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Access Economics

Economic analysis of potential end-states for the heavy vehicle road reform

Department of Infrastructure and Regional Development

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Glossary

Acronym	Full name
ABS	Australian Bureau of Statistics
ATAP	Australian Transport Assessment and Planning
ATC	Australian Transport Council
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CBA	Cost Benefit Analysis
COAG	Council of Australian Governments
CRRP	COAG Road Reform Plan
CSO	Community Service Obligation
DAE	Deloitte Access Economics
HML	Higher Mass Limit
HVCI	Heavy Vehicle Charging and Investment Reform
HVRR	Heavy Vehicle Road Reform
IRI	International Roughness Index
ITLS	Institute of Transport and Logistics Studies
LCV	Light Commercial Vehicle
LOS	Level of Service
MDL	Mass Distance Location
NHVR	National Heavy Vehicle Regulator
NKT	Net kilometres travelled
NPV	Net present value
PV	Present value
NRM	NAASRA Roughness Meter Counts
NTC	National Transport Commission
NTK	Net tonne kilometres
PBS	Performance-Based Standards
PC	Productivity Commission
PCU	Passenger Car Unit
PLCC	Pavement Life-cycle Costs
RIP	Roads Implementation Program
RIS	Regulator Impact Statement
RMS	Roads and Maritime services
RUC	Road User charges
SVMU	Survey of Motor Vehicle Use
VOC	Vehicle Operating Costs
WIM	Weigh-in-motion

Executive summary

Introduction

Reform to heavy vehicle road charging and investment has been a focus for Australian Governments for at least the past twenty years and a particular focus of the COAG's reform agenda since 2007. The reform seeks to enhance productivity by linking prices paid by users to maintenance and access incentives for road providers.

In 2013, Deloitte Access Economics (DAE) was engaged to undertake a cost benefit analysis of three potential end-states of the heavy vehicle road reform during the Heavy Vehicle Road Charging and investment Reform (HVCI) process.

The HVCI reform process was refreshed as Heavy Vehicle Road Reform (HVRR) in 2015 in response to the Harper Competition Review. HVRR is a joint reform process of the Commonwealth, state, territory and local governments aimed at establishing an economic market for the provision and use of heavy vehicle infrastructure services – one that provides clear links between the needs of users, the charges they pay and the services they receive. The COAG Transport and Infrastructure Council (TIC) has since endorsed a reform road map outlining a pragmatic, phased approach to implementing reform. The reforms is comprised of two components:

- the first component is road charging, where heavy vehicles would pay directly for their use of road networks. The full extent of the reforms would involve the use of vehicle mass, distance travelled and road type in determining the precise charge to influence the level of road use demand.
- the second component is investment which is primarily related to the approach used to allocate these charges back to road providers.

The purpose of this report is to provide an update to the cost benefit analysis that was produced in 2013 to analyse the potential end-states of the HVRR. Results from this report should be read alongside other analysis that explores the design and practical feasibility of the HVRR reform elements.

Five potential end-states of the HVRR reform (the 'reform options') are appraised in this report, comprising of the three reform options considered in the 2013 report (Option 1, 2 and 3) and two additional reform options (Options 1A and 2A):

- **Option 1** retains a national fuel-based charging system with greater emphasis on the road user charges (RUC) as a charging mechanism. Incremental pricing would be available for vehicles travelling above prescribed mass limits.
- **Option 2** introduces a state-based distance charge (a distance charge that is differentiated by vehicle class and road type and is different across jurisdictions). It allows for flexible implementation options, including low technology approaches to charging and revenue collection.
- **Option 3** involves a state-based full static mass distance location based charge and represents an efficient charging framework to deliver planning and expenditure outcomes.
- **Option 1A** retains a national fuel-based charging system with greater emphasis on an excise-based road user charges (RUC) as a charging mechanism. Incremental pricing would be available for vehicles travelling above prescribed mass limits. Road charges will be subject to a price regulatory framework. Option 1A can be seen as a variation of Option 1.
- **Option 2A** introduces a national-based distance charge (a distance charge that is differentiated by vehicle class and is consistent across jurisdictions), with mass distance based charge for heavy vehicles. It allows for flexible implementation options, including low technology approaches to charging and revenue collection. Nation-wide road related revenue and a proportion of fuel excise revenue will be hypothecated to a general road fund to improve road quality. The national-based distance charge will be subject to economic regulation. Option 2A can be seen as a variation of Option 2 and would place Australia in a similar position to New Zealand in terms of heavy vehicle charging.

Figure i Overview of the five reform options

Option 1	Option 2	Option 3	Option 1a	Option 2a
National based charges with rebalanced RUC and registration charges 	**State based distance RUC** 	**State based distance charge, varies by road class and vehicle type** 	**National based charges with minimal supply side reform** 	**Full-market supply side reform with national mass distance based RUC for HV (NZ Plus)** 
Fuel based charges RUC as revenue collection mechanism Incorporating the use of forecast cost and demand data	Distance based charges Vehicle type dependent & to some extent mass based (not like Option 3) Allows for differentiated pricing based on vehicle type Equal state-wide charges regardless of LoS	Mass-distance based charges Gradually change from static mass based to dynamic mass-distance based charges	Fuel based charges Excise based RUC Forward looking - cost based pricing	Vehicle type dependent national charges National mass distance based charges for HV (partial market model similar to NZ)
Partial hypothecation of revenues collected (as per baseline) Limited access improvement Forward looking pricing & independent economic regulation	Partial hypothecation at state level Extended access improvement Forward looking pricing & independent economic regulation	Partial hypothecation at state level Significant access improvement Forward looking pricing & independent economic regulation	Phased supply-side reform Partial hypothecation with possibility of revenue redirection to local governments Extended access improvement Forward looking pricing & independent price regulation	Full hypothecation of revenues (including light vehicle revenue) Earmarked to state based independent road funds Extended access improvement Forward looking pricing & independent economic regulation
Light vehicles exempted	Light vehicles exempted	Light vehicles exempted	Light vehicles exempted	Light vehicles exempted
National based charges, averaged between states Split between RUC and Rego shift towards RUC State based registration fee	Independent State based charges Significantly reduced registration fee	State based charges conditioned on LoS Significantly reduced registration fee	National based charges, averaged between states Additional charges for incremental access Unchanged registration fee (state based)	National based charges, weighted average between states Nationally agreed LoS Significantly reduced registration fee
PPP as in baseline	Strong financial incentive to provide better access	Strong financial incentive to provide better access	PPP as in baseline	Strong financial incentive to provide better access
Require new payment system	Require new vehicle based payment system and telematics	Require new vehicle based payment system and telematics	Technology for additional opt-in access	Require new payment system Mandatory vehicle telematics with paper based system as back up
Improved transparency in data collected for decision-making	Data owned by operator	Road user data for charging purposes only	Improved transparency in data collected for decision-making	Improved transparency in data collected for decision-making

