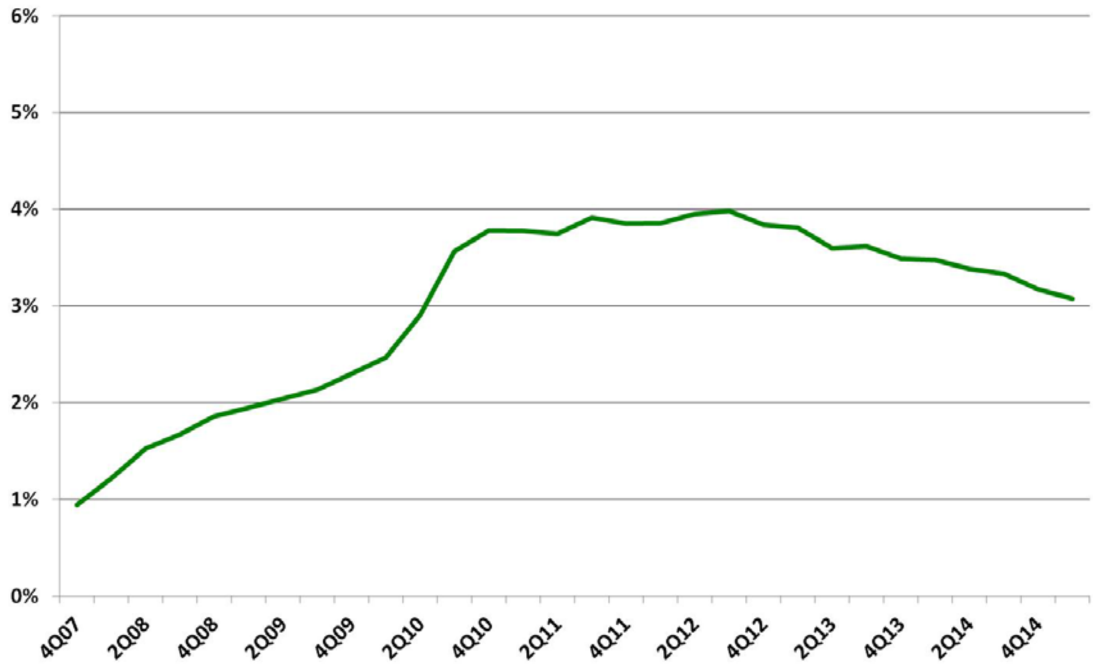

Figure 8: Historical share of ethanol in NSW petrol sales, image reproduced with permission from original source at: http://www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/office-of-biofuels/biofuels-results

There are two reasons why the 6 per cent ethanol target has not been achieved. The first is that the legislation allows exemptions for retailers committed to a long term business plan for biofuels and these exemptions have been awarded to several retailers. The second is that the ethanol target applies only to non-premium grade petrol. Consequently, there has been some diversion to premium grade petrol which undermines the ability of the target to reach the 6 per cent goal across all petrol. Noel and Roach (2014) have studied this diversion activity in detail and estimate that, at historical diversion levels, the maximum that the 6 per cent target on non-premium grade petrol will achieve is 4.5 per cent across all petrol.

[6] http://www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/office-of-biofuels/biofuels-results#_progress-charts

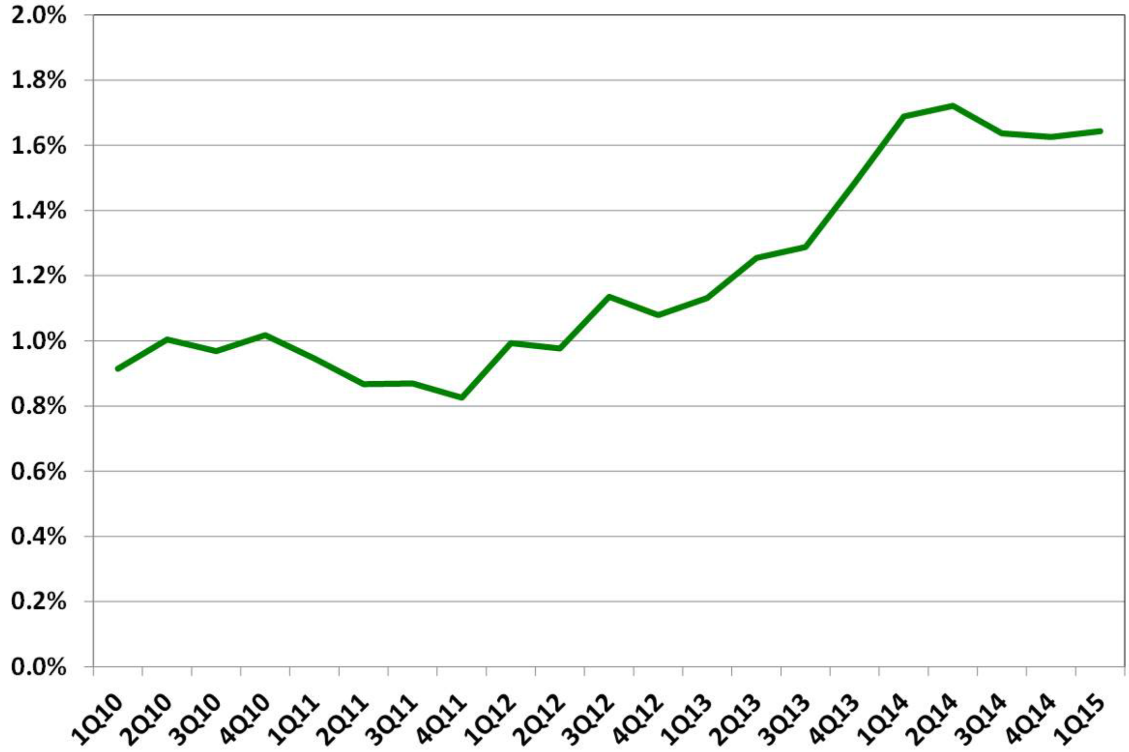

Figure 9: Historical share of biodiesel in NSW diesel sales, image reproduced with permission from original source at: http://www.resourcesandenergy.nsw.gov.au/energy-consumers/sustainable-energy/office-of-biofuels/biofuels-results

The ability for biofuels to expand depends largely on the future cost and availability of so-called second or advanced generation biofuels which include use of non-food feedstocks such as forest waste, algae and crop by-products. Figure 10 shows the cost curve the production of advanced generation road biofuels developed by CSIRO (Graham et al, 2011; Farine et al 2011). As noted in Graham and Hatfield-Dodds (2014), while the mix of feedstocks differs the total amount of resources aligns well with other studies. If all available biofuel was deployed it could contribute 10-20% to liquid fuel supply, depending on its level in the future.

Given the economic and technological uncertainties and difficulties of establishing a new supply chain we assume there will be considerable delay in deploying expanded volumes of biofuel even where the cost of production is below that of conventional fuels.

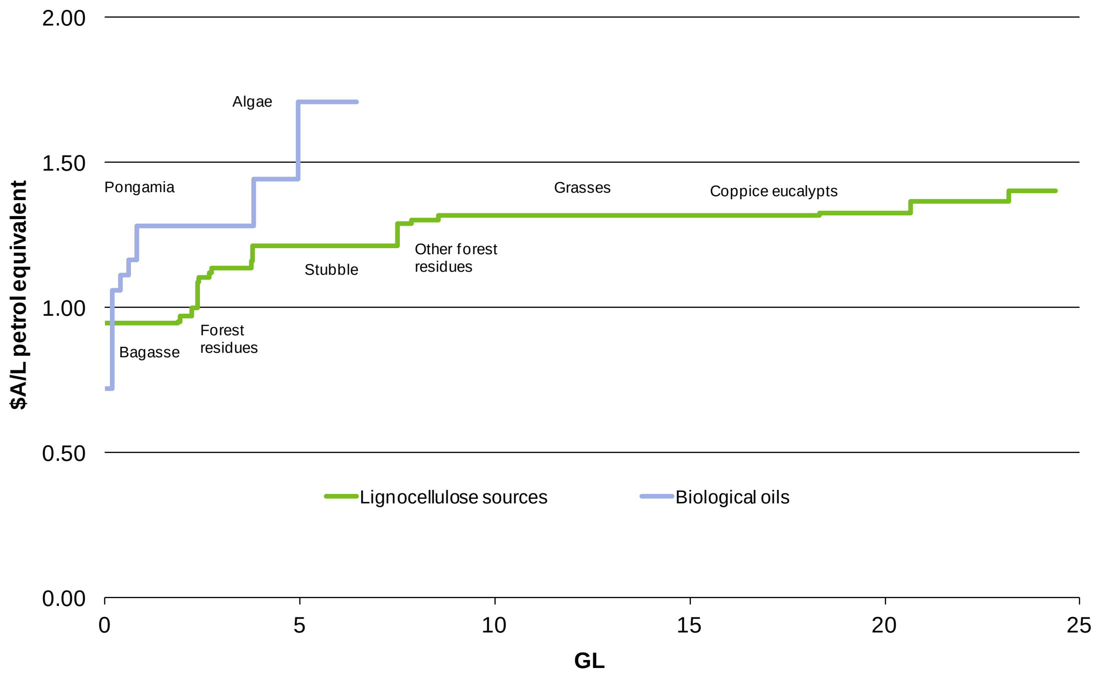

Figure 10: Cost curve for advanced generation road biofuels

Synthetic Fuels: gas to liquids (GTL), shale to liquids (STL) and coal to liquids (CTL)

Synthetic production of hydrocarbon fuels, primarily diesel, presents very little challenge from a fuel distribution and vehicle adoption perspective. The fuels produced are of similar quality to oil-derived petrol or diesel and can be handled and utilised in existing transport modes without any special infrastructure changes.

Rather, the major constraint to deployment of GTL, STL and CTL is the large non-recoverable investment risk that is presented by a refining project of this type. Efficient scale for Fischer Tropsch refining plant is around 1.2 gigalitres per annum. At a capacity development cost of around $2.5/L that equates to a minimum expenditure of $3 billion. Investments of this scale do occur in other sectors of the economy. However, as the fuel market is driven by oil price movements that are relatively volatile, investment markets may perceive this type of investment as more risky compared to other options.

IEA (2013b) states[7] that synthetic fossil fuel-based petroleum products can be produced in the range of $50 to $110 per barrel as it has consistently done so over the last decade of World Energy Outlook annual publications.

2.5.3 Electric and plug-in electric vehicles

Reductions in the cost of batteries for electric vehicles means that the uptake of electric vehicles in the long term looks more likely. To demonstrate, a 100km range electric vehicle requires roughly 20kwhs of storage. If, as projected, (Nykvist and Nilsson, 2015) batteries will be available for $150/kWh then the battery pack will only cost around $3000. Given the fuel savings associated with

[7] Page 454

using electric vehicles relative to conventional vehicles this additional vehicle cost could be paid off within a few years. However, electric vehicle (EV) adoption could be impacted by non-economic factors, some of which are detailed below.

Social constraints

“Range anxiety” is the term coined to describe the aversion some consumers may have to owning a reduced range vehicle. The issue may be overstated, given that some 80 per cent of trips are less than 100km, and there may be innovative solutions such as car hire arrangements for longer trips or off-road driving.

Because it is difficult to know how much of an issue range anxiety will be, to address this potential social constraint to adoption, we assume that there is a maximum 30% market share for electric only vehicles. This is based on uptake being led by two car households (which are currently 60% of households) who use their second vehicle when they plan to travel outside of their electric vehicle’s limited range. The maximum market share for electric rigid trucks is assumed to be 20 per cent, based on a small percentage of truck movements being within a limited urban range.

Vehicles without significant range limitations, such as plug-in hybrid electric vehicles, have no market share upper limit imposed.

Infrastructure constraints

Although electricity is distributed widely via the transmission and distribution system, there are potential infrastructure constraints to electric vehicle uptake due to the need both for recharging and for the production of electric vehicles for the global vehicle market to scale up in the short term. It is expected that home overnight recharging is a practical solution and the need for public recharging infrastructure is not a significant constraint. It is acknowledged, however, that there will need to be alternative solutions for those without off-street parking. It may also become more efficient for the electricity system if it can control the charging times of electric vehicles during daylight hours as well as overnight, particularly if solar power becomes a dominant technology resulting in supply peaks in the middle of the week-day while most cars are not at home.

