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Road transport sector modelling: Supplementary report on Clean Energy Future and Government Policy scenarios

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ACRONYMS AND ABBREVIATIONS

CO_2e	Carbon dioxide equivalent
CNG	Compressed Natural Gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTL	Coal-to-liquids
ESM	Energy Sector Model
EV	Electric vehicle
FCV	Fuel cell vehicle
GHG	Greenhouse gas
GJ	Gigajoule
GTL	Gas-to-liquids
HV	Heavy vehicle
ICE	Internal combustion engine
km	kilometres
LCV	Light commercial vehicle
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MJ	Megajoule
Mt	Megatonnes
PAS	Passenger vehicle
PHEV	Plug-in hybrid electric vehicle
PJ	Petajoule
t	tonne
TWh	Terawatt hour
VKT	Vehicle kilometres travelled

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1. INTRODUCTION

To support Treasury's role in supplying quantitative modelling in relation to the introduction of a carbon price, CSIRO was commissioned by the Commonwealth Department of Treasury to conduct economic modelling of the impact of alternative carbon price scenarios on the road transport sector in Australia out to 2050.

CSIRO previously provided a report called *Road Transport Sector Modelling* which outlined modelling results for the road transport sector in detail in support of the Commonwealth's report on the impact across the whole economy called *Strong Growth, Low Pollution: Modelling a Carbon Price (*Graham and Reedman, 2011;.Commonwealth of Australia, 2011)

This supplementary report provides details of road transport modelling results for two more scenarios: Clean Energy Future and Government Policy. The modelling primarily determines, given the model and scenario assumptions, the impact of alternative carbon price levels on the deployment of alternative road fuels and vehicles and the subsequent change in greenhouse gas emissions from the sector.

The road sector modelling is performed using CSIRO's Energy Sector model (ESM). The modelling outputs provided by ESM are as inputs to a broader suite of models whose interactions are coordinated by the Department of Treasury. The ESM model, its data assumptions and the process applied for linking with other models has been previously described in *Road Transport Sector Modelling*.

This report is structured as follows. Section 2 defines the scenario assumptions. The scenario results are discussed in Section 3.

2. SCENARIO DEFINITION

This report supplements the *Road Transport Sector Modelling* report (Graham and Reedman, 2011) in providing analysis of the response of the road transport sector to two additional scenarios.

In both additional scenarios a carbon pricing scheme is adopted and is assumed to commence on 1 July 2012 with a national emissions target of 5 percent below 2000 levels by 2020 and 80 percent below 2000 levels by 2050. The nominal starting carbon price in 2012-13 is $23 and grows by 2½ per cent per year real.

Other scenario assumptions such as oil and gas prices remain the same for both additional scenarios as they were in the Core Policy scenario. A set of retail electricity prices specific to each scenario was applied.

Clean Energy Future scenario
In this scenario the entire road transport sector is indefinitely excluded from the coverage of carbon pricing scheme.

Government Policy scenario
The carbon price coverage on transport is the same as for the Core policy scenario in *Strong Growth, Low Pollution: Modelling a Carbon Price* with exemptions for the heavy road transport sector only applying in the first two years. Thereafter heavy on-road vehicles face the full impact of the carbon price.

3. SCENARIO RESULTS

This section reports the modelling results for each scenario.

Both of the additional scenarios face retail electricity prices which are similar to those in the Core Policy from the *Strong Growth Low Pollution* report.

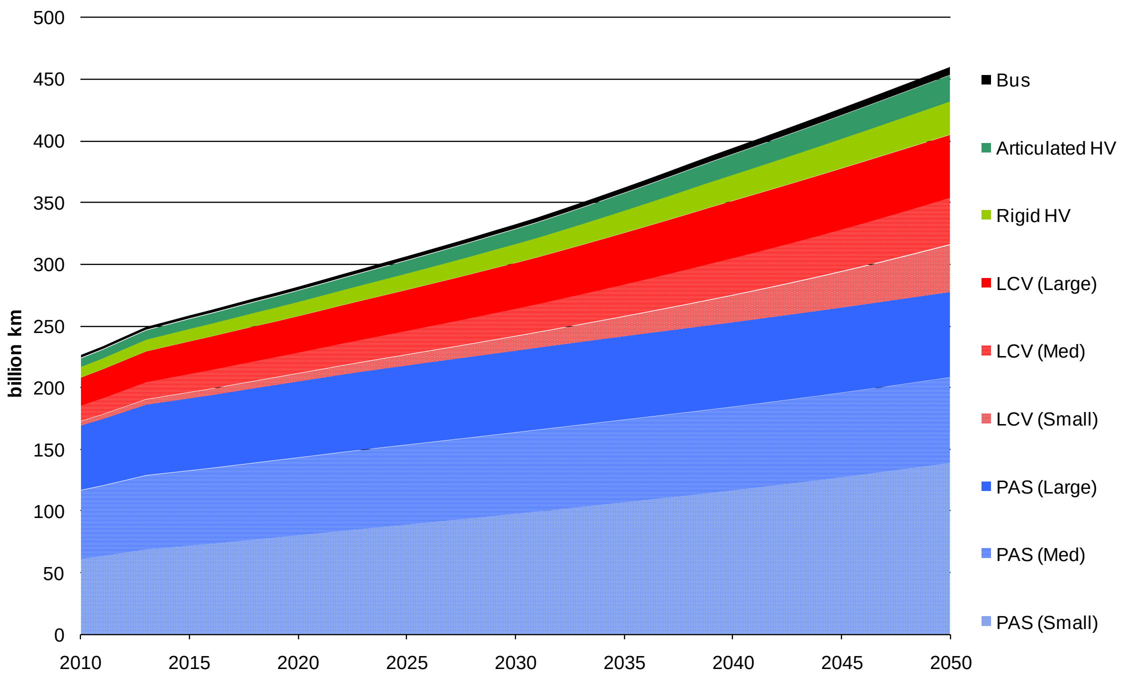
3.1 Clean Energy Future scenario

Under this scenario a carbon pricing scheme is adopted in Australia, however the transport sector is indefinitely shielded from its impact via fuel excise offsets and credits. This means there is no carbon price signal in the sector whilst other sectors it interacts with are responding to a carbon price.