All five reform options involve demand-side (through charging) and supply-side reforms (through influence on road service provision investment decision-making), though at different levels and involve different combinations of mechanisms, to achieve some degree of improved outcomes. Importantly, each option involves a form of independent regulatory regime by setting a forward-looking cost base to support more cost-reflective and transparent pricing and introduces expenditure accountability. In particular, except for Option 1A, all other options involve a more 'heavy-handed' form of economic regulation of heavy vehicles, which includes revenue cap, incentive regulation and efficiency benchmarking to encourage road providers make prudent long-term investment decisions. A forward-looking approach to setting prices that are reflective of long run efficient costs of road service provision is important for achieving the recovery of efficient costs over the economic life of the road service, avoid distorted price signals and achieve prudent and timely investment decision-making.

However, it is worth noting that jurisdictions will be allowed to determine how far along the supply-side reform spectrum they wish to go. This recognises that there is a level of upfront investment and institutional and technical changes (for example; in terms of better data collection and monitoring system) required to implement the reform and that this investment decision will have to be made at the jurisdictional level.

Until the required supply-side changes are made at the jurisdictional level to address issues with current PAYGO heavy vehicle charges methodology, as identified by NTC (2016), the benefits of the reform and the ability of independent price and economic regulation to set heavy vehicle charges that are reflective of long run efficient costs of road service provision will not fully realise.

Independent price regulation can improve transparency in price-setting, minimise the potential for significant price fluctuations, and create stronger incentives for prudent investment decisions. Implementation of independent price regulation requires improvements to current baseline data and enforcement of better evidence base to support investment decision-making. It is easier to implement than economic regulation and can be considered as a lighter form of regulation. For example; there are common elements required in setting up price regulation and economic regulation (also addressed by the Transport and Infrastructure Council (2017)), this include:

- establishment of asset registers that collect information on heavy vehicle road network, including: access condition, functions, location, length, economic life and maintenance cost;
- establishment of nationally consistent asset maintenance and investment reporting standards;
- establishment of principles for preparing road expenditure investment and maintenance plans that covers consideration of expected demand and level of service;
- establishment of the technical systems and protocols required for collecting baseline information and record-keeping investment and maintenance expenditure plans; and
- development of pricing principles that outline the methodology that will be followed by the regulator in conducting price determinations.

Economic regulation is the key source of supply-side efficiencies. However, implementation of a successful economic regulation framework for heavy vehicles is harder to achieve due to the complexity of the task and the higher-level of risks to implementation. Setting up economic regulation of heavy vehicle charges and investment requires fundamental structural and behavioural changes to existing jurisdictional practices to ensure charges are efficiently set and appropriate to incentivises forward-looking prudent, efficient and timely road network investments. A range of factors will need to be considered in making forward-looking investment decisions when there are competing investment priorities. This includes consideration of the following at a national level: the different priority classes of roads important to heavy vehicle freight task, current and projected key transport nodes, current and projected major freight routes, urban planning and land use, and projected level of demand and service conditions.

A phased approach to the implementation of regulatory oversight is being considered. This would involve improving the baseline to step into independent price regulation before considering the feasibility of transitioning into independent economic regulation.

Methodology

Fundamentally, the CBA aims to determine how a change in charging for and investment in roads will affect the behaviour of road users and road suppliers. The steps involved in building the CBA were:

- identify the likely costs and benefits of reform;
- develop a methodology for quantifying the costs and benefits of the reform options relative to the baseline;
- establish the baseline; and
- differentiate the reform options.

Identify costs and benefits of reform

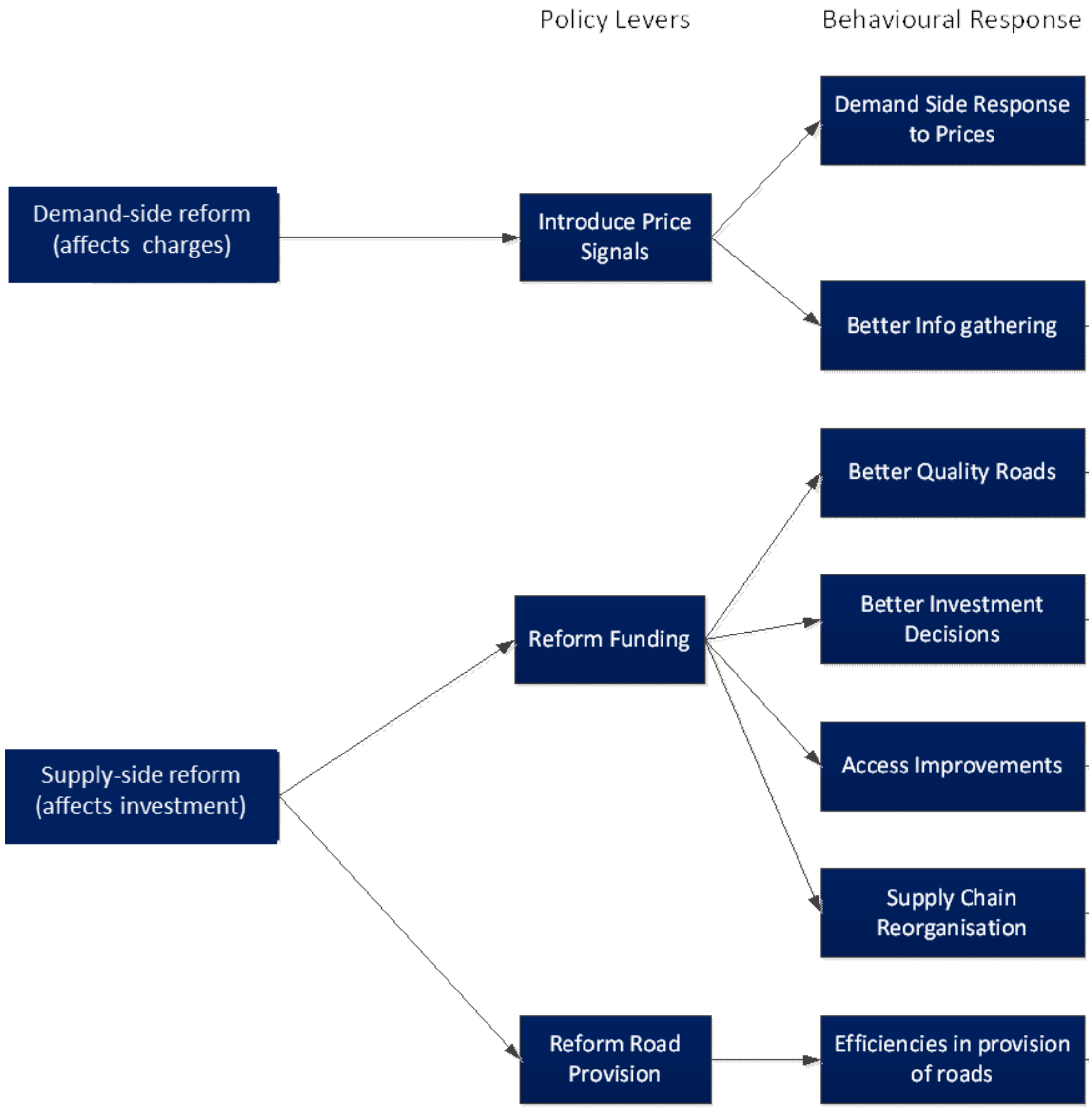
The potential effects of the reform were divided between those flowing from (i) the charging aspects of the reforms; and (ii) the investment aspects of the reforms. From there, the intermediate behavioural effects that are likely to ensue were determined and the magnitude of the final effects estimated. Of the two aspects of the reforms, the consultations indicated that supply-side impacts resulting from funding reforms could be expected to have the largest impact on freight productivity.