Global electric vehicle supply is assumed to be a limiting factor in the short run to 2020. Australia does not have relatively attractive electric vehicle subsidies, and so is not a priority market for vehicle manufacturers. It is assumed we are only able to access a fixed share of global electric vehicle supply, which is expected to be slow to ramp up in the short term.

Another issue is that local electricity distribution systems may come under some pressure due to the increased load, if electric vehicle uptake reaches a high level. How much of an issue this will become depends a lot on how recharging is managed more generally, which at this stage is unknown.

If electric vehicles are charged over several hours (at roughly equivalent to the load of a residential air-conditioner) during periods of low electricity demand they potentially do not impose any additional pressure on the capacity of the network. However, if some charging occurs at faster rates, or during times when the electricity load is high, then they could present some challenges to existing capacity. If an electric vehicle is used for daily commuting, it is not obvious why fast charging would be required except on rare occasions.

We conclude there are no specific constraints to the capacity of the electricity distribution system. Lower charging costs during off-peak times will encourage this outcome.

Hydrogen fuel cell vehicles

Hydrogen is a fuel that has not been widely distributed in Australia. It is typically used in industrial applications where it is manufactured from natural gas reforming on, or near, the site of use. If natural gas is the primary energy source for hydrogen then the existing natural gas pipeline network represents an advantage. Similarly, if the energy source for hydrogen production is electricity, via electrolysis, then the existing electricity distribution system is advantageous. Some hydrogen fuel cell vehicle manufacturers have been working towards developing small scale home electrolysis units (Honda, 2011).

However, if new hydrogen distribution systems have to be developed because, for example, it is desirable to manufacture the hydrogen at a central location (e.g. as a co-product of biomass to liquids processes or as a measure to smooth out the generation profile at a wind farm) trucking and pipeline transport distribution systems could be developed.

There have been many studies examining the optimal ways to distribute hydrogen (Mintz et al., 2006; Yang and Ogden, 2007; Pigneri, 2005; Cheng and Graham, 2009). The wide number of distribution options, and the ability to combine various options for alternative primary energy resources at alternative stages of fuel cell vehicle adoption, indicates there are no grounds for constraining hydrogen fuel cell uptake on the basis of a lack of existing distribution infrastructure.

Although there are many potential sources of hydrogen, for simplicity and consistency, we assumed it is generated via electrolysis from the grid at a conversion loss of 30 per cent[8]. We also include a cost for distribution and refuelling infrastructure equal to half the delivered price.

2.6 Changes in transport demand

The potential for growth in fuel excise revenue is strongly driven by rising transport demand. The projected rate of growth in demand (measured in kilometres travelled) for each transport mode has been sourced originally from Reedman and Graham (2013) and updated with new information from Bureau of Infrastructure, Transport and Regional Economics (2014) as well as applying transport price elasticities of demand to account for changes in fuel prices.

Road transport will be constrained by population growth (around 1.5% per annum) and whether car owners can find more time in their lifestyles to travel further (this factor is generally thought to be limited). Light commercial and road freight can grow slightly faster given that activity is more closely related to economic growth (2 to 3% per annum). However, some of this growth in demand for freight does not directly translate into higher kilometres because it is offset by increased vehicle weight (tonnes per kilometre) through improved logistics and changes in average vehicle carrying capacity. Overall, in terms of kilometres travelled the combined growth from both sectors is projected to be 81 per cent to 2050 (51 per cent by 2035), closer to the rate of the slowest growing part (Figure 13), reflecting that the passenger market is the larger of the two. Since the road freight sector collects less revenue per litre of fuel the contribution of demand to growth in excise by 2050, holding all else constant, will be less than 81 per cent.

Uncertainty in the underlying drivers and changes in preferences for road travel versus other alternatives (e.g. rail, telecommuting, teleconferencing, buses), perhaps driven by changes in urban design, creates some uncertainty in this outlook. In particular, some Australian capital cities have recently experienced an increase in rail and bus use during peak hour commuting times. We explore

[8] See for example http://energystorage.org/energy-storage/technologies/hydrogen-energy-storage

the potential for greater mode shift in an alternative scenario discussed in Part II. It should also be noted a full analysis of the road infrastructure required to accommodate this expected increase in demand for road transport kilometres has not been conducted.

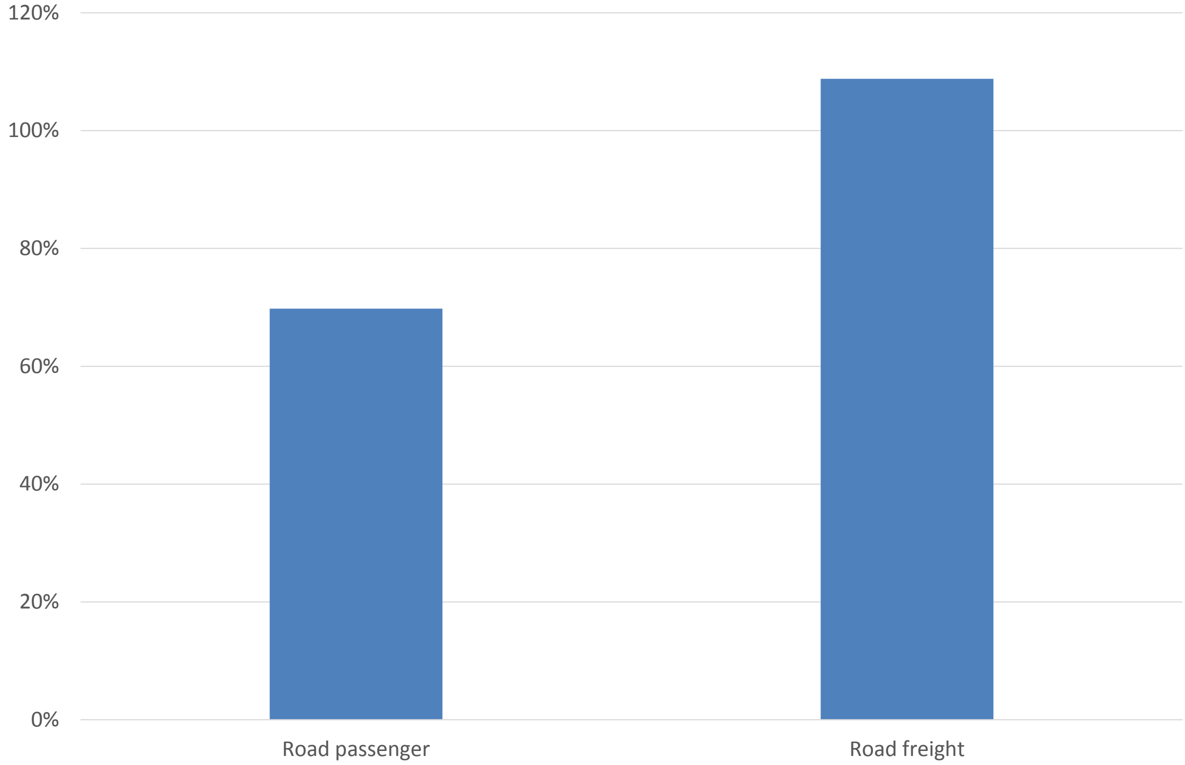

Figure 11: Expected baseline growth in road transport demand to 2050

2.7 Summary of impacts on road fuel excise revenue

Table 5 summarises the drivers of change in real fuel excise and their expected impact on revenue. It shows that overall there is a stronger weight of factors that will drive a reduction in real fuel excise than an increase. We will model these factors in detail in Part II of this report. However, a simple analysis of this preliminary data, multiplying through, indicates the real value fuel excise will be only slightly higher by 2035 and decline by 2050 compared to 2015.

Table 5: Summary of drivers of change in fuel excise revenue and their expected impact

Driver of change	Indicative impact on real fuel excise revenue (holding all else constant)	
	2035	**2050**
Growth in transport demand	51 per cent increase	81 per cent increase
Indexation of excise rates	Neutral	Neutral
Increasing share of rebate eligible heavy vehicles in total fuel consumption	2.6 per cent decrease	4.4 per cent decrease
Improvements in fuel efficiency (excluding impact of EVs)	24 per cent decrease	39 per cent decrease
Uptake of alternative fuels and EVs	22 per cent decrease (12% electricity, 5% biofuel, 5% other)	45 per cent decrease (30% electricity, 5% biofuel, 10% other)

3 Key factors impacting on vehicle registration revenue

3.1 Changes in the vehicle registration rate and vehicle preferences

Past and present state and territory governments have generally demonstrated that they are willing to increase registration rates to ensure that revenue collected from this fee per vehicle is maintained in real terms. However, the timing of registration rate increases in some states can at times be intermittent rather than on a regular yearly basis.

It is also important to note that each of the states and territories have slightly different fee structures. Most charge a flat registration fee and then impose an additional charge based on either: vehicle weight, size or number of engine cylinders. Some charge a separate administration fee.

In this study we make two main assumptions about future vehicle registration fee policy. Firstly we assume that, on average, the State and territory governments increase their vehicle registration fees at the rate of consumer price inflation to maintain their value in real terms. Holding all else constant this assumption would maintain the real level of vehicle registration revenue.

The second assumption we make is that state and territory governments will continue to offer lower vehicle registration fees for smaller vehicles, however that is measured (engine cylinders or weight). Holding all else constant this assumption will decrease the real value of vehicle registration revenue because there is a trend towards purchasing smaller vehicles.

Figure 14 shows the trend away from larger cars since 2001. There has also been a slightly offsetting trend towards SUVs (increasing from 20% of new vehicles sales to 31 per cent in 2014). While this impacts fuel efficiency, discussed in the previous section, it has less impact on registration fees so we include SUVs with other cars.

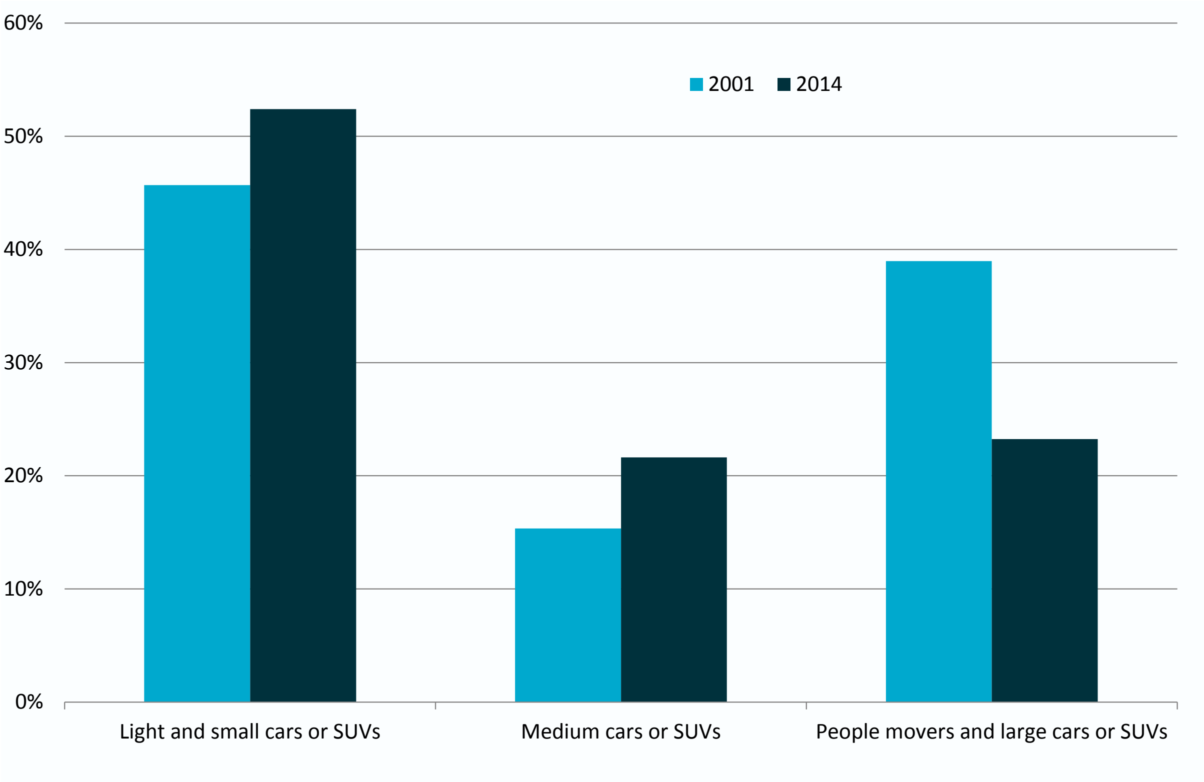

Figure 12: Shares of vehicles by type (FCAI, various)

We assume that the trend towards lighter vehicles will continue, although will be partly moderated by lower oil prices in the short term. Light and medium sized vehicles are assumed to increase their share of vehicle numbers so that large cars lose a further 4 per cent share by 2050. With larger passenger vehicle registration fees being on average 40 per cent higher, transferring 4 per cent of vehicles to a lower fee would be expected to reduce vehicle registration revenue by 1.6 per cent.