The Clean Energy Future scenario is closest in design to the Medium Global Action scenario documented in Graham and Reedman (2011) which was a scenario where no carbon price was imposed on road transport or any other sector.

The assumed level of vehicle kilometre demand growth in this scenario is around 460 billion kilometres (Figure 3-1). This represents a reduction in total activity in 2050 of around 0.5 per cent from the Medium Global Action scenario and is marginally higher than in the Core Policy scenario.

It should be noted that the share of kilometres travelled by small passenger (PAS) and light



commercial vehicle (LCV) modes is increased over the projection period, based on the observation that vehicle purchase decisions tend toward smaller vehicles as oil prices rise. This assumption applies across all scenarios.

Figure 3-1: Transport demand by mode and road vehicle type, Clean Energy Future scenario

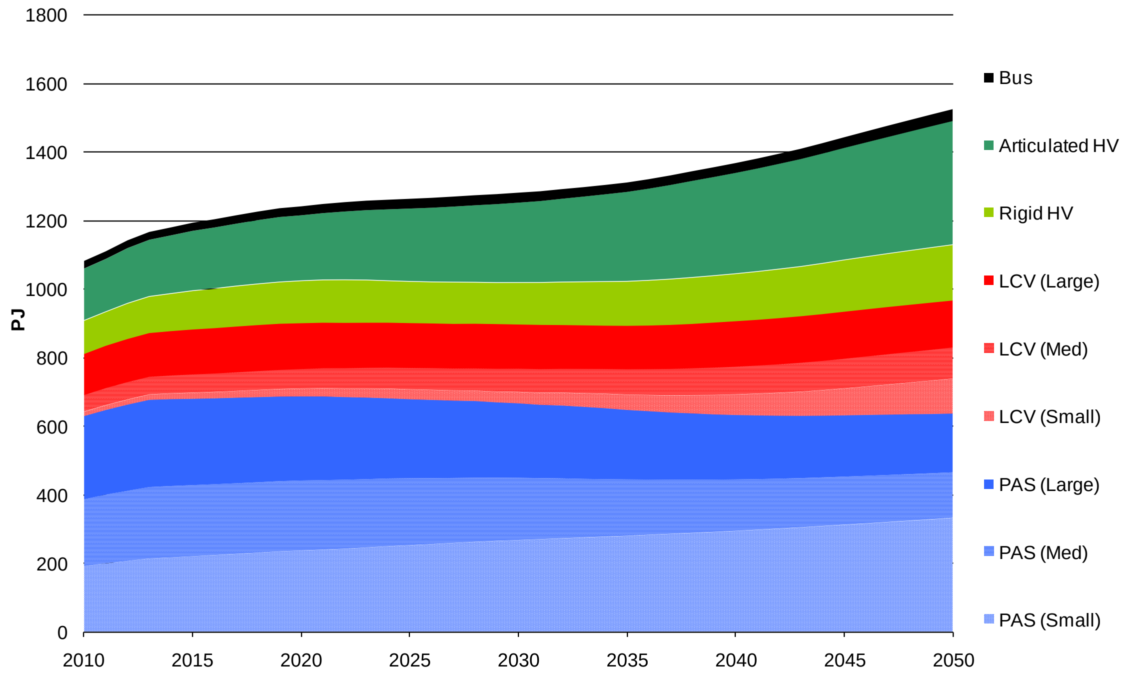


Figure 3-2: Road transport energy consumption by mode, Clean Energy Future scenario