The costs and benefits of the reform are summarised in the diagram below. While the diagram presents a simplified, linear picture of the proposed reforms there is actually a complex relationship between access, road quality, road wear and maintenance expenditure:

- allowing access can increase road wear costs and lead to a need for additional maintenance expenditure; and
- given current maintenance budgets and road quality there may be a hesitancy to allow access due to risks of increased road wear.

This complex relationship is the cause of 'asset protection' mentalities towards restricting access. The methodology below incorporates calculations covering the first point but the second point is not directly addressed. Instead, it is assumed that the HVRR reforms will bridge the gap between road use, road maintenance and funding. That is, under the reform, the second concern will be eliminated as the potential additional road wear from allowing access will be compensated with access charges paid by heavy vehicles.

Figure ii Conceptual framework for estimating benefits



Methodology for quantifying the costs and benefits of the reform
The quantification and paramaterisation of the above costs and benefits was achieved by both drawing on previous research as well as undertaking original data analysis. The key components of costs and benefits that were quantified are summarised in Table i with further detail also provided below.

Charging ➔ price signals ➔ demand-side response

Although there have been significant improvements in recent years, the current heavy vehicle pricing system does not align costs paid by road users with the costs they generate for the road network (or society more broadly).

From an economic perspective, this results in an inefficient mix of heavy vehicles being used. That is, the current freight task is not being completed at minimal social cost when social costs take into account road wear and vehicle operating costs.

By more closely aligning prices with these social costs we will see a **more efficient mix of vehicles** being used. In this sense more efficient vehicles do not necessarily mean larger vehicles but **vehicles which are better matched to the particular task they are carrying out**. For high-quality interstate highways this could indeed result in larger vehicles being used. For lower-quality local roads this could see a reduction in vehicle size.

An additional benefit of rebalancing access charges more heavily towards RUC and MDL based charges is that it will likely reduce the level of registration charges. Some vehicle owners currently access debt financing to pay for vehicle registration fees and so this has the indirect benefit of potentially reducing any debt funding costs associated with vehicle registrations.

Charging ➔ price signals ➔ better information gathering

At the moment there is a great deal of dispersed data gathered on freight including Weigh-in-motion (WIM) and Culway data, vehicle surveys and detailed information on the engineering aspects of road wear and strength. This information is useful for the technical task of constructing roads and helps with monitoring road usage but it is not well suited to providing information to inform decision-making about investments.

Information for investment decision-making needs to understand both the current and potential demand as well as what the least cost response to this demand is. MDL data has the potential to provide up-to-date information on the current level of demand for particular routes as well providing enough detail to assess the lowest cost investment. For example, by analysing the origin and destination locations of freight, a set of investments could be identified which could complete an open access freight network for high productivity vehicles.

Investment → reform funding → better quality roads

In this context better quality roads are improvements in roads which reduce road user costs. This is a combination of both vehicle operating costs and driver preferences (such as a preference for ride smoothness). At the moment, although there is a genuine attempt to provide quality roads in each jurisdiction, there is no feedback loop for potentially translating road quality preferences to level of road use.

The negative effects of a lack of a feedback loop on road quality are compounded by the fact that the amount of expenditure on road maintenance and refurbishment is currently based on uncertain future funding levels, meaning road authorities are not able to make optimal lifecycle decisions as they would in a more certain funding environment.

More closely aligning funding to the use of roads will encourage provision of a level of road quality which takes close account of the demands of road users as well as the whole of life costs of maintenance. That is, the reforms could encourage an economically efficient level of road maintenance.

Investment → reform funding → better investment decisions

The pricing reforms will allow for better information to be gathered which will allow road providers to make better decisions about what to invest in. In addition to this, the funding reforms will introduce an economic regulator with power to approve or reject investment, capital and maintenance expenditure programs. This will introduce a level of discipline in road investment which has not been widely present before.

As in other regulated industries, the remit of the economic regulator would allow it to approve investments which meet a cost benefit test (as well as necessary investments for issues such as safety and CSOs). The economic regulator will therefore act as a check to ensure that investments in road infrastructure are beneficial from an economic perspective. This will mean that heavy vehicle road users are not paying for unproductive and uneconomic investments.

Investment → reform funding → Access improvements

At the moment there are significant last-kilometre problems in Australia (although these vary from state to state and from region to region) as well as mass and vehicle restrictions on some major highways.