3.2 Change in proportion of owners qualifying for concessional registration fee

All states and territories, with the exception of New South Wales and the Australian Capital Territory (ACT), offer an approximate 50 per cent[9] discount on vehicle registration fees for those qualifying for the pension as well as other welfare, disability and military veteran services. New South Wales and

[9] https://www.vicroads.vic.gov.au/registration/registration-fees/concessions-and-discounts/registration-concessions

https://www.qld.gov.au/transport/registration/fees/cost/index.html

https://www.sa.gov.au/topics/transport-travel-and-motoring/transport-fees/motoring-fees/registration-and-licence-concessions

http://www.transport.wa.gov.au/licensing/concessions.asp

http://www.transport.tas.gov.au/fees_forms/registration_licensing/rebates_exemptions

http://www.health.nt.gov.au/library/scripts/objectifyMedia.aspx?file=pdf/71/09.pdf&siteID=1&str_title=Concession%20Information%20A4%20Pen%20Con%20Form.pdf

ACT waive the fee entirely[10]. Of the concessional groups, those qualifying for the aged pension are at the most risk of demographic change. Due to the post World War II baby boom and improvements in health care, we can expect a significant increase in the population of people aged over 65.

The Treasury (2015) *Intergeneration Report Australia in 2055* projects that the number of people aged 65 and over will increase from 3.6 million in 2015 to 8.9 million in 2055 (Figure 15). In proportional terms, that is an increase from 15.1 to 22.4 per cent.

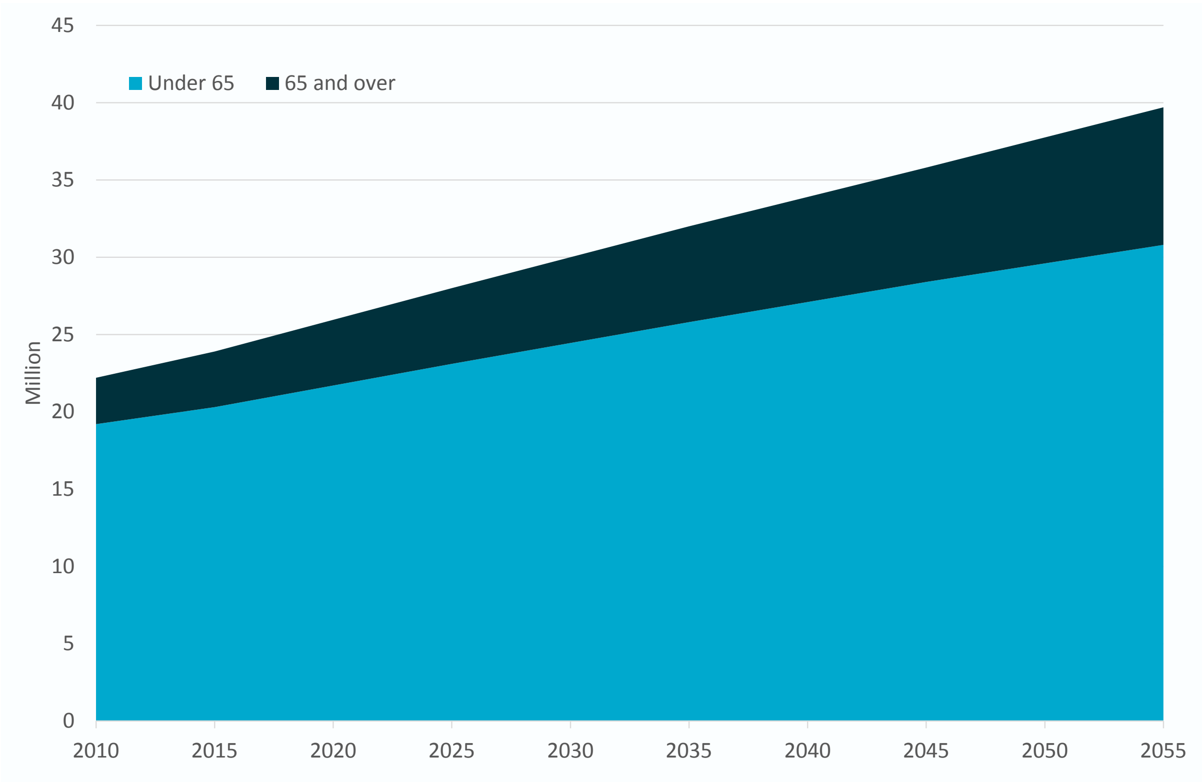

Figure 13: Projections of those aged under 65 or 65 and over (Treasury, 2010)

Given New South Wales has a different policy to the other states we have applied the national level projection of demographic changes in the aged population to ABS (2014) estimates of the state level age distribution. Using these two data sets we can make a projection of the number of persons in each state aged over 65[11].

Using these data and projections we estimate that concessional rates provided to pensioners are costing the states in the range of between 4 and 10 per cent of total potential revenue. However, in this study we are not interested in that statistic so much as how will increased amounts of persons eligible for concessions impact on future registration revenue levels relative to existing policy settings.

---

[10] Note, for simplicity New South Wales and ACT are modelled as one region. Their registration concession policies may be found here:

http://www.rms.nsw.gov.au/roads/registration/fees/index.html#Pensionerconcessions

http://www.rego.act.gov.au/registration/concessions

[11] The author is aware that the qualifying pension age will only equilibrate at 65 between men and women in 2017 and rise to 67 by 2023. However, we do not seek to incorporate these nuances of pension age eligibility into this study because the Treasury (2015) projections are not sufficiently detailed to do so and would only make a minor difference relative to other sources of inaccuracy in the projections.

We find potential future losses in vehicle registration revenue relative to 2012 (and holding all else constant) due to increases in the proportion of the population eligible for the aged pension is expected to be between 1.8 and 4.2 per cent by 2050 (Figure 14).

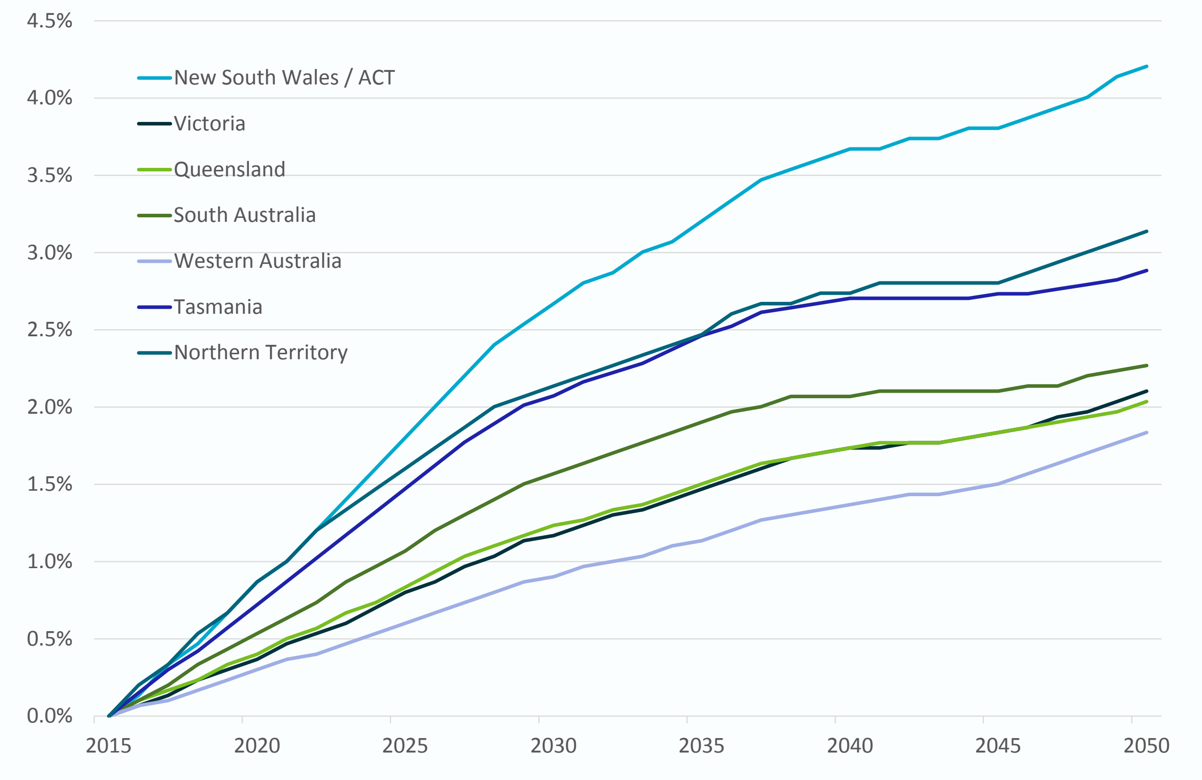

Figure 14: Projected reduction in future vehicle registration revenue (holding all else constant) due to increases in the proportion of the population eligible for concessional rates

3.3 Growth in vehicles to be registered

The number of kilometres travelled per vehicle has been stable in Australia reflecting the fairly well accepted view that kilometres per vehicle has saturated in developed countries. This means that regardless of how inexpensive transport becomes we cannot expand our consumption any further because users are only willing to spend up to a certain amount of time in their vehicles to satisfy all their various demands for transport – such as commuting, errands and accessing services or environments. Beyond a certain point travelling in a vehicle is competing with other priorities – such as sleep, meals, socially connecting and participating in services and environments.

Travel for work purposes (i.e. the light commercial vehicle category) also shows some saturation due to the limits of working hours and economic disincentives of the cost of travel[12].

Given the saturation effect we assume that average kilometres per vehicle will be constant into the future. This means that its inverse – vehicles per kilometre – is also constant. Based on this

[12] Unfortunately the latest Survey of Motor Vehicle Use is for 2012 and so is somewhat out of date. However it shows passenger vehicle average vehicle kilometres per year decreased from 14,100 to 13,200 between 2005 and 2012. Over the same period light commercial vehicle average kilometres per year remained constant at 16900.

assumption and the transport demand projections already discussed in Section 1.5, the number of all road vehicle types increases at a similar rate to transport demand, at just over 50 and 80 per cent by 2035 and 2050 respectively.

While not yet evident in available data, new technologies such as automated vehicles and social vehicle sharing services could change attitudes to vehicle ownership in the long run such that the number of people who opt for private vehicle ownership is reduced. While still speculative, Daniels (2015) conducted some modelling for the United States which suggested that car sharing and self-driving vehicles could lead to a combined 9 percent reduction in average distance travelled by 2050. We partially explore the impact of low vehicle ownership in a scenario in the next section.

3.4 Summary of impacts on road fuel excise revenue

Table 5 summarises the drivers of change in real vehicle registration revenue and their expected impact. It shows that overall that there is a stronger weight of factors that will drive an increase in real vehicle registration revenue than a decrease. We will model these factors in detail in Part II of this report. However, a simple analysis of this preliminary data, multiplying through, indicates real vehicle registration revenue will increase by 48 and 77 per cent by 2035 and 2050 respectively.