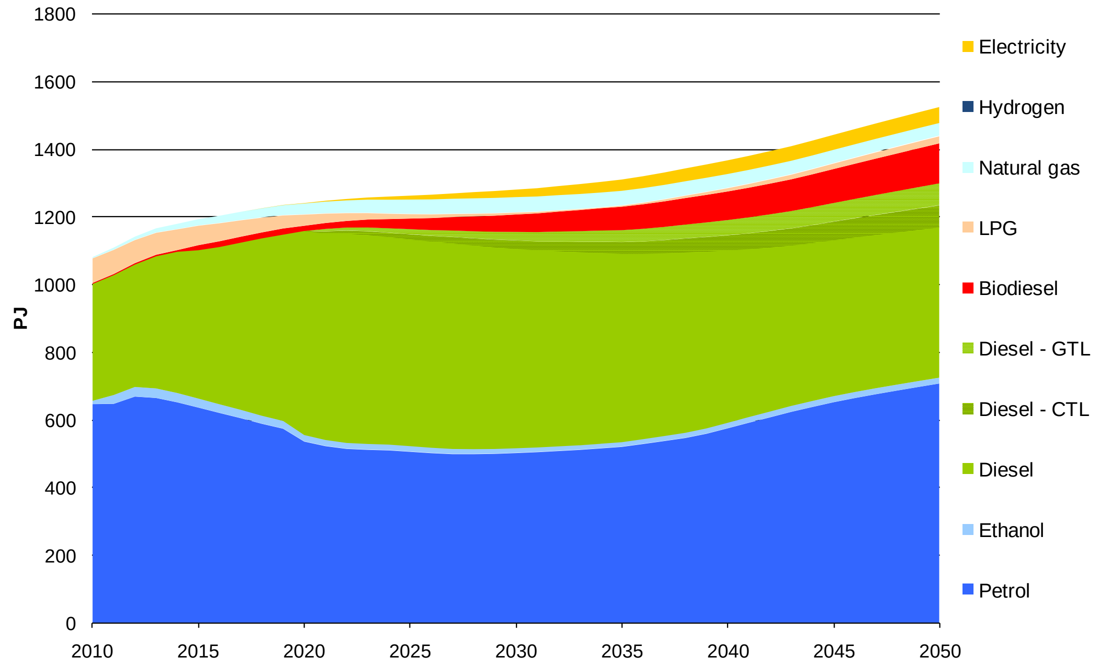
The Clean Energy Future scenario results in a 1.3 per cent reduction in fuel consumption relative to the Medium Global Action scenario in 2050. Total road transport fuel consumption in 2050 under Clean Energy Future is 1527 PJ (Figure 3-2).

Figure 3-3 shows the uptake of low emission fuels such as biofuels and electricity is fairly modest reflecting the complete shielding of the road sector from a carbon price. The absence of a carbon price signal means that there is no additional signal to road transport fuel users to switch to low carbon fuels other than the existing signals such as rising oil prices.

The uptake of biofuels, particularly biodiesels, is not driven by relative emission intensities of fuels. While the adoption of biofuels results in a reduction in the overall emission intensity of road transport this occurs in the medium global action scenario and is not a result of the imposition of a carbon price outside the road transport sector.

The Clean Energy Future scenario has strong uptake of hybrid vehicles and limited uptake of fully electric and plug-in electric vehicles. This is a direct result of the weak signals to switch from liquid fuels to electricity (Figure 3-4) which are not related to emission intensity, but rather are a response to rising conventional fuel prices and relative fuel efficiencies of technologies.

Figure 3-3: Road transport fuel consumption by fuel, Clean Energy Future scenario



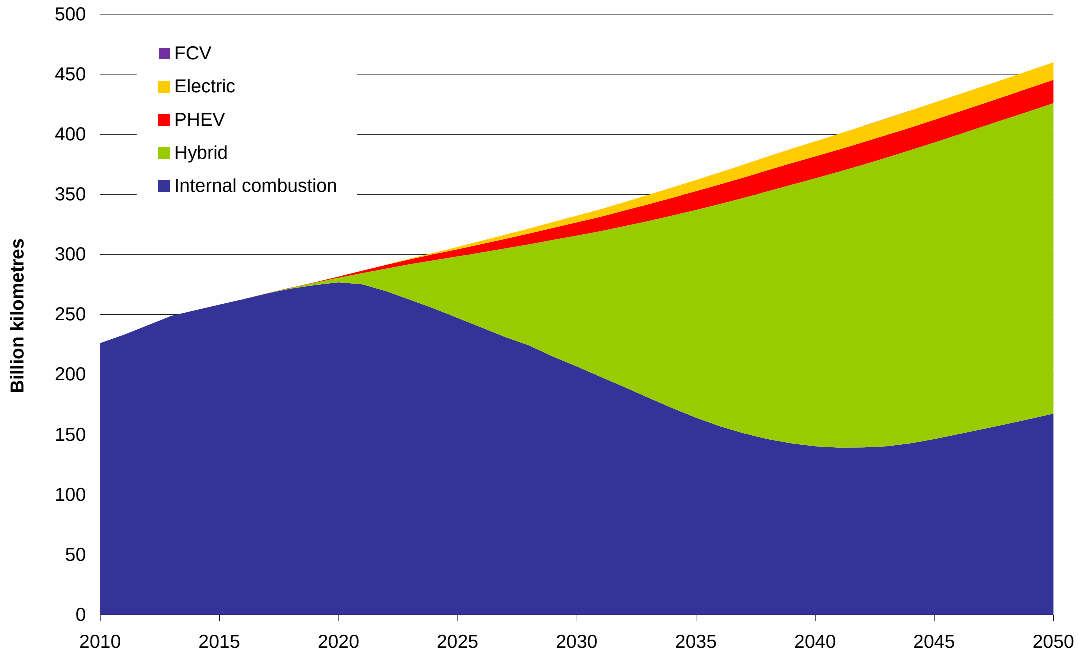


Figure 3-4: Engine type in road kilometres travelled, Clean Energy Future scenario

Figure 3-5 shows the greenhouse gas emissions for the Clean Energy Future scenario compared to the Medium Global Action scenario from *Road Transport Sector Modelling*. The emissions from road transport in theClean Energy Future scenario have a slightly lower trajectory when compared to Medium Global Action, reflecting slightly lower road transport demand.