Although community concerns about the presence of large vehicles on particular roads can play a role in reducing access, consultations indicate that the main cause of access restrictions is that road providers (particularly local governments) have no guarantee of receiving any benefits from allowing access for larger vehicles but are certain of bearing the costs from having to maintain their roads. This leads to an asset protection rather than asset utilisation mentality when considering whether to allow access for heavy vehicles.

The asset protection mentality is a consequence of road funding not being tied to road use. The proposed funding reforms will help ensure that the incentives of road providers are better matched to the needs of the freight sector by aligning funding flows to the provision of access. Once this funding gap has been bridged, it is likely that road providers will move from a defensive position where they try to protect their assets towards an open access regime where they encourage use of their asset in order to generate funds for further road provision and maintenance.

Ultimately, more open access will result in vehicle operators being able to choose a mix of vehicles and routes which minimises freight costs.

Investment → reform funding → supply chain reorganisation

Changes in the pattern of access will allow for long-term reorganisation of supply chains to take full advantage of the benefits offered by higher productivity vehicles. For example, if access for B-triples or A-Doubles is achieved on an Australia-wide network we could see the development of large scale, specialised distribution centres on the edges of this network. At these distribution centres, larger vehicles could be broken down into smaller vehicles which could be used for distribution within enhanced B-double networks.

This change would create benefits discussed above in terms of reduced vehicle operating costs flowing from access improvements but would also create further supply chain benefits. This is because newer, larger logistics facilities have the potential to operate at lower costs than existing facilities. This cost saving will then flow through the supply chain as logistics acts as an input into most businesses.

Investment → reform road provision → Efficiencies in the provision of roads

The final benefit identified from the reforms is the potential for efficiency in the provision of roads. The proposed reforms will allow greater flexibility in the supply of road infrastructure through a better governance structure to regulate prices and improve investment decision-making. Under the reforms, a forward looking cost base will be established to ensure prices are cost reflective and incentivise timely investment.

Revenue certainty enabled through setting efficient prices will allow greater flexibility in approaches for the supply of roads to allow more efficient practices to emerge over time and could result in cost savings.

This is a similar outcome to that anticipated in other areas of microeconomic reform (such as telecommunications, water and to some extent, electricity). In these industries, one of the main perceived benefits of microeconomic reform has been an increased focus on minimising costs of providing services.

Costs of investment reform

A significant cost of the investment reforms relate to any capital expenditure which may have to be made to enable access. While details on the type of investments that would be made are unknown, an estimate of increased expenditure is included.

This estimate was developed by taking the estimated capital expenditure in the CRRP feasibility study (2011) of $50m a year as the initial annual capital expenditure under Option 1. Expenditure was then increased at average annual rates seen historically (1.7%) and scaled for the relative difference in access improvements under each option.

The total investment is then split for each state based on their historical share of total road expenditure with an adjustment for the extent of change in vehicle use patterns that have been modelled.

Establish the baseline

The CBA requires a realistic base case to be articulated which would describe the heavy vehicle industry and broader economy if no regulatory reform was undertaken. Key aspects of the baseline include:

- the size of the freight task in terms of net tonne kilometres (NTK);
- the split of the freight task (by vehicle type);
- the size of the heavy vehicle fleet (by vehicle type);
- road maintenance expenditure;
- road quality;
- vehicle operating costs (VOC); and
- externalities.

A central part of estimating a reasonable baseline is to recognise that key aspects of the heavy vehicle industry and the road network are not fixed in time and will vary over the 20-year timeframe of the analysis. Accordingly, the baseline must not only estimate these dimensions in their current state, but also forecast them over the lifetime of the analysis.

For this modelling update, the approach used to establish the baseline has not changed from that used in the 2013 CBA. However, estimates underpinning the baseline has been updated based on recent publications.

Baseline estimates and forecasts in the 2013 CBA were mostly established based on infrastructure statistics and road freights estimates and forecasts from BITRE (2010) and BITRE (2012). Updated infrastructure statistics to 2015 is available from BITRE for this CBA and the modelling has been updated with these estimates (BITRE 2016a). In terms of road freight estimates and forecasts, BITRE has released revised estimates to 2015 (BITRE 2016b). While this update does not change forecasts to 2030, it does change the baseline level estimates to 2015 used in the model. The modelling has been updated accordingly.

Table i Summary of CBA inputs

Behavioural response	Economic Effect	Modelling treatment	Detailed input
Demand-side response	• Reduce freight costs • Externalities	• Elasticities from ITLS (2013) study • ATC recommended values and other recommended values	See Appendix C. See Section 3.
Better information gathering	Better decision-making for investments	Qualitative	N/A
Better quality roads	• Reduced freight costs • Increased maintenance cost • Externalities	Detailed assessment of optimal maintenance intervention based on data provided by jurisdictions	A 0.4% improvement per year. Expenditure determine within the model.
Better investment decisions	Capital investments generate net economic benefits	Qualitative	N/A
Access improvements	• Reduced freight cost • Increased road investments to enable access • Externalities	• Detailed assessment of transition in vehicle shares based on BITRE forecasts • Expenditure estimates developed from CRRP feasibility study, extrapolated for access improvements	Details provided in Appendix G. Expenditure estimates determined within model. • Option 1: $567 m (NPV, $2013) • Option 2: $1,309 m (NPV, $2013) • Option 3: $2,428 m (NPV, $2013) • Option 1A: $1,309 m (NPV, $2013) • Option 2A: $1,309 m (NPV, $2013)
Supply chain reorganisation	• Long term reorganisation of supply chains	• Elasticity based on literature review (see Section 2.2.1)	Vehicle operating cost reduction determined within model. A 10% reduction in vehicle operating cost leads to 1% reduction in supply chain costs. • Option 1: 0.5% cost saving • Option 2: 0.9% cost saving • Option 3: 1.1 % cost saving • Option 1A: 0.8% cost saving • Option 2A: 0.9% cost saving
Efficiencies in provision	• Reduced expenditure due to whole of life approach to asset management • Improved governance and investment decision-making	• Literature review on whole of life management costs and pavement management systems (see Appendix B and Appendix I) • Literature review on benefits from improved governance and investment decision-making (see Section 2.2.1)	Whole of life management: • Option 1: 8.60% efficiency gain • Option 2: 10.20% efficiency gain • Option 3: 13.50% efficiency gain • Option 1A: 7.83% efficiency gain • Option 2A: 13.50% efficiency gain Governance reform: • Efficiency gain from better governance and investment decision-making not modelled but sensitivity analysed at 15% and 25%.