Table 6: Summary of drivers of change in vehicle registration revenue and their expected impact

Driver of change	Impact on real vehicle registration revenue (holding all else constant)	
	2035	**2050**
Vehicle registration rate (proxy) indexation	Neutral	Neutral
Vehicle size preference	0.9 per cent decrease	1.6 per cent decrease
Change in proportion of persons eligible for concessions	1.1-3.2 per cent decrease	1.8-4.2 per cent decrease
Growth in vehicle numbers	51 per cent increase	81 per cent increase

Part II Scenario design and results

4 Modelling framework and scenario design

The future levels of fuel excise and vehicle registration revenue will be projected using CSIRO's Energy Sector Model. The Energy Sector Model has been applied in a number of Australian government policy analyses (Graham and Hatfield-Dodds, 2014; Reedman and Graham 2013a and 2013b; Graham and Smart, 2011; Reedman and Graham, 2011). The Energy Sector Model is an economic model which solves a partial equilibrium representation of the transport and electricity sectors. The electricity sector is important to include in such a model because electricity competes with transport for some fuels (e.g. biomass and natural gas) and, in the future, may supply increasing amounts of transport fuel (electricity). The details of the model structure and assumptions, where not discussed here, are available in the references provided with Reedman and Graham (2013a) being the most recent description of the model.

4.1 The scenario set

Three scenarios will be modelled: Baseline, low and high (Table 7). The purpose of the low and high scenarios is to provide an uncertainty range around the central scenario which indicates the extent to which the projected changes in road transport revenue might vary with the key uncertainties in the sector. Based on past modelling work the authors selected demand, oil and gas prices, passenger car ownership and electric vehicle limiting factors as the most important drivers that would impact road excise revenue outcomes.

Table 7: The scenario set and key assumptions

	Low	Baseline	High
Demand	10% less than baseline by 2050 (reflecting price elasticity, greater urban densification and public transport adoption)	Based on Reedman and Graham (2013), updated with BITRE (2014c) and adjusted for price differences using a price elasticity of demand	10% more than baseline by 2050 (reflecting price elasticity, slower urban densification and public transport adoption)
Passenger car ownership rate per kilometre	Reduced by 10% by 2050 reflecting adoption of car sharing and automated driving service models	No change	No change
Oil and gas prices	Modified EIA 2015 High	Modified EIA 2015 baseline	EIA 2015 low
Electric vehicle limiting factors	Relaxed	Moderate	Limited

Electric vehicles deserve special attention because of their large potential market share and their zero road fuel excise rate. We established demand's importance in Part I of this report. However, for the low scenario we have also added an additional related factor which is the car ownership rate per kilometre. For the low scenario we assume a 10% reduction in passenger car ownership by 2050 reflecting adoption of car sharing and automated driving service models. This is a somewhat arbitrary reduction amount as it is uncertain just how far this business model can develop[13].

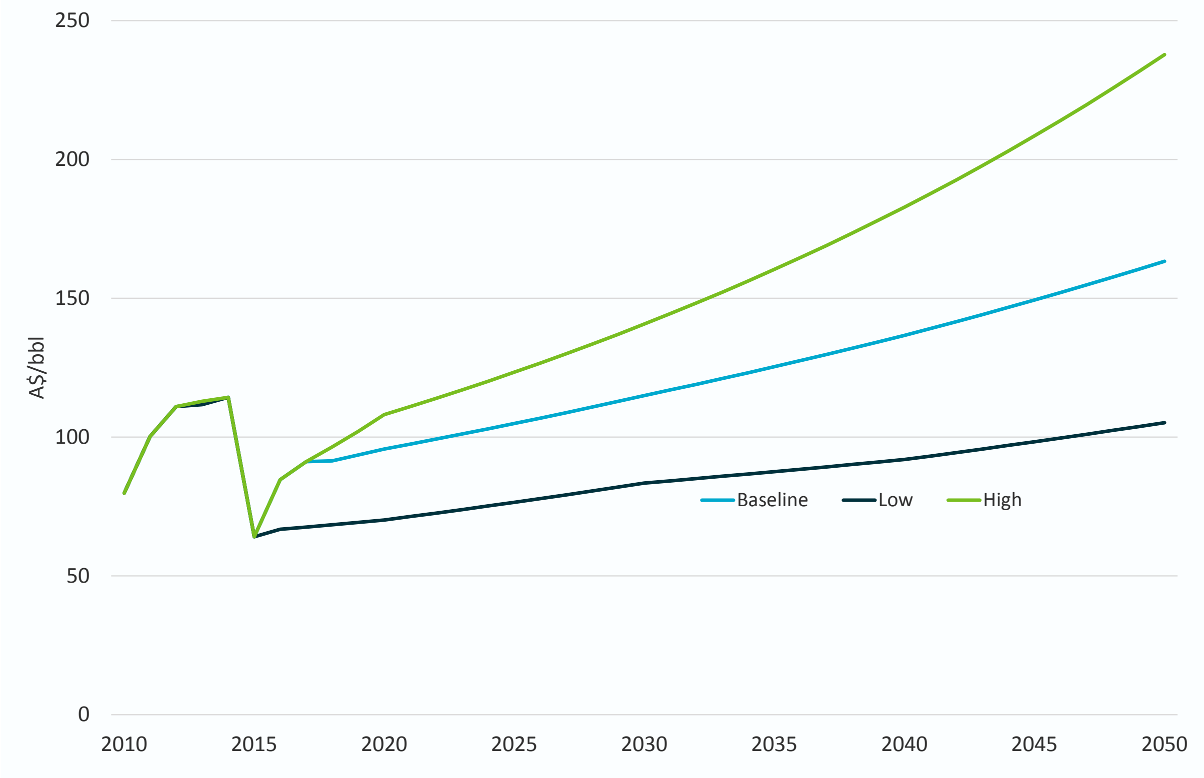

Figure 15: Assumed oil prices for the Baseline, Low and High scenarios (real 2015 dollars)

The selection of oil and gas prices was also difficult because of the present uncertainty in the oil market following a deep reduction in oil prices at the end of 2014. Most of the projections available before that do not take into account the impact of that fall. In particular, we would normally apply the International Energy Agency's forecasts since they are the only group who regularly take into account the impact of increasing action on climate change on the world oil price (most are projections are based on a no action or current policies framework). Given the IEA (2014) oil and gas projections are out of date we apply the Energy Information Administration (2015) projections and reduce them slightly to make them more consistent with the IEA's methodology.

In regard to electric vehicles, our assumed cost projections indicate that this type of vehicle will be an economically viable type. This means that non-price factors such as social attitudes, range anxiety and infrastructure constraints will be important in determining the rate of their uptake and we have discussed these in Part I of this report[14]. We design the "moderate", "relaxed" and "limited" views on these constraints so that we get a diversity of outcomes for electric vehicle uptake. The projected outcomes are shown in Appendix B.

---

[13] A high upside view would suggest that the improved safety and reduced congestion outcomes of the two models are so great that they will become the dominant models. A downside view might point to our present dominant culture of pride in vehicle ownership. Daniels (2015) suggests self-driving will not be adopted until after 2030.

[14] Graham and Smart (2011) also provided various sensitivity cases examining this topic

5 Scenario modelling results

The projected road excise and vehicle registration revenues to 2050 for the baseline, low and high scenarios are shown in Figure 16 and Figure 17.

For fuel excise revenue, all scenarios experience a rising trend in the near term but that trend slows and switches to a flat to declining trend from the 2020s. By 2035, relative to 2015, the modelling projects a low scenario outcome of a 17 per cent reduction or a high scenario outcome of a 22 per cent increase in revenue with a baseline or central estimate of a 6 per cent increase. However, by 2050, as the declining trend strengthens, both the baseline and low scenario see further decreases in revenue with 15 and 45 per cent reductions respectively relative to 2015. For the high scenario the increase in revenue, relative to 2015, has eroded slightly to 20 percent by 2050.

The real value of revenue from road vehicle registration is projected to increase under all scenarios. For vehicle registration the modelling projects a 40 to 55 per cent increase in revenue by 2035 with a central estimate of 49 per cent. By 2050 the modelling projects a 60 to 94 per cent increase in revenue with a central estimate of 78 per cent

Additional tables of revenue estimates broken down by light and heavy vehicle duty sectors are provided in Appendix A. The projected transport fuel and technology mix for each scenario is presented in Appendix B.

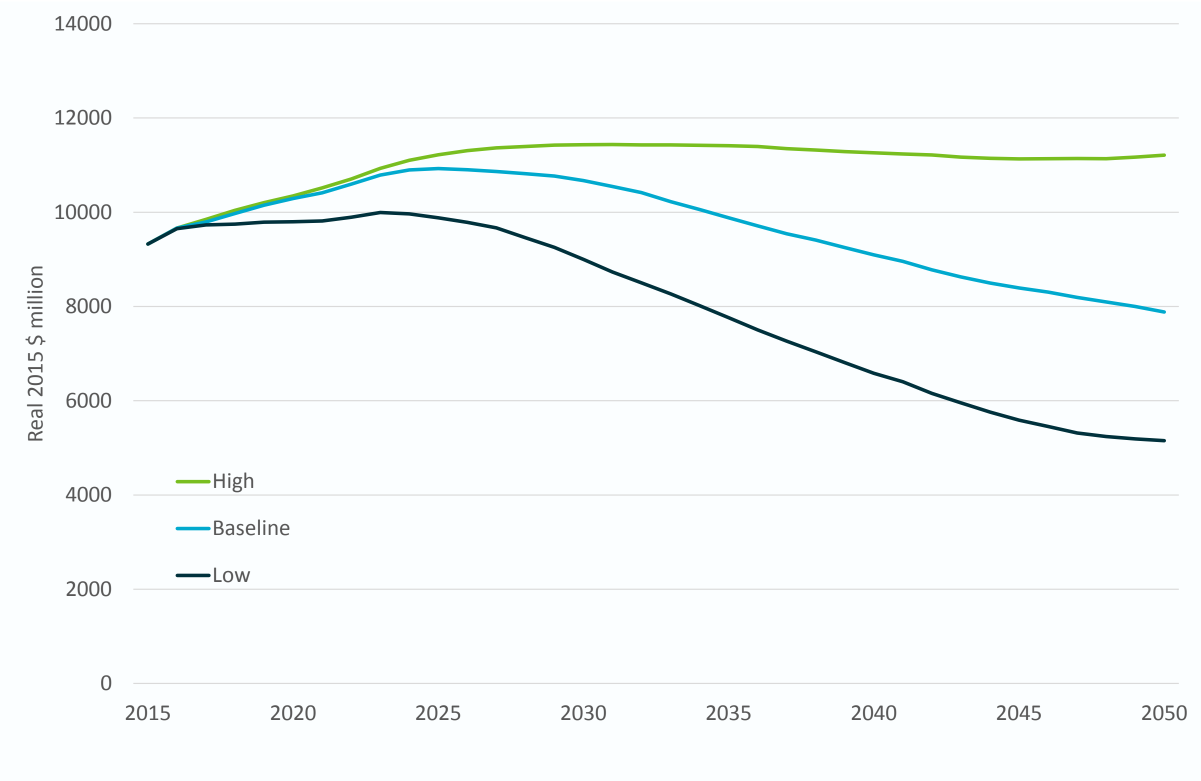

Figure 16: Projected road excise revenue to 2050 for the baseline, low and high scenarios (real 2015 dollars)