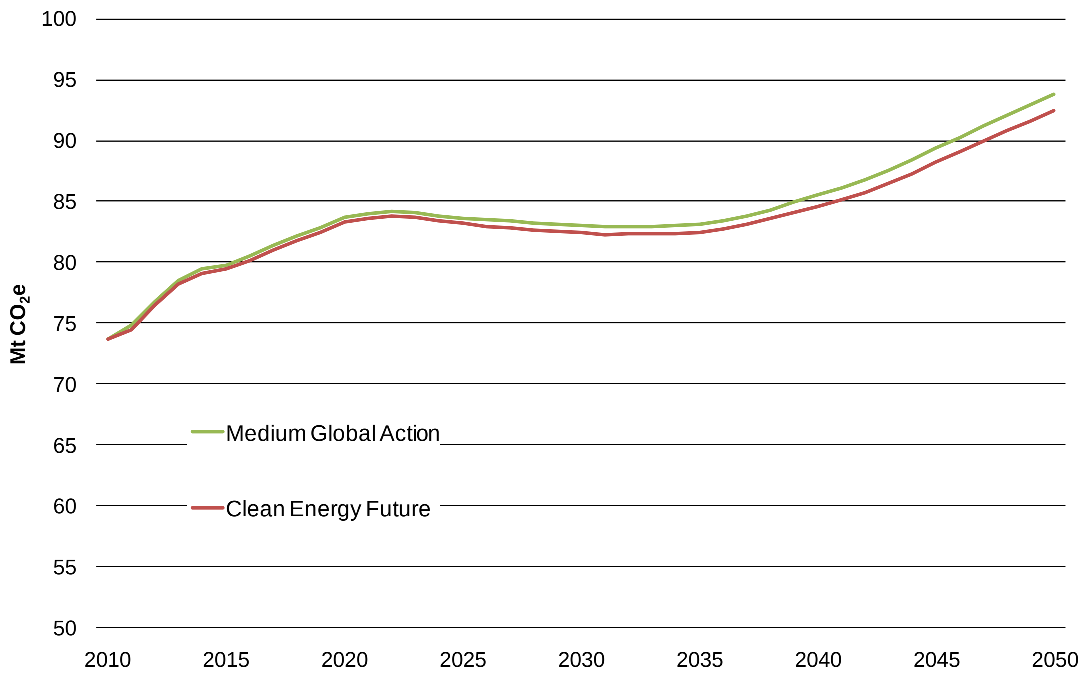


Figure 3-5: Road transport greenhouse gas emissions, Clean Energy Future scenario

3.2 Government Policy scenario

Under this scenario, a carbon price is imposed on the heavy road transport sector from 2014-15. The light commercial vehicle and passenger transport sectors are shielded from the effects of the carbon price indefinitely. Gaseous fuels and the combustion emissions from biofuels are also excluded from the carbon price.

Figure 3-6 shows the transport demand by mode and road vehicle type, expressed in vehicle kilometres travelled (VKT), grows to around 460 billion km by 2050. It should be noted that the share of kilometres travelled by small passenger (PAS) and light commercial vehicle (LCV) modes increases over the projection period, based on the observation that vehicle purchase decisions tend toward smaller vehicles as oil prices rise. This assumption applies across all scenarios.

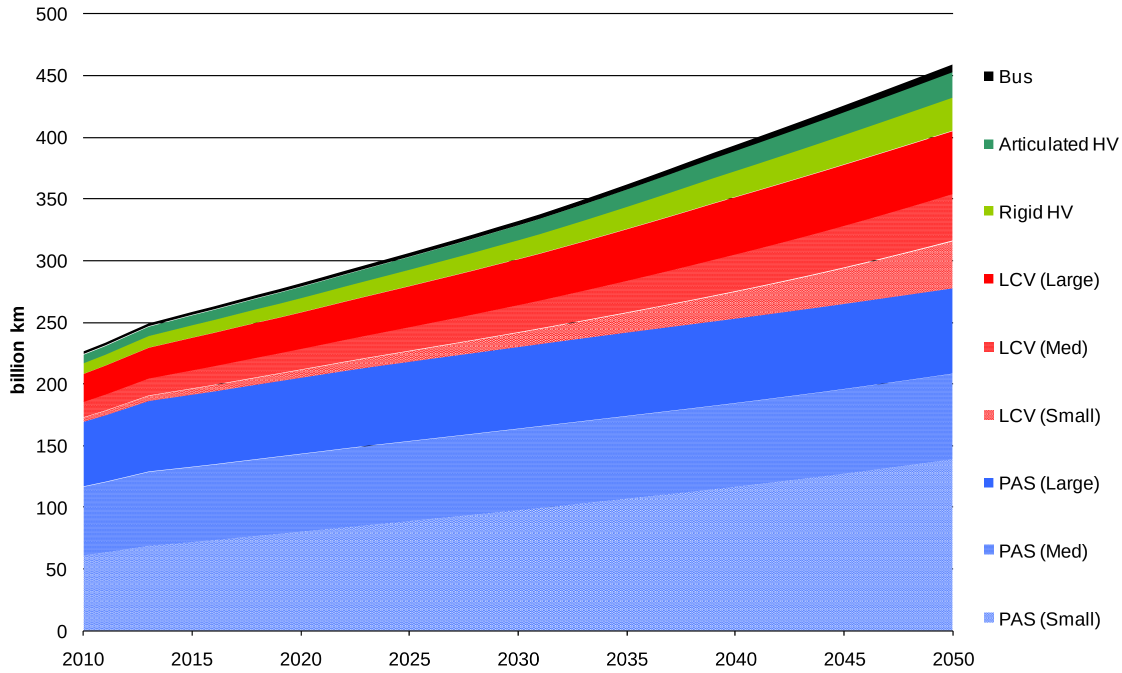


Figure 3-6: Transport demand by mode and road vehicle type, Government Policy scenario