Behavioural response	Economic Effect	Modelling treatment	Detailed input
Vehicle monitoring costs	Cost of installing/upgrading technology	KPMG (2013) estimates	• Option 1: $0.9bn (NPV, $2013) • Option 2: $1.5bn (NPV, $2013) • Option 3: $1.8bn (NPV, $2013) • Option 1A: $0.9bn (NPV, $2013) • Option 2A: $1.2bn (NPV, $2013)
User compliance costs	Increased administrative burden associated with complying with the reforms	KPMG (2013) estimates	Included in above.
Government administrative costs	Costs associated with additional administrative burden for government	Bottom-up approach based on staff numbers required	See Section 2.2.2. • Option 1: $79 m (NPV, $2013) • Option 2: $160 m (NPV, $2013) • Option 3: $210 m (NPV, $2013) • Option 1A: $117m (NPV, $2013) • Option 2A: $186 m (NPV, $2013)

Differentiating the reform options
The approach outlined so far provides an estimate of the potential gains available to reform if it leads to the optimal management and use of the road network. To distinguish between options, it is necessary to identify the extent to which each option is able to achieve these benefits.

In principle, each option could allocate the same total quantum of funding to road management and hence the difference between options will depend on the mechanisms via which this funding is allocated efficiently and whether these mechanisms present decision makers with the optimal incentives. This is addressed against each of the key benefits below:

Efficient road use: requiring heavy vehicle operators to face the true marginal costs of their road usage will ensure that vehicles use selected routes only if the benefits of doing so outweigh the costs. This is expected to lead to a shift in routes and fleet composition, ultimately reducing maintenance costs and potentially affecting productivity. It is worth noting that, although governments have not agreed to light vehicle pricing at this time, efforts to transition to a more market based approach to road investment and charging would be expected to bring benefits for the entire road network over time. MDL pricing for heavy vehicles is the more effective mechanism to achieve this, and hence Options 2, 2A and 3 will see greater net benefits from the charging reforms, while Options 1 and 1A will confer some lesser benefits as appropriate. On the other end of the spectrum, in some cases, roads have the characteristics of a natural monopoly and so efficient pricing will require regulatory oversight to ensure only long run average costs for a forward looking cost base are recovered.

Optimal access decisions: under all options there will be some ability for road owners to better recover the costs associated with any changes to road access. However, large access benefits will require detailed information gathering and a close link between road use and road charges. This means that Options 2, 3, 1A and 2A will see greater access improvements while Option 1 will only see minor improvements.

Optimal maintenance and capital decisions: there is expected to be greater revenue certainty under all options and this will help ensure that maintenance decisions can be made based on optimal lifecycle management rather than current ad hoc revenue streams. The reduced VOC and road maintenance costs estimated will therefore be attributed to all options.

Administrative and compliance costs: there is likely to be an administrative burden of the reforms regardless of which option is pursued. However, the burden is expected to be higher under Option 3 than compared to other options. For this model update, it is assumed that Options 1A and 2A will require a large increase in regulatory positions and so the same number of regulatory FTE is set for Option 3. For Option 1A this is a conservative assumption as there is the possibility that regulation which only focuses on pricing and not broader economic performance may require fewer regulatory staff. In particular, Option 1 will use a low estimate of administrative costs while Option 3 will use a high estimate and Options, 2, 1A and 2A will use estimates toward the middle of the range. The options are also differentiated based on the costs of vehicle monitoring.

Supply chain costs: as supply chain costs are estimated based on changes in vehicle operating costs, they will be higher when greater access improvements are achieved. That is, supply chain cost savings will be higher under all options except for Option 1.

In summary, the following approach has been used to differentiate between the options:

Table ii Approach to differentiating reform options

	Option 1	Option 2	Option 3	Option 1A	Option 2A
Access Prices	RUC	State-based distance charge differentiated by vehicle type (flexible mass distance pricing implementation)	Full static mass distance location based charge	Excise-based RUC	National-based distance charge with mass distance charge for heavy vehicles
Compliance costs	RUC based	As for Option 3 but without on-board technology	Cost to comply with full static mass distance location based charge	RUC based with on-board technology	Similar to Option 3 but require new payment system and telematics collection technology
Government Costs	$79 m (NPV)	$160 m (NPV)	$210 m (NPV)	$117 m (NPV)	$186 m (NPV)
Access benefits	Minimal departure from baseline	Initial step change with accelerated growth in access	Stronger initial step change with higher growth in access	Initial step change with accelerated growth in access	Initial step change with accelerated growth in access
Road investment	$567 m (NPV)	$1,309 m (NPV)	$2,428 m (NPV)	$1,309 m (NPV)	$1,309 m (NPV)
Maintenance efficiency	8.6%	10.2%	13.5%	7.83%	13.5%
Supply Chain benefits:	0.5% cost saving	0.9% cost saving	1.1% cost saving	0.8% cost saving	0.9% cost saving

Note: NPV presented in $2013 dollars. Source: DAE (2017).

Overall results

The first set of results below use a real discount rate of 7%; this is in line with standard practice in conducting cost benefit analysis in Australia (OBPR 2016). The second set of results uses a real discount rate of 3%, more in line with social discount rates. It should be noted that Australia sits at the upper end of discount rates used internationally (Hepburn 2007). As the proposed reforms deliver long run benefits, a high discount rate may understate the true scale of benefits from the reform as much greater weight is given to early costs rather than long run benefits.

The overall net benefit from the reform options vary significantly but all five options present strong net benefits, as is shown below:

Table iii Summary of costs and benefits ($2013 m) – 7% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	8,265	14,135	17,869	10,884	14,482
Costs (NPV)	1,814	3,193	4,613	2,545	2,938
Net Benefit (NPV)	**6,451**	**10,942**	**13,256**	**8,340**	**11,544**
Benefits					
Maintenance	4,377	5,562	7,691	4,378	7,212
Externalities	395	1,545	1,568	942	899
ATC Standard	173	1,054	541	387	864
Congestion and Accident	221	491	1,027	555	35
VOC	3,359	6,763	8,327	5,357	6,132
Supply chain	134	265	282	207	239
Total	**8,265**	**14,135**	**17,869**	**10,884**	**14,482**
Costs					
Data collection costs	41	343	548	0	219
Compliance & enforcement costs	371	624	671	371	477
Core system costs	323	323	323	313	313
Business support & administration	213	213	213	213	213
Road investments	567	1,309	2,428	1,309	1,309
Government Administration	79	160	210	117	186
Road quality improvements	221	221	221	221	221
Total	**1,814**	**3,193**	**4,613**	**2,545**	**2,938**
Periods of Analysis					
2017-2037	6,451	10,942	13,256	8,340	11,544
2038 and beyond	3,348	6,117	7,665	5,212	6,219
Total	**9,799**	**17,059**	**20,921**	**13,551**	**17,763**

Source: DAE (2017).