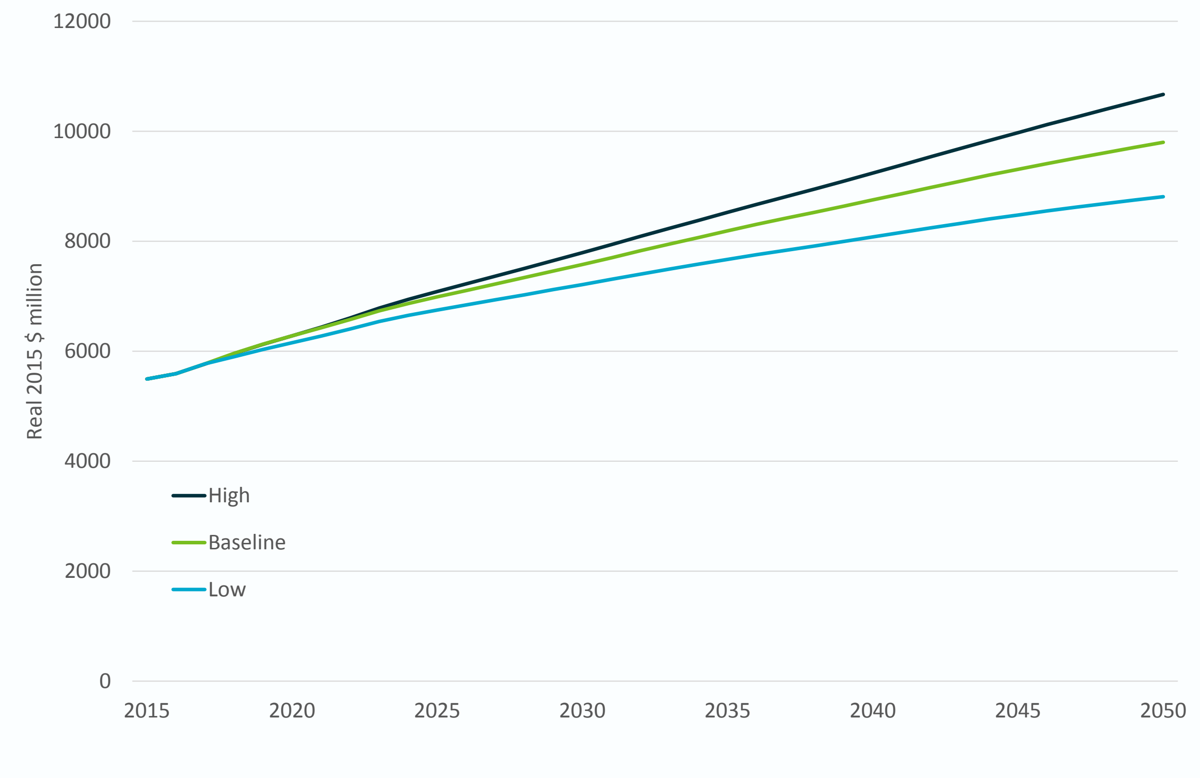

Figure 17: Projected vehicle registration revenue to 2050 for the baseline, low and high scenarios (real 2015 dollars)

5.1 A short note on stamp duty revenue

Stamp duty was excluded from this study to keep the scope manageable and because the Energy Sector Model lacks the capability to determine second hand car sales. The Energy Sector Model tracks the vehicle stock and determines new car sales. However, after new vehicles enter the vehicle stock there is no mechanism within the model to track how often they are re-sold to new owners during their life.

However, in examining vehicle registration it was observed that between 1997-98 and 2006-07 the relationship between stamp duty and vehicle registration revenue was very stable at a ratio of between $0.51 and $0.57 dollars of stamp duty collected for every dollar of vehicle registration. If this ratio had persisted in that range then it would be stable enough to provide a reasonably reliable forecast for stamp duty revenue based on the vehicle registration revenue projections included here.

However, in 2007-08, the ratio changed increasing to 0.63, dropped back to 0.54 in 2008-09 but later declined and stabilised to 0.47 by 2012-13. This reflects the period when the oil price spike occurred. We know from vehicle sales figures that during this period the rate of annual new passenger vehicle sales fell and there was a change in vehicle preferences to smaller vehicles both of which would decrease vehicle registration revenue and cause the ratio to go up. However, stamp duty revenue also increased suggesting there was also a change in activity in the resale market itself – perhaps an increase the rate of second hand vehicle sales.

It is possible that the change in the ratio was merely a short term phenomenon. Certainly the previous six years of a stable relationship are suggestive of that. If the ratio returns to the pre-2007 average ratio of 0.53, the projected 2050 stamp duty revenue (holding all else constant) would be an increase to $5236 million in the baseline scenario. If the new ratio of 0.47 persists then the baseline value is $4618 million compared to the reported value of stamp duty revenue in 2012-13 of $2471 million (BITRE, 2014).

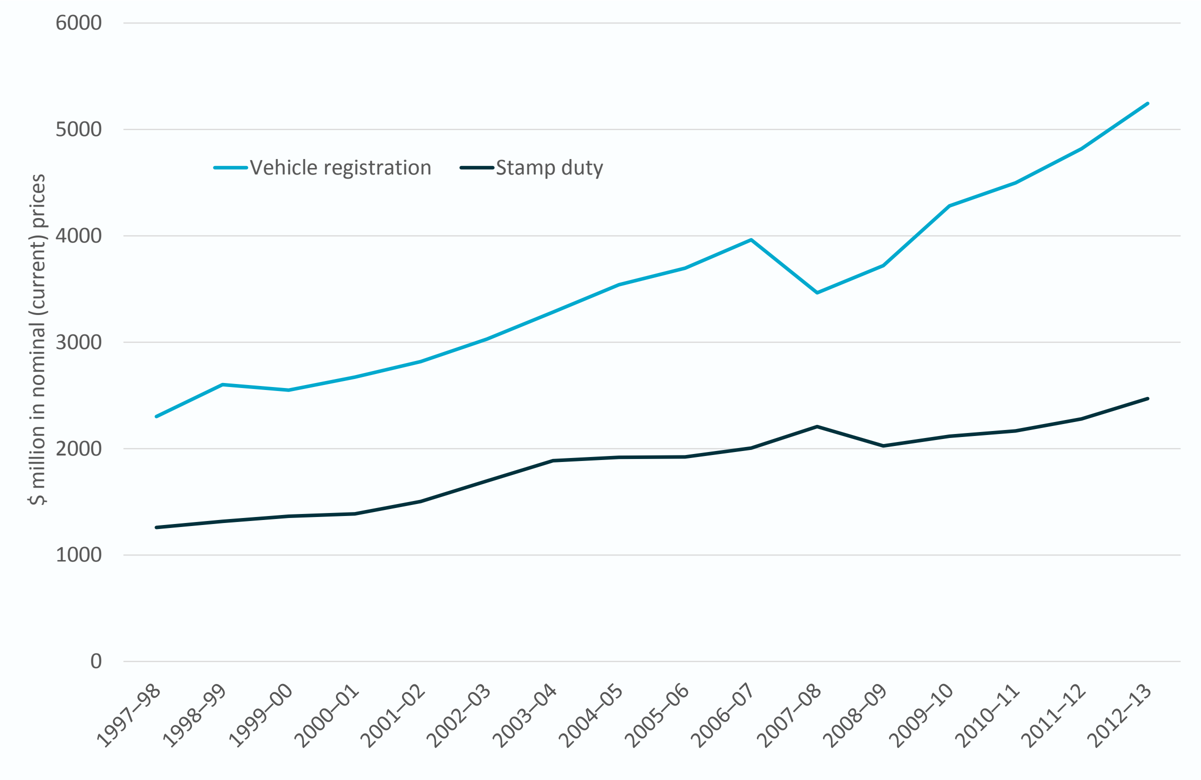

Figure 18: Historical stamp duty and vehicle registration

6 Conclusions

The report outlines the main factors likely to drive changes in the road transport revenue streams of fuel excise and vehicle registration. These are the largest sources of road transport revenue. We also noted a simplified way of assessing stamp duty revenue by observing its close relationship to vehicle registration revenue.

The drivers we have explored were:

- fuel indexation
- price inflation
- fuel efficiency
- alternative fuels and vehicles
- demand for road transport
- the ageing of the population
- vehicle size preferences
- vehicle ownership preferences.

The reimplementation of fuel indexation has dramatically improved the outlook for road revenue from this source. Without this change the real value of the excise rate would have declined by 60 per cent by 2050 (based on historical rates of inflation). However, this development has not entirely removed the risk that the real value of fuel excise revenue could decline in the future.

There are two main drivers of declining fuel excise: improvements in fuel efficiency and increased adoption of zero or lower excise rate alternative fuels. Adoption of electric vehicles has the strongest revenue reducing factor (both improving vehicle energy efficiency per kilometre and utilising a fuel source that does not attract road fuel excise). However, 80 per cent growth in transport demand is just strong enough to offset these negative factors to achieve a modest 6 per cent growth in the baseline scenario.

There is significant uncertainty in all of the main factors considered. The oil price remains volatile and its impact on the rate of developments and adoption of alternative fuels and vehicles is also difficult to predict.

These uncertainties in the data are compounded by limitations in the modelling framework. CSIRO's Energy Sector Model assumes vehicle and fuel choices are largely made on the basis of relative costs. In reality we are aware that such decisions can be based on many factors such as vehicle presentation, amenity and brand loyalty. The potential shift to electric vehicles is particularly characterised by a number of important non-price factors such as range anxiety, independence from the liquid fuel market, infrastructure and technology awareness.

As check on the model performance, we have sought to establish an expectation of how each individual factor drives the change in revenue outcomes holding other factors constant. When the factors were combined in the modelling, our expectations about the combined impacts of the individual factors were largely met.

References

Australian Bureau of Statistics (ABS) 2015, *Consumer Price Index*, 6401.0., ABS, Canberra

Australian Bureau of Statistics (ABS) 2012 *Survey of Motor Vehicle Use, 9208.0*, ABS, Canberra.

Australian Bureau of Statistics (ABS) 2014 *Australian Historical Population Statistics, 20083105.0.65.001,* ABS, Canberra.

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2014a, *Australian Infrastructure Statistics Yearbook 2014*, BITRE, Canberra.

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2014b, *BITRE Road Construction and Maintenance Price Index – 2014 update*, BITRE, Canberra.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2014, *Freightline 1 – Australian freight transport overview*, BITRE, Canberra.

Cheng, J.Y. and Graham, P. W. 2009, *Modelling hydrogen fuel distribution*, in Anderssen, R.S., R.D. Braddock and L.T.H. Newham (eds), 18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand and International Association for Mathematics and Computers in Simulation, July 2009, pp. 1979-1985 [ISBN: 978-0-9758400-7-8]. http://www.mssanz.org.au/modsim09/A3/cheng_j.pdf

Daniels, L. *Does America's Transportation Future Really Need More and Bigger Roads?: Rethinking the Highway Trust Fund*, Rocky Mountain Institute, 27 May 2015, http://blog.rmi.org/blog_2015_05_27_does_americas_transportation_future_really_need_more_and_bigger_roads

Energy Information Administration 2015, *Annual Energy Outlook 2015*, US Department of Energy.

Farine, D., O'Connell, D., Raison, J., May, B., O'Connor, M., Crawford, D., Herr, A., Taylor, J., Jovanovic, T., Campbell, P., Dunlop, M., Rodriguez, L., Poole, M., Braid, A. and Kriticos, D. 2011, An assessment of biomass for bioelectricity and biofuel, and for greenhouse gas emission reduction in Australia, *GCB Bioenergy*, doi: 10.1111/j.1757-1707.2011.01115.x

FCAI (various), *Vehicle sales*, Federal Chamber of Automotive Industries, http://www.fcai.com.au/sales.

Graham P. W. 2012, *Projecting future road transport revenues*, CSIRO, Australia

Graham, P., Reedman, L., Rodriguez, L., Raison, J., Braid, A., Haritos, V., Brinsmead, T., Hayward, J., Taylor, J., O'Connell, D., Adams, P., 2011, Sustainable Aviation Fuels Road Map: Data Assumptions and Modelling, CSIRO. http://www.csiro.au/~/media/CSIROau/Flagships/Energy%20Transformed%20Flagship/SustAviationFuelsRoadMap_ETF_pdf%20Standard.ashx

Graham, P. and Reedman, L. 2011, Road Transport Sector Modelling, http://www.treasury.gov.au/carbonpricemodelling/content/consultants_reports/CSIRO_Road_transport_sector_modellingv2.pdf

Graham, P.W. and Hatfield-Dodds, S. 2014, Transport sector In: Sue, W., Ferraro, S., Kautto, N., Skarbek, A., and Thwaites, J. editor/s. Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world: Technical report, ClimateWorks Australia, 23-52

Graham, P.W. and Smart, A. 2011, *Possible Futures: Scenario Modelling of Australian Alternative Transport Fuels to 2050*, Prepared for the Department of Resources, Energy and Tourism.

Honda 2011 Home energy station, http://automobiles.honda.com/fcx-clarity/home-energy-station.aspx

International Energy Agency (IEA) 2014, *World Energy Outlook 2014*, OECD/IEA, Paris.

King Review 2007, The King Review of Low-carbon Cars Part I: The Potential for CO2 Reduction, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/pbr_csr07_king840.pdf.

Mintz, M., Gillette, J., Elgowainy, A., Paster, M., Ringer, M., Brown, D. and Li, J. 2006, Hydrogen Delivery Scenario Analysis Model for Hydrogen Distribution Options, *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 1983, pp.114-120.