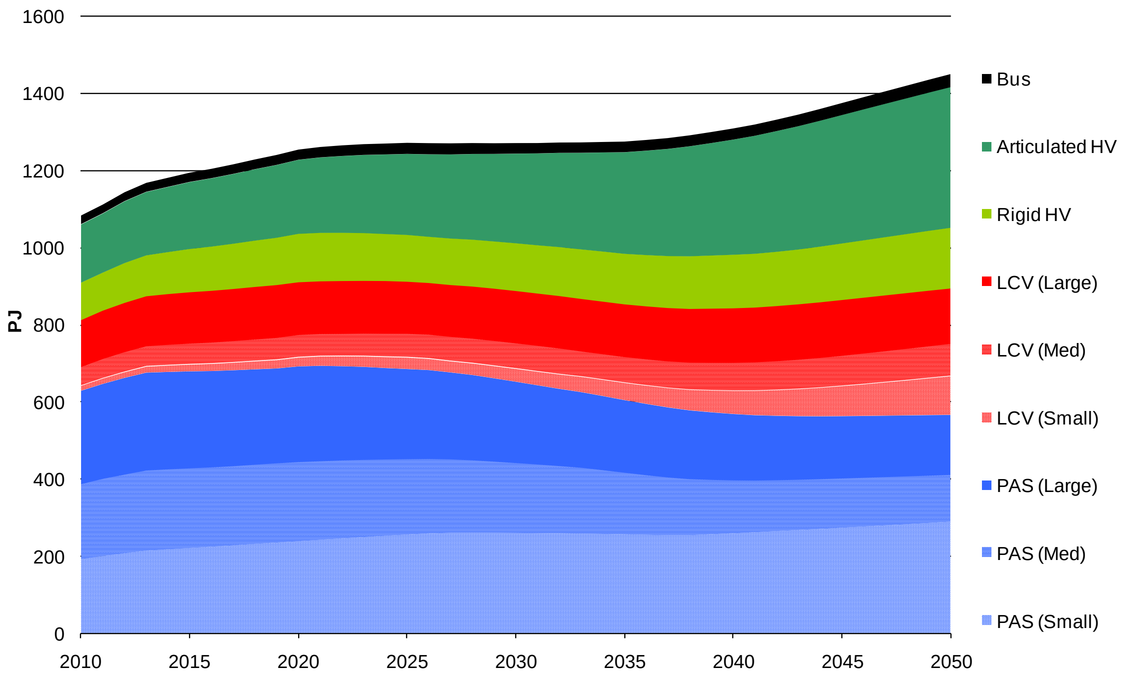


Figure 3-7: Road transport energy consumption by mode, Government Policy scenario

The fuel mix resulting from this scenario reflects the freight and passenger components of the transport sector both being exposed to different incentives and having available different opportunities. In response to the carbon price signal received, the freight sector is electrifying the limited portions of that sector that are suitable for short haul transport (e.g. rigid trucks in urban areas) whilst adopting biodiesel and liquefied natural gas (LNG) in other rigid trucks and articulated trucks. LNG provides a modest reduction in greenhouse gas emissions compared to diesel. However, it is mainly taken up as a cost saving measure, in response to high diesel prices with and without a carbon price.

The passenger and light commercial sector receive no carbon price signal but nevertheless do take up some low emission fuel and engine technologies. This is due to a spill over effect between the passenger and freight sectors which is an assumption of the modelling framework. That is, it is assumed that, if the freight sector stimulates demand for biofuel production or vehicle electrification, then more cost competitive biofuels are available and more hybrid and electric vehicles are supplied to the whole road transport sector by international vehicle suppliers.

The basis for this assumption is the observation that biofuel refineries are likely to produce multiple products and it is a feature of the refinery industry that core profits are made on one product line while supplying many others. Economies of scale in refining might also dictate that refineries target not just the freight transport sector. In the electric vehicle market, vehicle sales support dictates that some domestic parts manufacturing and servicing as well as other infrastructure (e.g. refuelling) will be developed locally. This common infrastructure will similarly support penetration of vehicle electrification beyond the freight sector making it more attractive to support this vehicle type in Australia.

With oil prices increasing throughout the projection period, the increased supply of low emission alternative fuels (and their infrastructure) is taken up by consumers.