In the results above, potential externality benefits from a reduction in road accidents and congestion are included as a separate item. This is because these externalities do not form part of the recommended externality values quoted in the ATC Handbook (2006). However, recent guidelines from Transport for NSW (2016) provide a basis for estimating congestion and accident externalities.

The tables below presents the results at a 3% discount rate:

Table iv Summary of costs and benefits ($2013 m) – 3% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	15,019	25,738	32,667	20,343	26,217
Costs (NPV)	3,241	5,550	7,915	4,506	5,124
Net Benefit (NPV)	**11,778**	**20,188**	**24,752**	**15,838**	**21,092**
Benefits					
Maintenance	7,506	9,599	13,223	7,603	12,377
Externalities	838	2,986	3,229	2,011	1,774
ATC Standard	345	1,880	996	776	1,567
Congestion and Accident	493	1,106	2,232	1,235	207
VOC	6,417	12,662	15,693	10,334	11,617
Supply chain	258	491	523	396	449
Total	**15,019**	**25,738**	**32,667**	**20,343**	**26,217**
Costs					
Data collection costs	58	545	864	0	345
Compliance & enforcement costs	771	1,193	1,251	771	929
Core system costs	522	522	522	518	518
Business support & administration	425	425	425	425	425
Road investments	966	2,230	4,134	2,230	2,230
Government Administration	133	270	354	198	314
Road quality improvements	364	364	364	364	364
Total	**3,241**	**5,550**	**7,915**	**4,506**	**5,124**
Periods of Analysis					
2017-2037	11,778	20,188	24,752	15,838	21,092
2038 and beyond	20,251	36,997	46,362	31,523	37,613
Total	**32,029**	**57,184**	**71,114**	**47,361**	**58,705**

Source: DAE (2017).

Considering the source of benefits in each of the reform options:

- in Option 1, the main source of benefits is from reduced maintenance expenditure. In particular, there are significant externality cost savings associated with Option 1 while it has relatively minor benefits in terms of supply chain cost reduction.
- in Options 2, 3, 1A and 2A, reductions in vehicle operating costs flowing from access improvements are significant and comparable in magnitude to maintenance efficiencies. Compare to Options 1, 1A and 2A, Options 2 and 3 achieve the highest benefit, on a relative basis, from reduced externality costs. Options 2, 3, 1A and 2A also see higher additional benefits in the supply chain compare to Option 1 as businesses re-organise to take advantage of higher productivity vehicles.
- Option 1 has lower source of benefit from vehicle operating costs for a combination of reasons. The charging arrangements in Option 1 mean that there is a looser link between road use, payments by

road users and funding for road providers. On the supply-side this will not be able to create as strong incentives for improving access as are expected under the other options, in particular Option 3. On the demand-side this may create less incentive for efficient vehicle use patterns (such as ensuring that trailers are fully utilised).
- the difference in costs under each of the options is also significant. While the core systems and business support costs are estimated to be the same under each of the reform options, there is large variation in costs related to vehicle monitoring, user compliance and the level of investment in roads.

Considering how results from this updated modelling differ from the results presented in the 2013 CBA:

- the results for Options 1, 2 and 3 are different from the results in the previous report and the results for Options 1A and 2A are different from the results for Options 1, 2 and 3. Understanding the reasons for these differences is complex due to a number of changes in inputs as well as interactions within the modelling. In terms of inputs, the main changes have been to values such as vehicle operating costs, the relationships between road quality and VOC, externalities, elasticities for vehicle use choices, current vehicle use shares and underlying cost assumptions (such as maintenance costs and administrative staff costs).
- comparing the results for Options 1, 2 and 3 to previous analysis, the main driver of changes comes through adjustments to current vehicle use patterns, this affects the benefits of increased access, as well as changes in vehicle operating costs. As a result of these changes there are flow on changes to the expected costs and benefits of the proposed reforms. For example, different vehicle use patterns result in changes to the level of capital expenditure required and also changes in the supply chain benefits. It's also important to note that the previous analysis presents values from the point of view of 2013 (where the reform was still four years away) while the current analysis presents results from the point of view of 2017 (where reform is expected to commence shortly). Tables are provided where updated results are presented in terms of dollars of 2013 to allow for a direct comparison between this report and the previous analysis (see Section 4). In particular:
  - comparing the results for Option 1 to the previous analysis (Option A), key changes to Option 1 are: higher benefits from reduction in vehicle operating cost, supply chain efficiency gains, reduction in congestion and traffic accidents, and lower government administration costs; and these are partially offset by higher capital investment cost and lower savings from lifecycle maintenance. Overall, net benefit for Option 1 increased in this update compared to the previous analysis.
  - comparing the results for Option 2 to the previous analysis (Option B), key changes to Option 2 are: higher benefits from reduction in vehicle operating cost, supply chain efficiency gains, and lower government administration cost; and these are partially offset by higher capital investment cost, lower savings from lifecycle maintenance and lower reduction in traffic externalities. Overall, net benefit for Option 2 increased in this update compared to the previous analysis.
  - comparing the results for Option 3 to the previous analysis (Option C), key changes to Option 3 are: higher benefits from reduction in congestion and traffic accident externalities, lower government administration and data collection cost. However, these are not sufficient to offset lower benefits from lifecycle maintenance, vehicle operating cost reduction and supply chain efficiency gains and higher capital investment costs. Overall, net benefit for Option 3 decreased in this update compared to the previous analysis.
- comparing the results for Options 1A and 2A to the results for Options 1 and 2, benefits in terms of improvements in access are the same for Options 1A, 2 and 2A. This suggests that access improvements under Option 1A are expected to be higher than under Option 1 and reflects improvements in the outlook for access since the previous analysis, including since the establishment of the National Heavy Vehicle Regulator. For Option 2A, maintenance benefits are expected to be greater than under Option 2 due to the fact that Option 2A would implement hypothecation more extensively. However, there is an offsetting force that Option 2A involves nationally averaged vehicle charges while Option 2 involves charges that are differentiated at the state level. A nationally averaged charge lowers the benefits from efficient use of vehicles as prices cannot be as accurately matched to costs. On net, the increased maintenance benefits more than offset the decreased vehicle efficiencies.