Pigneri A. 2005, Hydrogen Strategies: *An Integrated Resource Planning Analysis for the Development of Hydrogen Energy Infrastructures*, Proceedings of the International Hydrogen Energy Congress and Exhibition IHEC 2005, Istanbul, Turkey, 13-15 July 2005, http://pubs.its.ucdavis.edu/publication_detail.php?id=123

National Transport Commission (NTC) 2014a, *Carbon Dioxide Emissions from New Australian Vehicles 2013*, NTC, Melbourne.

National Transport Commission (NTC) 2014b, Submission to the Productivity Commission Inquiry into public infrastructure, NTC, Melbourne.

National Transport Commission (NTC) 2012, *Heavy vehicle charges: Report to the Standing Council of Transport and Infrastructure*, NTC, http://www.ntc.gov.au/filemedia/Reports/HVChargesSCOTIFeb2012.pdf.

Noel, M.D. and Roach, T. 2014, Regulated and Unregulated Almost-Perfect Substitutes: Aversion Effects from a Selective Ethanol Mandate, https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=IIOC2014&paper_id=159

Nykvist, B. and Nilsson, M. 2015, Rapidly falling costs of battery packs for electric vehicles, *Nature climate change*, 23 March 2015.

Reedman, L., and Graham, P., 2013a, Transport Sector Greenhouse Gas Emissions Projections 2013–2050, Report No. EP139979, CSIRO, Australia, http://www.climatechangeauthority.gov.au/Node/102

Reedman, L., and Graham, P., 2013b, Sensitivity Analysis of Modelling of Light Vehicle Emission Standards in Australia, Report No. EP1312837, CSIRO, http://climatechangeauthority.gov.au/node/154

Reedman, L. and Graham, P. 2011, Road Transport Sector Modelling: Supplementary Modelling of Clean Energy Future and Government Policy scenarios, http://carbonpricemodelling.treasury.gov.au/carbonpricemodelling/content/consultantreports.asp

Treasury 2015, *Intergeneration report: Australia in 2055*, Commonwealth of Australia, Treasury Canberra.

Yang, C. and Ogden, J. 2007, Determining the lowest-cost hydrogen delivery mode, *International Journal of Hydrogen Energy*, 32(2), 268-286.

Part III Appendices

Appendix A Projected revenue by light and heavy vehicles

Table 8: Projected fuel excise revenue by light and heavy road vehicles, real 2015 million dollars

Year	Light vehicles			Heavy vehicles		
	Low	Baseline	High	Low	Baseline	High
2015	7637	7637	7637	1690	1690	1690
2016	7900	7913	7913	1749	1749	1749
2017	7912	7973	8034	1820	1820	1815
2018	7863	8073	8149	1883	1901	1890
2019	7851	8182	8245	1938	1966	1959
2020	7806	8264	8325	1993	2028	2021
2021	7777	8334	8437	2038	2079	2080
2022	7800	8457	8558	2092	2141	2147
2023	7861	8589	8720	2132	2200	2210
2024	7827	8670	8843	2136	2226	2259
2025	7743	8692	8929	2140	2234	2290
2026	7650	8657	9000	2136	2245	2309
2027	7536	8612	9040	2132	2253	2325
2028	7341	8562	9065	2119	2254	2330
2029	7150	8503	9080	2105	2263	2344
2030	6946	8418	9089	2054	2254	2342
2031	6684	8311	9074	2049	2235	2361
2032	6466	8175	9050	2035	2240	2379
2033	6249	8043	9026	2019	2182	2400
2034	6019	7889	8995	1997	2169	2424
2035	5791	7733	8962	1972	2149	2449
2036	5556	7571	8923	1944	2138	2473
2037	5342	7419	8891	1922	2125	2460
2038	5141	7269	8842	1897	2139	2478
2039	4937	7125	8790	1872	2125	2497
2040	4732	6984	8743	1849	2112	2517
2041	4574	6856	8698	1829	2100	2537
2042	4347	6687	8657	1810	2089	2558
2043	4160	6548	8617	1794	2080	2552
2044	3977	6423	8583	1783	2076	2561
2045	3812	6316	8556	1776	2074	2576
2046	3677	6231	8538	1775	2075	2599
2047	3534	6115	8528	1782	2078	2612
2048	3439	6011	8495	1799	2084	2640
2049	3373	5916	8500	1815	2085	2669
2050	3316	5826	8512	1837	2056	2699

Table 9: Projected vehicle registration revenue by light and heavy road vehicles, real 2015 million dollars

Year	Light vehicles			Heavy vehicles		
	Low	Baseline	High	Low	Baseline	High
2015	4321	4321	4321	1174	1174	1174
2016	4380	4380	4380	1213	1213	1213
2017	4511	4511	4511	1260	1260	1258
2018	4600	4649	4649	1298	1311	1309
2019	4697	4775	4775	1334	1355	1353
2020	4786	4885	4885	1370	1396	1394
2021	4876	4994	5005	1401	1432	1433
2022	4967	5102	5129	1437	1473	1479
2023	5067	5219	5262	1473	1515	1524
2024	5155	5325	5385	1497	1544	1558
2025	5228	5416	5493	1521	1572	1592
2026	5299	5505	5600	1545	1601	1625
2027	5369	5594	5707	1567	1629	1659
2028	5437	5683	5813	1590	1658	1692
2029	5506	5773	5921	1615	1687	1727
2030	5574	5862	6030	1639	1716	1762
2031	5643	5953	6140	1664	1747	1798
2032	5714	6047	6253	1689	1779	1835
2033	5782	6140	6365	1714	1811	1871
2034	5846	6228	6472	1737	1841	1907
2035	5909	6317	6580	1762	1873	1945
2036	5969	6403	6686	1786	1905	1982
2037	6028	6484	6791	1809	1934	2019
2038	6084	6564	6895	1832	1964	2055
2039	6141	6645	7000	1854	1993	2091
2040	6200	6727	7108	1878	2024	2130
2041	6258	6809	7216	1902	2055	2169
2042	6318	6893	7328	1926	2086	2209
2043	6374	6974	7437	1949	2117	2247
2044	6431	7056	7547	1972	2147	2286
2045	6483	7132	7653	1994	2176	2324
2046	6536	7209	7759	2015	2204	2361
2047	6584	7282	7862	2034	2231	2397
2048	6631	7353	7964	2053	2257	2433
2049	6677	7424	8066	2072	2283	2469
2050	6720	7492	8166	2089	2307	2504

Table 10: Projected fuel excise revenue by light and heavy road vehicles, real 2015 cents/km

Year	Light vehicles			Heavy vehicles		
	Low	Baseline	High	Low	Baseline	High
2015	3.4	3.4	3.4	8.0	8.0	8.0
2016	3.4	3.4	3.4	8.0	8.0	8.1
2017	3.4	3.4	3.4	8.1	8.0	8.0
2018	3.3	3.3	3.3	8.2	8.1	8.1
2019	3.2	3.3	3.3	8.2	8.1	8.2
2020	3.1	3.2	3.2	8.2	8.2	8.2
2021	3.1	3.2	3.2	8.2	8.2	8.2
2022	3.0	3.2	3.2	8.2	8.2	8.2
2023	3.0	3.1	3.1	8.2	8.3	8.3
2024	2.9	3.1	3.1	8.1	8.2	8.3
2025	2.8	3.1	3.1	8.0	8.1	8.2
2026	2.8	3.0	3.0	7.8	8.0	8.1
2027	2.7	2.9	3.0	7.7	7.9	8.0
2028	2.6	2.9	2.9	7.5	7.7	7.8
2029	2.5	2.8	2.9	7.4	7.6	7.7
2030	2.4	2.7	2.8	7.1	7.4	7.6
2031	2.2	2.6	2.8	6.9	7.2	7.5
2032	2.1	2.6	2.7	6.8	7.1	7.4
2033	2.0	2.5	2.7	6.6	6.8	7.3
2034	1.9	2.4	2.6	6.5	6.7	7.2
2035	1.9	2.3	2.6	6.3	6.5	7.2
2036	1.8	2.2	2.5	6.1	6.4	7.1
2037	1.7	2.2	2.5	6.0	6.2	6.9
2038	1.6	2.1	2.4	5.8	6.2	6.9
2039	1.5	2.0	2.4	5.7	6.0	6.8
2040	1.4	2.0	2.3	5.5	5.9	6.7
2041	1.4	1.9	2.3	5.4	5.8	6.7
2042	1.3	1.8	2.2	5.3	5.7	6.6
2043	1.2	1.8	2.2	5.2	5.6	6.5
2044	1.2	1.7	2.1	5.1	5.5	6.4
2045	1.1	1.7	2.1	5.0	5.4	6.3
2046	1.1	1.6	2.1	5.0	5.3	6.3
2047	1.0	1.6	2.0	4.9	5.3	6.2
2048	1.0	1.5	2.0	4.9	5.2	6.2
2049	0.9	1.5	2.0	4.9	5.2	6.2
2050	0.9	1.5	1.9	4.9	5.1	6.2

Table 11: Projected vehicle registration revenue by light and heavy road vehicles, real 2015 cents/km

Year	Light vehicles			Heavy vehicles		
	Low	Baseline	High	Low	Baseline	High
2015	1.94	1.94	1.94	5.59	5.59	5.59
2016	1.91	1.91	1.91	5.57	5.57	5.59
2017	1.93	1.91	1.91	5.61	5.56	5.58
2018	1.92	1.91	1.91	5.62	5.60	5.62
2019	1.92	1.91	1.91	5.62	5.62	5.63
2020	1.92	1.91	1.91	5.64	5.65	5.65
2021	1.91	1.91	1.90	5.64	5.65	5.65
2022	1.91	1.90	1.90	5.65	5.66	5.67
2023	1.91	1.90	1.90	5.69	5.70	5.71
2024	1.91	1.91	1.90	5.68	5.70	5.71
2025	1.91	1.90	1.90	5.68	5.69	5.70
2026	1.91	1.90	1.90	5.67	5.69	5.70
2027	1.90	1.90	1.89	5.66	5.68	5.70
2028	1.90	1.90	1.89	5.65	5.67	5.69
2029	1.90	1.89	1.89	5.64	5.66	5.69
2030	1.90	1.89	1.89	5.64	5.66	5.68
2031	1.89	1.89	1.88	5.64	5.66	5.68
2032	1.89	1.89	1.88	5.64	5.66	5.69
2033	1.89	1.89	1.88	5.64	5.66	5.69
2034	1.89	1.89	1.88	5.63	5.66	5.69
2035	1.89	1.89	1.88	5.63	5.66	5.69
2036	1.89	1.88	1.88	5.63	5.66	5.69
2037	1.89	1.88	1.88	5.63	5.66	5.69
2038	1.89	1.88	1.88	5.62	5.66	5.70
2039	1.88	1.88	1.88	5.62	5.66	5.69
2040	1.88	1.88	1.88	5.62	5.66	5.70
2041	1.88	1.88	1.87	5.62	5.67	5.70
2042	1.88	1.88	1.87	5.62	5.67	5.71
2043	1.88	1.88	1.87	5.62	5.67	5.71
2044	1.88	1.88	1.87	5.62	5.68	5.72
2045	1.88	1.88	1.87	5.62	5.68	5.72
2046	1.88	1.88	1.87	5.62	5.68	5.73
2047	1.88	1.88	1.87	5.62	5.68	5.73
2048	1.88	1.88	1.87	5.61	5.68	5.73
2049	1.88	1.87	1.87	5.61	5.68	5.73
2050	1.87	1.87	1.87	5.61	5.68	5.74

Appendix B Projected fuel and technology mix

The following figures provide the projected fuel and engine technology mix for each of the low, baseline and high scenarios. The projected changes are consistent with the discussion of alternative fuel potential discussed in Part I.