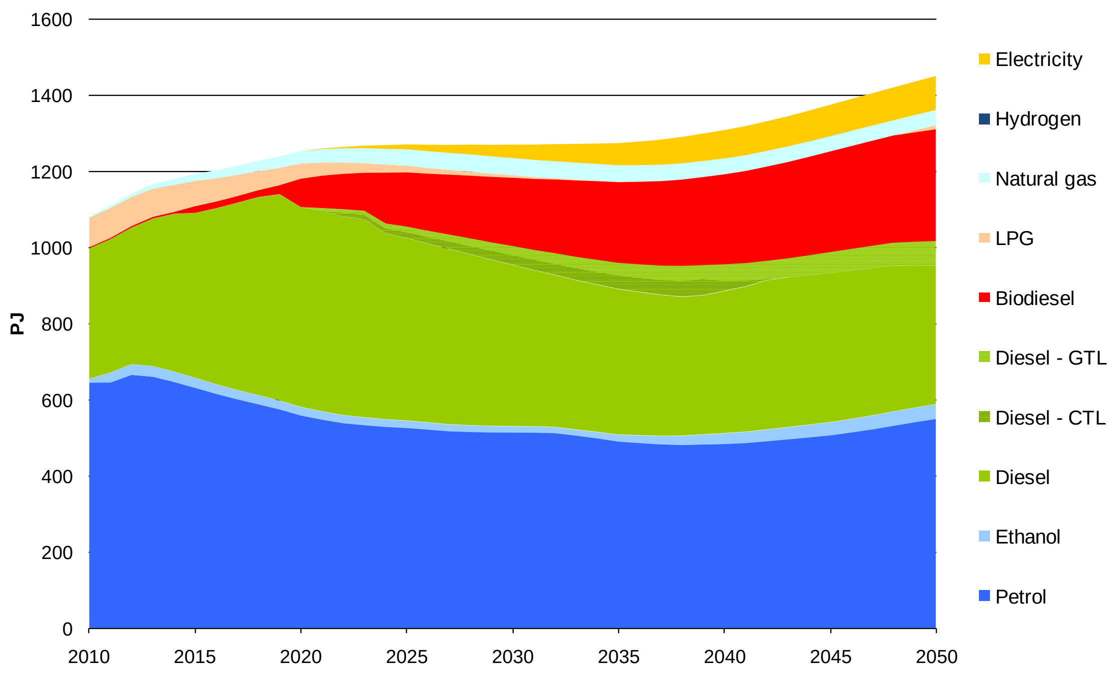


Figure 3-8: Road transport fuel consumption by fuel, Government Policy scenario

Figure 3-9 provides more detail about the adoption of alternative engine types under the Government Policy scenario. It shows that hybrid, electric and plug-in electric vehicles generally become a cost effective form of transport by 2020. Fast adopters will take up the vehicles prior to this date and indeed models of these vehicles are already available and part of the fleet. However, the modelling projects the time at which they will be economically attractive to all vehicle purchasers.

By 2050 hybrid drivetrains dominate the vehicle mix providing around 50 percent of vehicle kilometres. The contribution of fully electric and plug-in hybrid electric vehicles is around 10 per cent. The dominance of internal combustion only engines in the engine fleet is projected to end at around 2030. However, other engine configurations will dominate new vehicle sales in the 2020s.

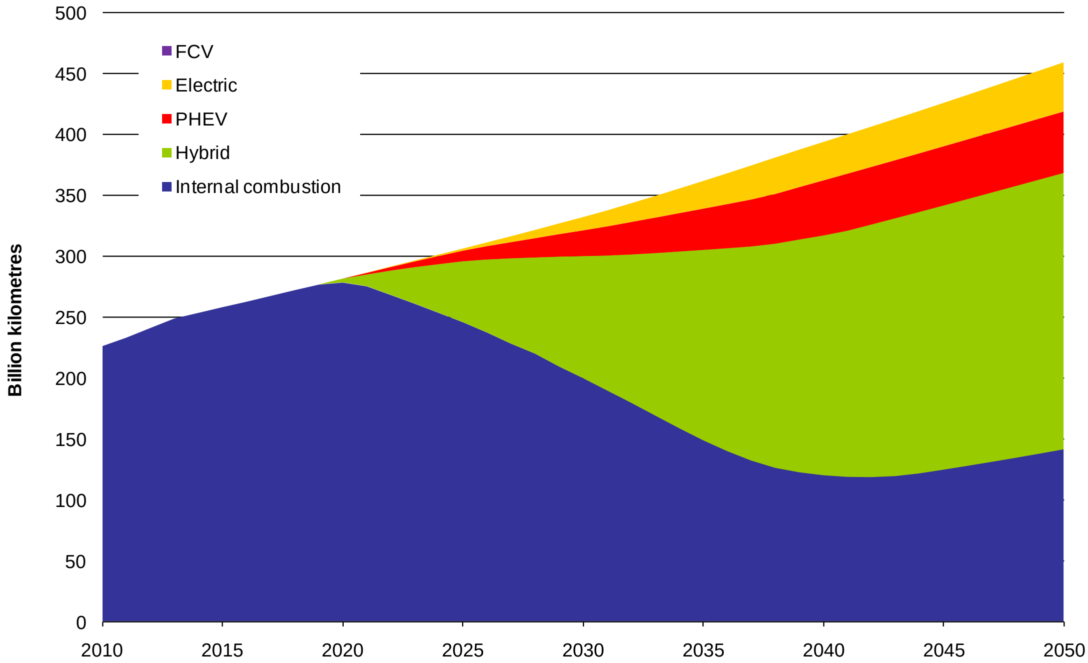


Figure 3-9: Engine type in road kilometres travelled, Government Policy scenario

Figure 3-10 shows the difference between greenhouse gas emissions from road transport in the Government Policy and the Core Policy scenario from Graham and Reedman (2011). It shows that there is minimal difference in road transport GHG emissions between the Government Policy and Core Policy scenarios throughout the projection period. The carbon price paths are simply too similar to observe any major differences. The maximum difference in the carbon price trajectory is a real value of $2/tCO2e (2010 dollars) in 2014-15 after which the carbon price paths are nearly identical. This amounts to an additional half a cent per litre price signal to petrol and diesel users in the Government Policy scenario for a single year.