Consistent with the theoretical framework of a CBA, this CBA has assessed the benefits and costs of the HVRR reform with reference to five potential end-states of the HVRR. This report provides a framework for evaluating the possible states of the world under the HVRR reform – with each associated with different levels and distribution of net impact across jurisdictions and varying capability in achieving the HVRR reform objective - improve the long run efficient provision and use of road services. Results from this CBA are useful in identifying the types of outcomes that may be achievable under each reform option and the elements of the reform that are more critical than others to achieving the overall objective of the HVRR reform.

It is also worth considering how these costs and benefits will align with the implementation plan proposed by HVRR. Much of the costs to be faced by road users (such as compliance and administration) will not be made until supply-side changes have been committed and many of the supply-side changes are underway. This significantly reduces the risks for road users associated with meeting the costs associated with the reform as they essentially get to follow on a path of reform that is already well underway. The vast bulk of economic benefits will be achieved as supply-side changes are made with indirect externality benefits to be felt upon improvements to road quality and access.

Realisation of the net benefit estimated for each reform option rests heavily on the assumption that the supply-side reforms will be implemented successfully and in a logical and practical manner across jurisdictions over time to achieve the benefits at a national level. Under the current baseline, there are differences across jurisdictions in the definition of heavy vehicle revenue and expenditure, investment reporting standards, asset maintenance practices, methodology for translating heavy vehicle charges to investment expenditure, and derivation of average level of expenditure and revenue requirement. All of these differences will need to be addressed at a national level for the successful implementation of an economic regulation framework. These issues are critical in determining the role, objective, responsibility, and scope of the regulator’s function and power.

As identified by the Transport and Infrastructure Council (2016), a phased approach to supply-side reform is required. The first stage of the reform will require improvements to data collection to improve transparency around expenditure, investment and service delivery. The second stage of the reform will require establishment of a formal approach for governments to develop a forward looking plan on road expenditure and investment, to ensure access and road service provisions on key freight routes are concurrently improved nationally. Each stage will involve a set of activities to understand and define the current issues and then to identify and test the optimal approach for addressing the current issues in alignment with the proposed reform. Maximisation of the benefits achievable under each reform option requires endorsement from governments and industry on each phase of the reform.

Having said this, analyses of the risks to implementation and the optimal sequencing of reform elements, in particular the supply-side reforms, proposed under each option are beyond the scope of this CBA. This CBA has not assessed the degree to which realisation of the net benefit measured for each option will be affected by reform complexity and the level of jurisdictional and organisation change required. As such, results from this CBA should not be interpreted as conclusive of the only optimal approach to implementing the HVRR. For example; there is potentially alternative cost-effective or lower risk reform options to achieving the same outcomes; and/or that as the HVRR reform is implemented, elements to a reform option may need to be changed or merged with components of other option(s).

Overall, this CBA shows there are clear benefits to reforming heavy vehicle road charging and investment, with the level of benefit and types of outcomes achievable dependent on the reform option selected. Ability to realise the full suite of benefits identified under each option is critically dependent on the reform being successfully implemented at the supply-side and that the industry actually takes up the reform and changes their behaviour over time to meet the requirements of the reform at the demand-side.

Results by jurisdiction

The model tracks all variables at the jurisdictional level. This allows the CBA to be broken down for each jurisdiction. The tables below present the results for the 7% discount rate. The shares of each state would remain roughly constant using a 3% discount rate but the overall level of benefit would increase.

Table v PV of net benefits of reform, by state ($2013 m) (7% discount rate)

State	Option 1	Option 2	Option 3	Option 1A	Option 2A
NSW	1,820	3,851	3,732	2,437	3,407
Vic	1,675	2,399	3,448	2,276	2,656
Qld	2,002	3,273	4,689	2,470	3,828
WA	437	626	402	482	709
SA	334	437	571	433	636
Tas	80	266	206	122	151
NT	87	74	145	96	137
ACT	16	16	63	22	20
Total	**6,451**	**10,942**	**13,256**	**8,340**	**11,544**

Source: DAE (2017).

Table vi PV of net benefits of reform, by state ($2013 m) (3% discount rate)

State	Option 1	Option 2	Option 3	Option 1A	Option 2A
NSW	3,336	6,977	7,060	4,656	6,273
Vic	3,040	4,528	6,473	4,306	4,837
Qld	3,657	6,060	8,582	4,689	6,972
WA	798	1,134	763	897	1,268
SA	610	824	1,070	815	1,155
Tas	152	478	402	244	292
NT	154	139	261	176	246
ACT	31	48	142	54	49
Total	**11,778**	**20,188**	**24,752**	**15,838**	**21,092**

Source: DAE (2017).

There are large differences between the states but the driving factors of the different results can be roughly grouped as follows:

- **Queensland, New South Wales and Victoria**
  Qld, NSW and Victoria are responsible for the bulk of benefits estimated. This not only reflects the fact that they are responsible for a large portion of the nation's road freight task but also that they currently have lower levels of access and use less efficient vehicles than more northerly and westerly states.

  For these states there are maintenance benefits but the bulk of benefits come from shifts out of general access vehicles and into B-doubles and B-triples. In practice, this could be thought of as line-haul freight on the east coast moving more towards the use of B-triples on appropriate roads with distribution in metropolitan areas relying more heavily on B-doubles.

- **Western Australia, Northern Territory and South Australia**
  Western Australia and the Northern Territory see lower levels of benefit from the proposed reforms. Both of these states currently sit above the average level of access and type of heavy vehicle use that occurs around Australia and so it is expected that the proposed reforms would mostly see a shuffling of vehicle use patterns between road-trains, B-Doubles, B-Triples and AB-Doubles rather than wholesale change in the type of vehicles that are being used. Both states do, however, see significant maintenance savings. Similar access and planning outcomes will be delivered in South Australia and

Western Australia under the proposed reform. However, a slightly higher per capita benefit will be realised in South Australia. South Australia currently has a relatively good access framework and the proposed reforms will improve access level in South Australia further to that between NSW/VIC and WA.