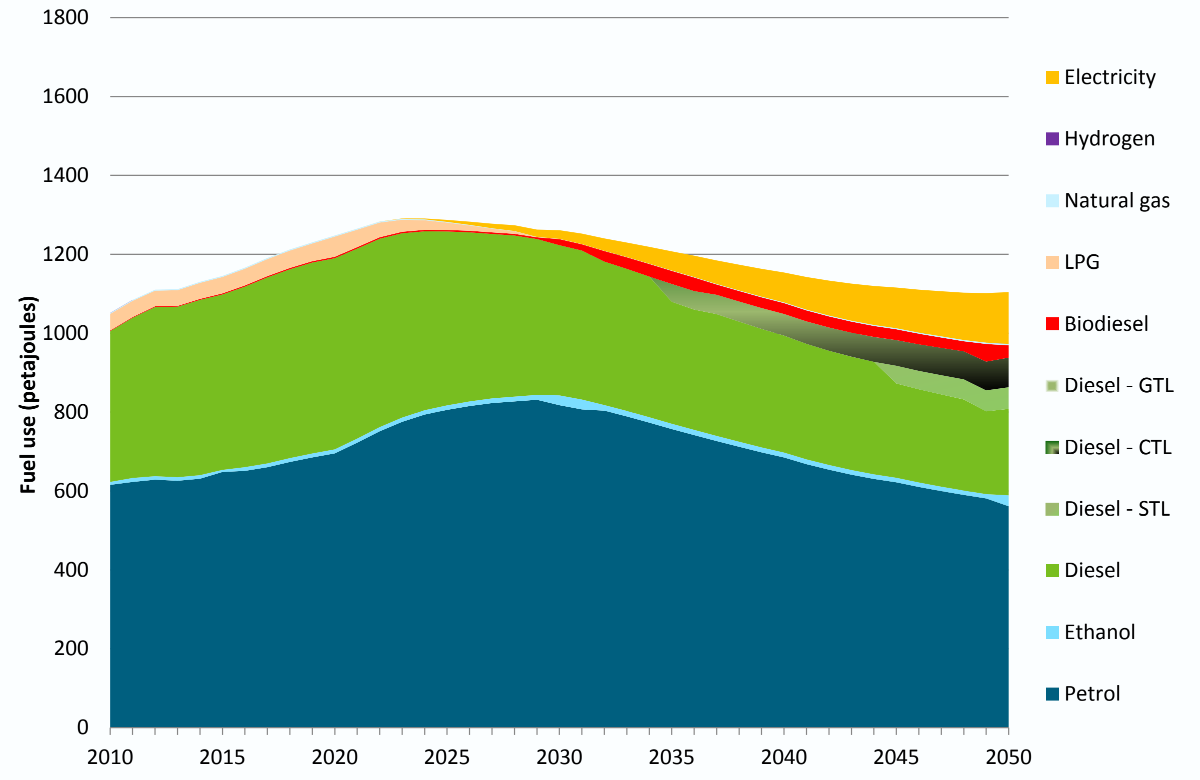

Figure 19: Projected transport fuel mix to 2050 for the baseline scenario

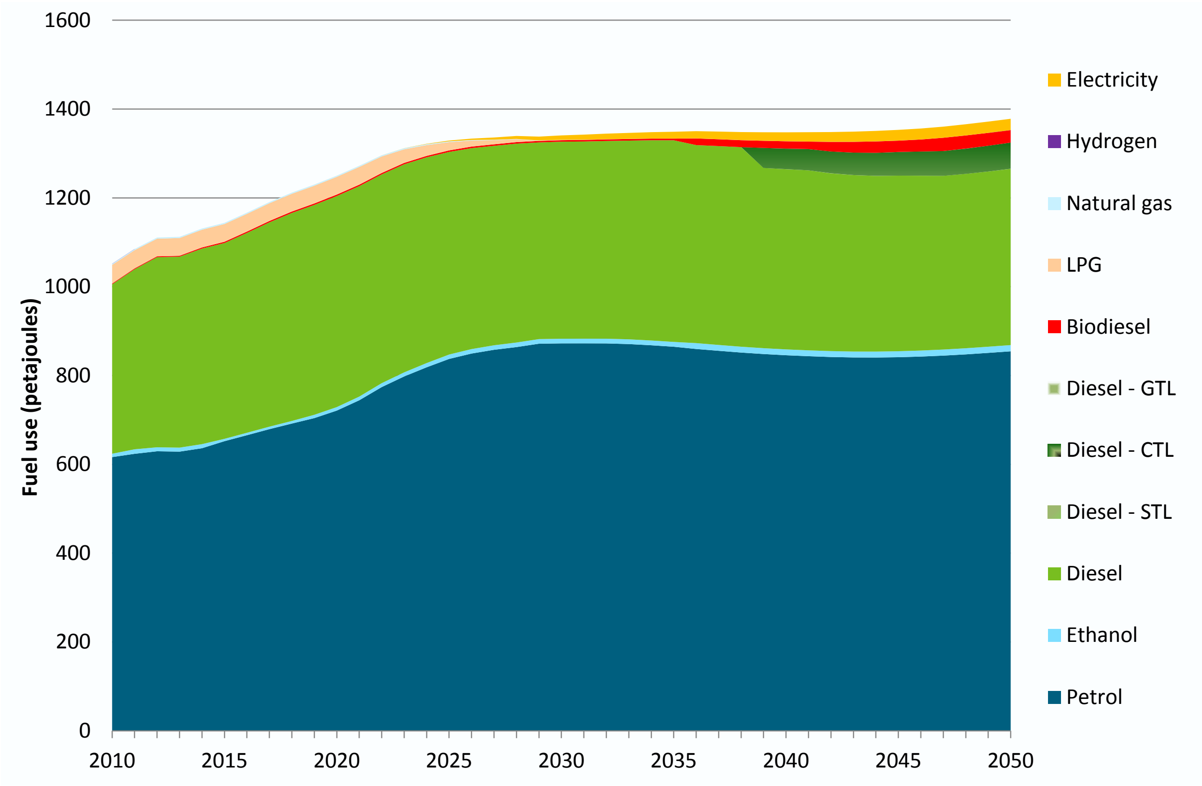

Figure 20: Projected transport fuel mix to 2050 for the high scenario

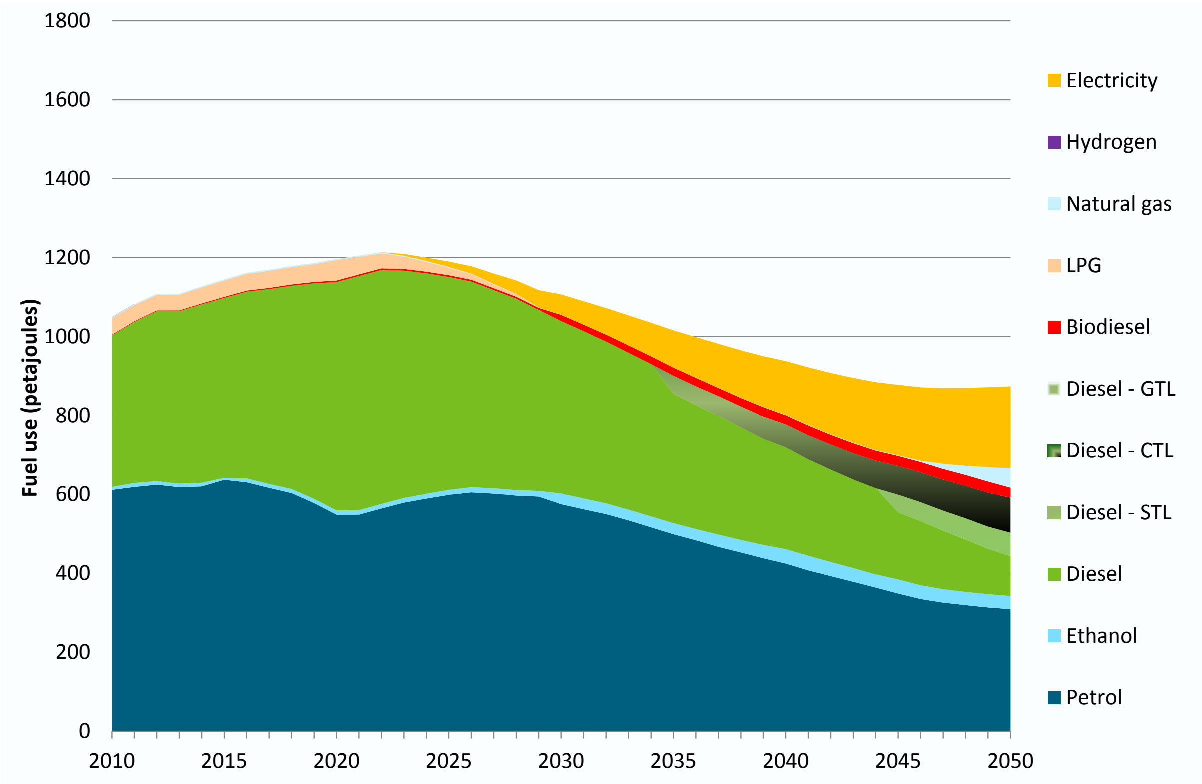

Figure 21: Projected transport fuel mix to 2050 for the low scenario

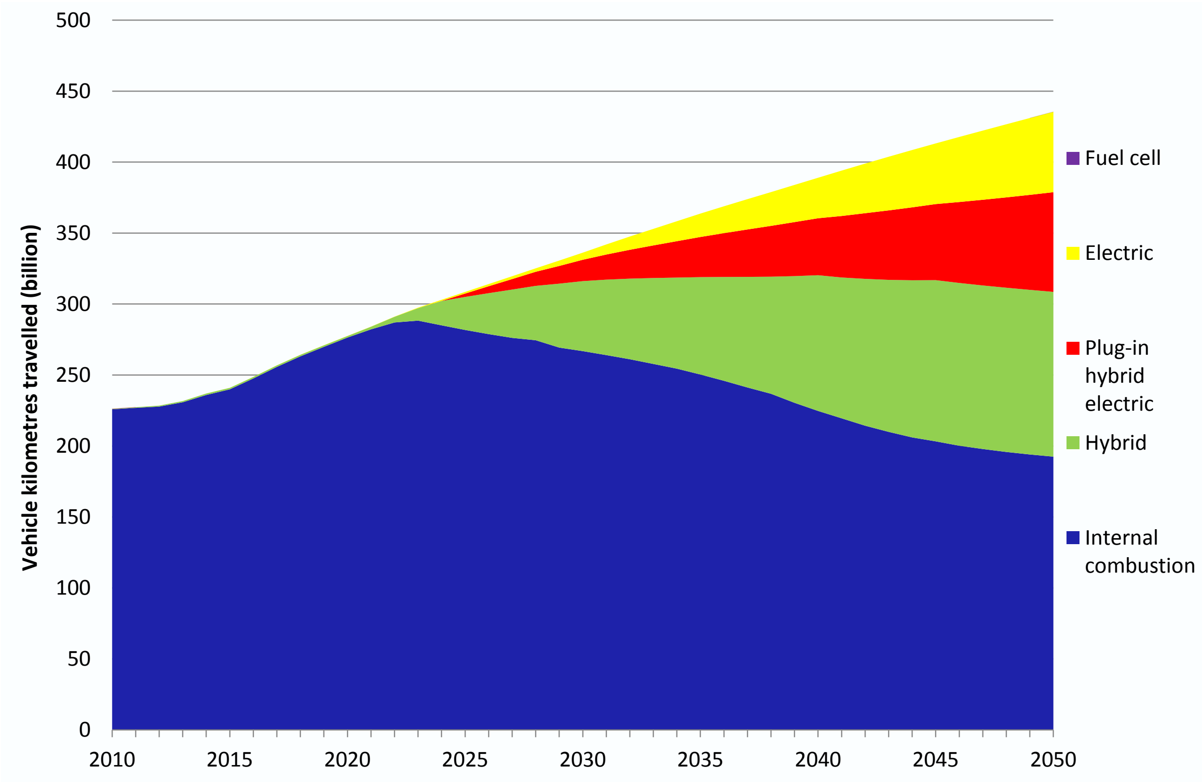

Figure 22: Projected road kilometres travelled by engine technology mix to 2050 for the baseline scenario