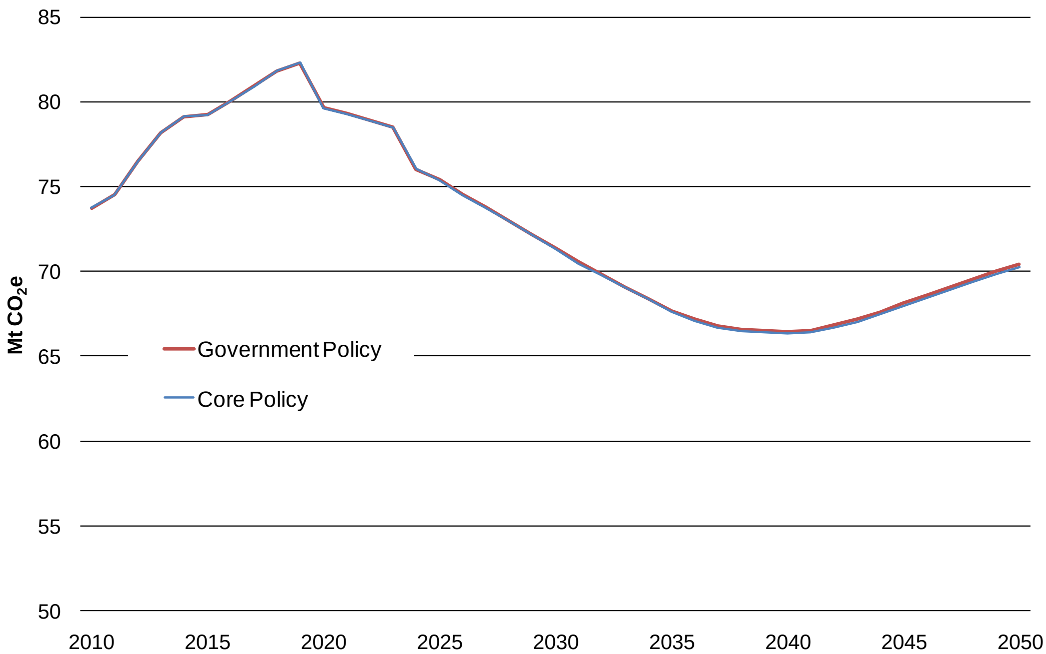


Figure 3-10: Comparison of Government Policy and Core Policy road transport greenhouse gas emissions

3.3 Summary and comparison of results

Figure 3-11 shows the modelling results for road transport greenhouse gas (GHG) emissions by scenario. The model projects that the Government policy scenario will lead to a long term decline in road sector greenhouse gas emissions commencing from around 2018 when the supply of low emission biofuels and cost competitive electric vehicles become more widely available. By 2050, road transport sector emissions are around 70 MtCO_2e, lower than their 2010 level despite an assumed doubling of road transport sector kilometres travelled.
Road sector greenhouse gas emissions in the Clean Energy Future scenario increase over time to around 92 MtCO_2e by 2050.

The higher oil prices assumed in all scenarios ensures that there are incentives for greenhouse gas abatement by ensuring that low emission alternative fuels are closer to their competitive range compared to existing fuels.

However, as shown in Figure 3-11, the lack of any carbon price signal in the Clean Energy Future policy means that road transport sector emission are 31 percent higher compared to the Government Policy scenario.

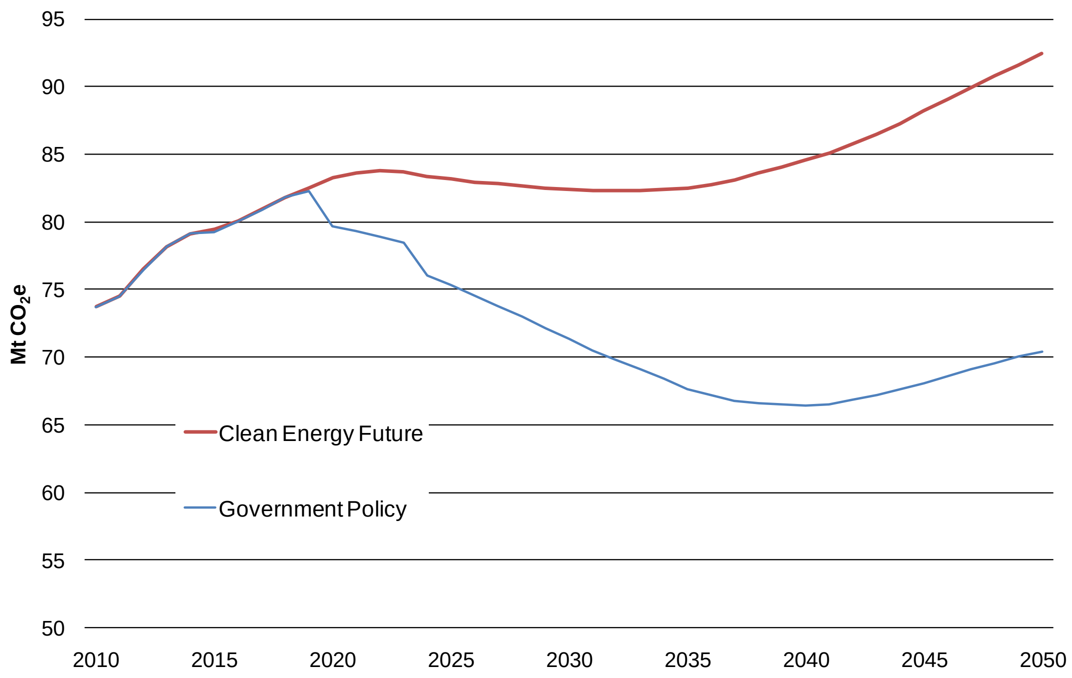


Figure 3-11: Road transport greenhouse gas emissions by scenario

In regard to the uptake of alternative fuels, Figure 3-12 shows biofuels (ethanol and biodiesel) and electricity grow more strongly under the Government Policy scenario reflecting the effect of the carbon price signal.

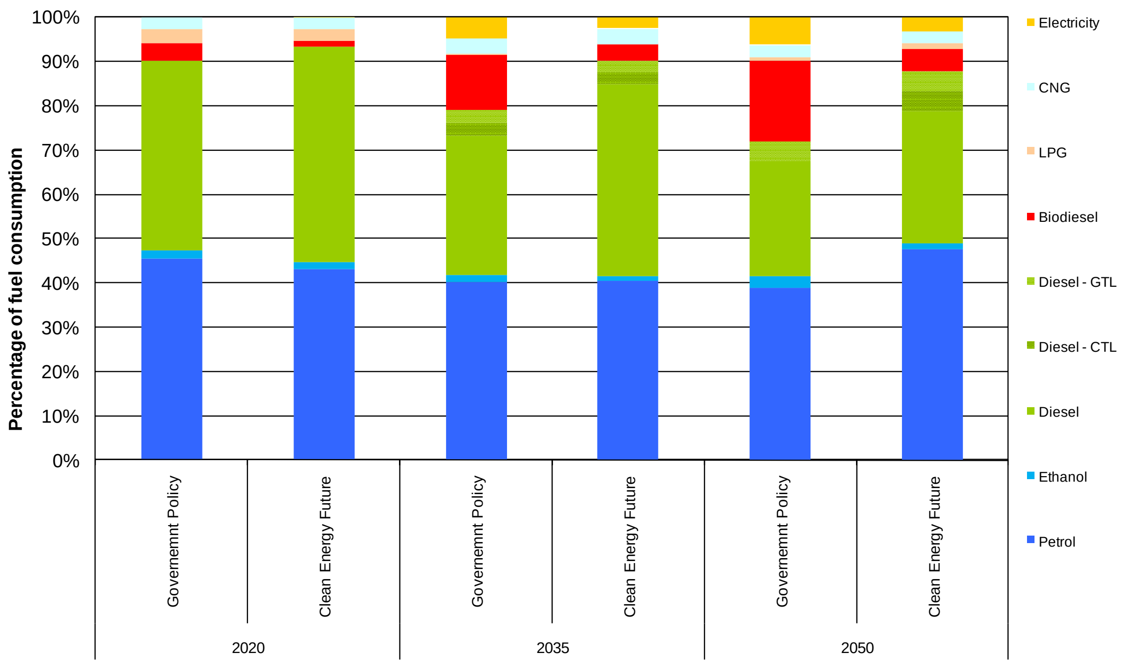


Figure 3-12: Road transport fuel consumption by scenario

Figure 3-13 shows that uptake of alternative engine configurations to the conventional internal combustion engine commences by 2020. By 2035, hybrid, electric and plug-in electric vehicles become the dominant vehicle types in terms of road kilometres travelled. This trend strengthens further by 2050. The level of uptake of low emission electricity as a transport fuel is strongest under the Government Policy scenario reflecting the influence of the carbon price.

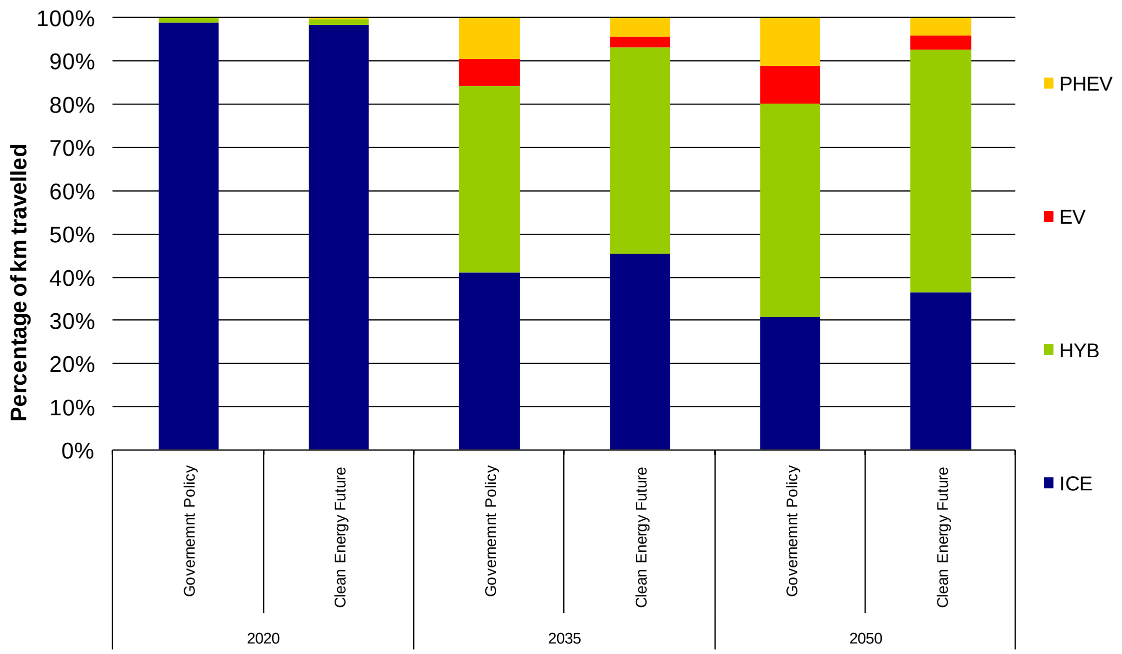


Figure 3-13: Road transport vehicle mix by scenario

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