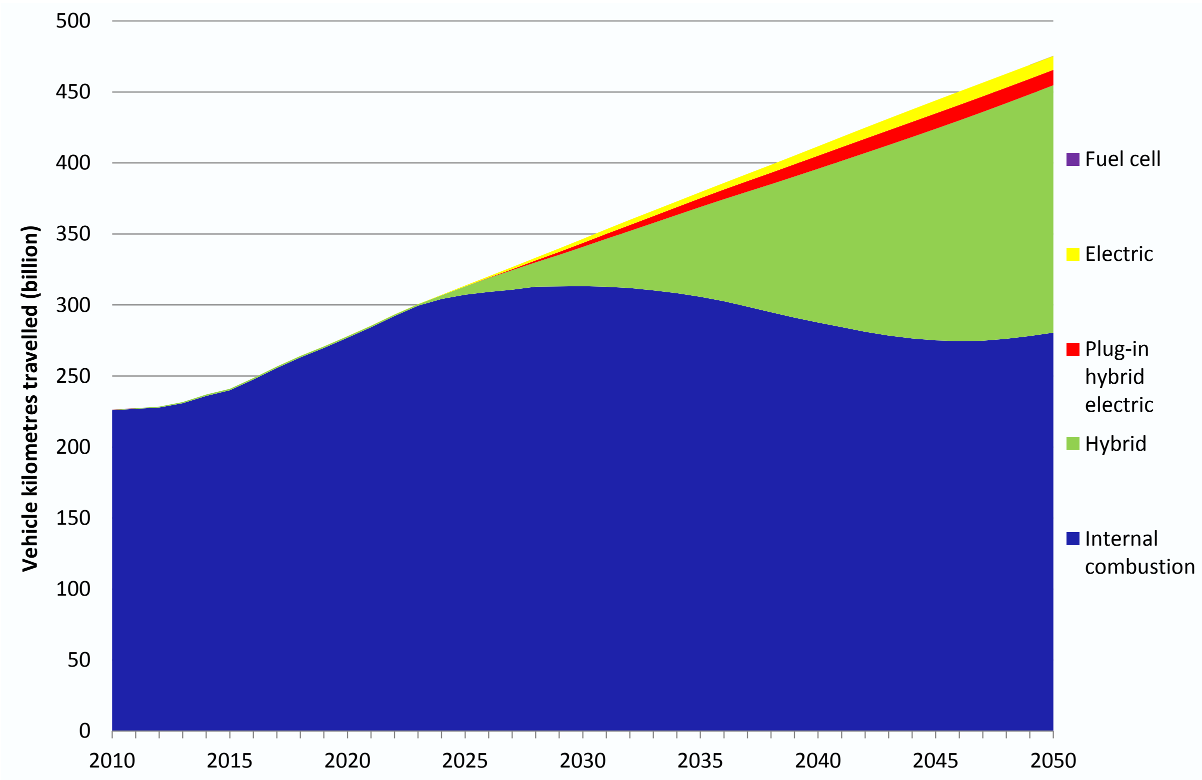

Figure 23: Projected road kilometres travelled by engine technology mix to 2050 for the high scenario

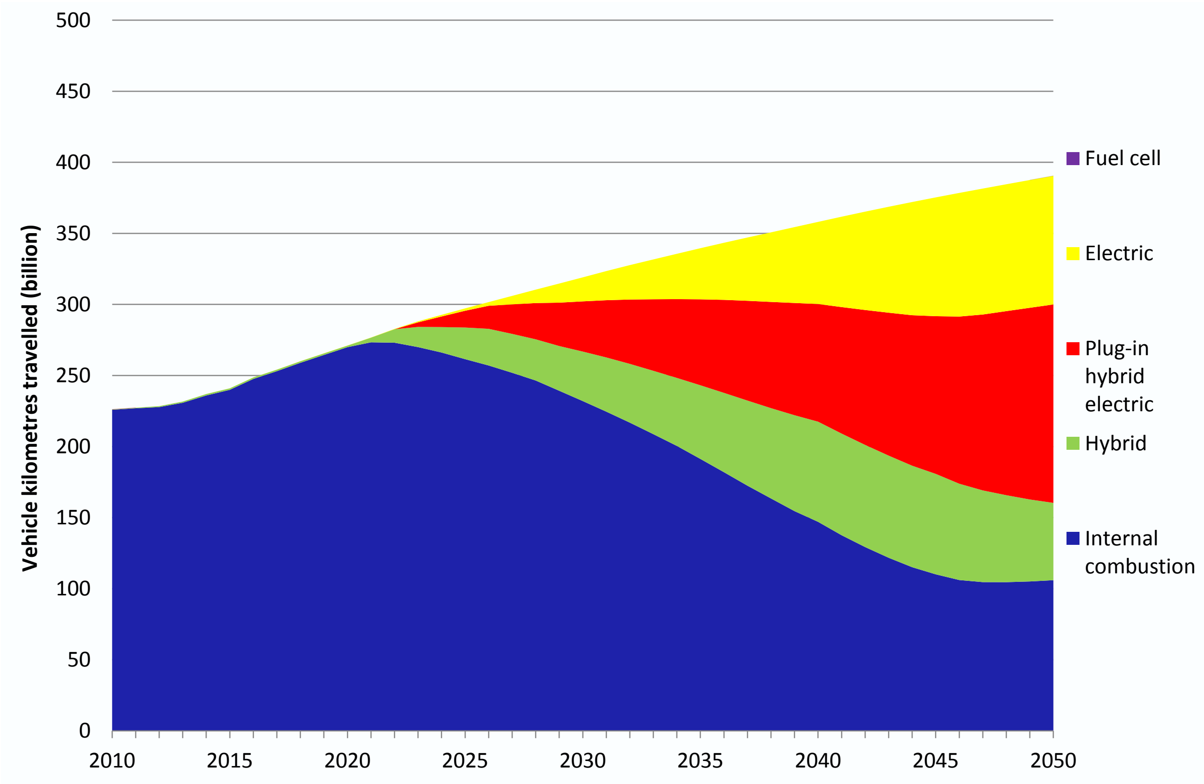

Figure 24: Projected road kilometres travelled by engine technology mix to 2050 for the low scenario

Appendix C Comparison with 2012 road transport revenue projections

CSIRO conducted an analysis of road revenue projections in 2012 (Graham 2012; NTC 2014b). We reproduce the results here for comparison in Figure 25 and Figure 26. In the 2012 study, for fuel excise revenue, the modelling projected a 49 to 80 per cent reduction in revenue with a central estimate of a 62 per cent reduction. For vehicle registration the modelling projects a 72 to 126 per cent increase in revenue with a central estimate of 98 per cent.

For fuel excise the much lower (around 60%) projected outcome for revenue mostly reflects that fuel excise had not been re-indexed and that policy was assumed to remain in place to 2050 in the 2012 projections. Also, to a much lesser extent than the indexation change, the 2014 policy change to impose a positive effective excise on biofuels has reduced the negative impact of the potential adoption of biofuels in the 2015 projections.

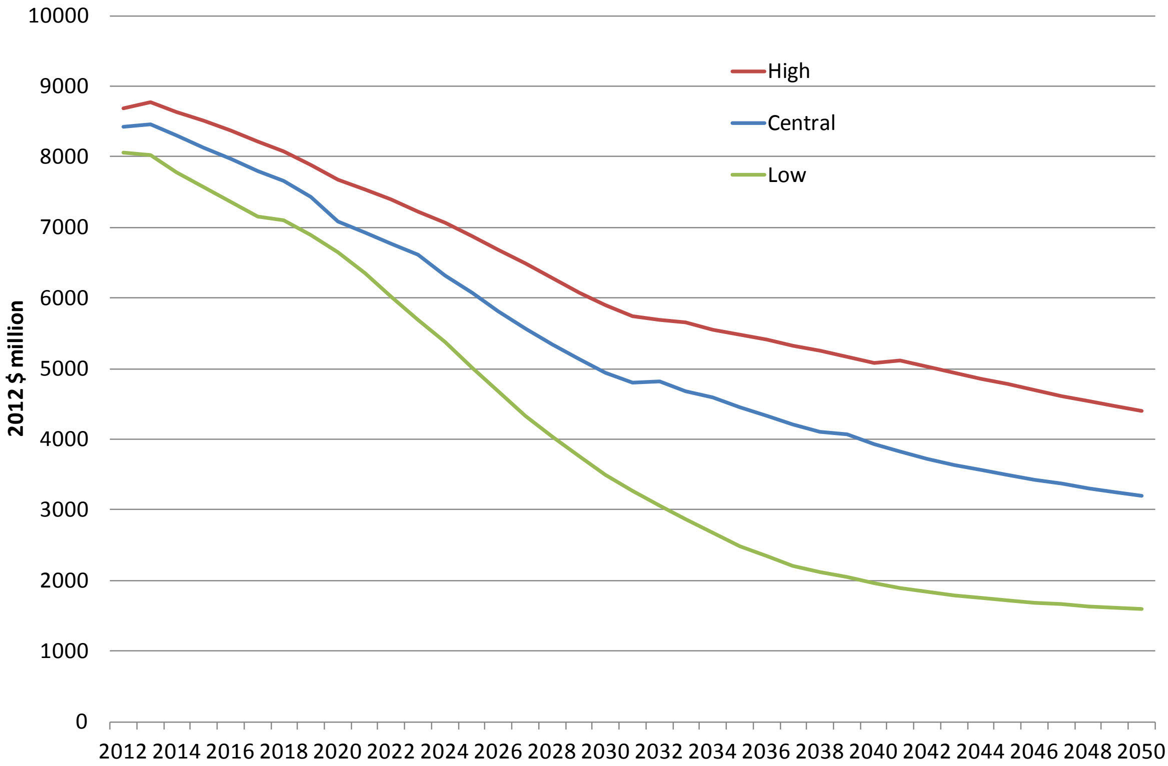

Figure 25: 2012 study projection of road fuel excise revenue, real 2012 dollars

For vehicle registration the 2012 and 2015 projections are fairly similar in magnitude and both have a positive trend. However, the 2012 projection is lower reflecting lower assumed freight demand growth and some upward revisions in registration fees in the 2015 assumptions.

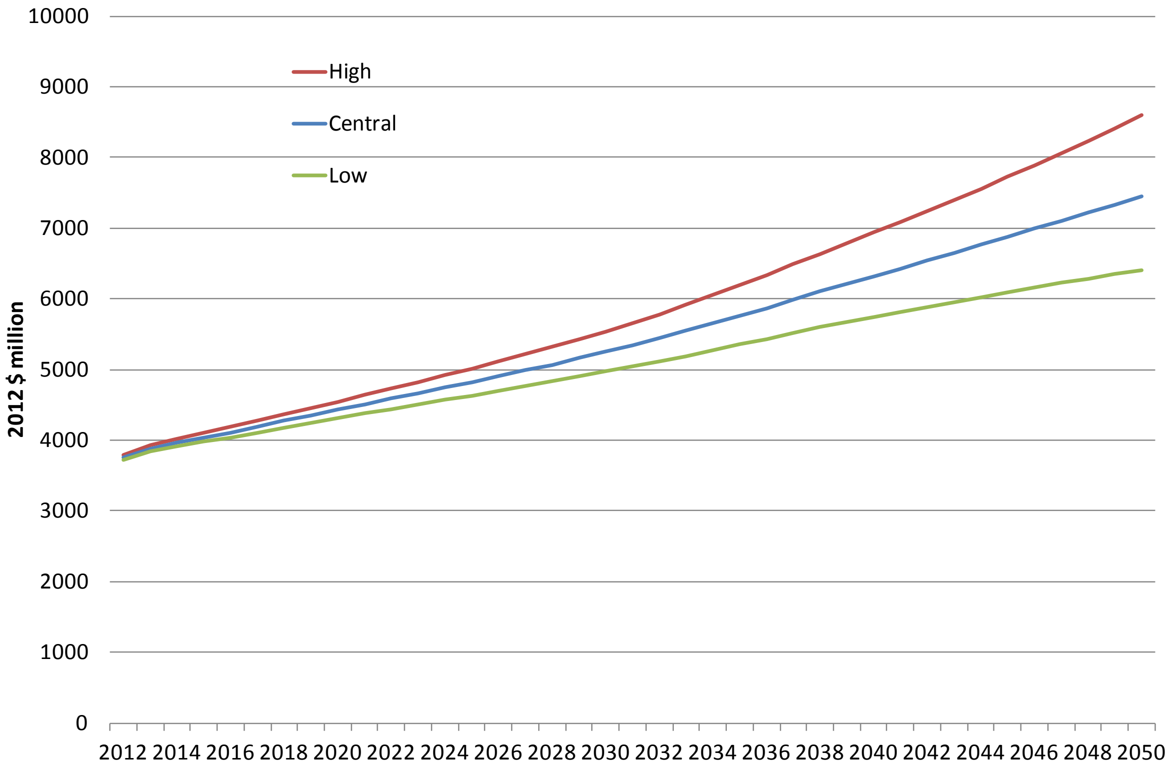

Figure 26: 2012 study projection of road vehicle registration revenue, real 2012 dollars