These states are also likely to see benefits that are not captured in the figures given above. These benefits include the ability to make better investment decisions due to better information flow from road users to road suppliers. That is, under the reform options, road suppliers should face incentives that reward them for providing the level and type of service that their customers demand. This alignment of incentives can lead to a close alignment between the demand and supply side of the market in terms of investment decisions, service quality and the overall type of product supplied, creating benefits for road users.

- **ACT and Tasmania**
  ACT and Tasmania see little benefit from the proposed reforms. Although these states have relatively low levels of access and so use relatively inefficient heavy vehicles, the modelling outlined in Appendix F suggested that it would be difficult for these two states to achieve the patterns of heavy vehicle use that are seen in larger states. As such, although there is a strong shift in these states towards more efficient vehicles, it is simply not as large as that seen in other states. This limits the total quantum of benefits that can be achieved from the reform in either state.

Sensitivity analysis

The CBA results presented above rely on a large number of inputs sourced from statistical analyses, literature reviews, and case studies. It is important to recognise that changes in some of these inputs could have consequences on the overall net benefits estimated from the reforms. For example, in the case of maintenance efficiency gains from governance reforms, if significant efficiencies can be generated from corporatisation or privatisation then this could make the reforms far more appealing. A range of sensitivity analyses were therefore undertaken. These are summarised in the table below:

Table vii Sensitivity analysis inputs

	Baseline	Sensitivity 1	Sensitivity 2
Road train elasticity of substitution	As in CRRP study	Set to zero	
Maintenance efficiency gains	Lifecycle: Varies Corporatisation: 0% Total: Varies	Lifecycle: Varies Corporatisation: 15% Total: Varies%	Lifecycle: Varies Corporatisation: 25% Total: Varies%
Road quality in baseline	Deterioration of 0.015 IRI per year	Deterioration of 0 IRI per year	Deterioration of 0.03 IRI per year
Investment in roads and government costs	Varies by Option	Options 1,2,3 set to Option 1 Options 1A,2A set to Option 1A	Options 1,2,3 set to Option 3 Options 1A,2A set to Option 2A
Access benefits	Varies by Option	Options 1,2,3 set to Option 1 Options 1A, 2A set to Option 1A	Options 1,2,3 set to Option 3 Options 1A,2A set to Option 2A

The results of the sensitivity analysis based on inputs tested are presented in tables below.

Table viii Sensitivity analysis results (NPV in $2013 m)

	Option 1	Option 2	Option 3	Option 1A	Option 2A
NPV - Baseline	$6,451	$10,942	$13,256	$8,340	$11,544
Road train elasticity of substitution					
NPV - Sensitivity 1	$6,453	$10,942	$13,256	$8,340	$11,544
Maintenance efficiency gains					
NPV - Sensitivity 1	$14,060	$18,492	$20,722	$15,886	$19,093
NPV - Sensitivity 2	$19,133	$23,525	$25,699	$20,916	$24,126
Road quality in baseline					
NPV - Sensitivity 1	$5,043	$9,526	$11,844	$6,930	$10,131
NPV - Sensitivity 2	$8,013	$12,512	$14,822	$9,904	$13,112
Investment in roads					
NPV - Sensitivity 1	$6,451	$11,765	$15,247	$8,340	$11,613
NPV - Sensitivity 2	$4,459	$9,774	$13,256	$8,271	$11,544
Access benefits					
NPV - Sensitivity 1	$6,451	$8,897	$6,666	$8,340	$10,797
NPV - Sensitivity 2	$13,123	$9,423	$13,256	$9,085	$11,544

Source: DAE (2017) analysis.

Overall, most of the detailed assumptions (such as road quality and elasticities) do not have a significant effect on the estimated net benefits. The largest movements are seen under the maintenance cost savings sensitivity and the access benefits sensitivity. In the case of maintenance savings, the NPV can increase by up to $13 billion while in the case of the access benefits sensitivity the NPVs become fairly different between the reform options, this suggests that the level of access benefits are the main differentiating factor between the Options.

Deloitte Access Economics

1 Introduction

1.1 Background on proposed reforms

Heavy vehicle road charging and investment reform has been a focus for Australian Governments for at least the past twenty years and a particular focus of the COAG's reform agenda since 2007. The reform seeks to enhance productivity by linking prices paid by users to maintenance and access incentives for road providers.

Currently, the costs of road provision are recovered by multiple levels of government (Commonwealth, State and Territory) under a pay as you go approach (PAYGO), which involves two sets of charges: a fixed registration charge component and a variable fuel based road user charge. These two sets of charges aim to capture the direct road expenditure costs that are 'attributable' to heavy vehicles as well as the proportion of common costs for operating and maintaining the road network for provision of access. The PAYGO approach, which involves averaging of costs and charges to establish nationally uniform charges was implemented on 1 July 2015.

However, over time, a number of shortfalls to the PAYGO has been identified. Most notably, charges did not fully recover 'attributable' costs from B-doubles, and over-recovered costs from rigid trucks.

In its 2007 review of road and rail freight infrastructure pricing, the Productivity Commission (PC) found that road charging arrangements in use at the time did not provide a clear relationship between road revenue and spending decisions. As a result, the PAYGO model and the governance arrangements supporting it provide poor price signals to the transport market, and distorts the incentive needed for efficient road use and provision.

In 2013, Deloitte Access Economics (DAE) was engaged to undertake a cost benefit analysis of three potential end-states of the heavy vehicle road reform.

The reform process was refreshed as Heavy Vehicle Road Reform (HVRR) in 2015 in response to the Harper Competition Review. The COAG Transport and Infrastructure Council (TIC) has since endorsed a reform road map outlining a pragmatic, phased approach to implementing reform. The current round of the reform seeks to enhance productivity by linking prices paid by users to maintenance and access incentives for road providers. The reform is comprised of two components:

- the first component is road charging, where heavy vehicles would pay directly for their use of road networks. The full extent of the reforms would involve the use of vehicle mass, distance travelled and road type in determining the precise charge.
- the second component is investment which is primarily related to the approach used to allocate these charges back to road providers.

By linking the charges for road use to the revenue of road providers the reforms aim to provide greater funding certainty by ensuring that any maintenance cost increases would be offset by appropriate revenue streams. This is expected to encourage the removal of current access restrictions. The data collected under the road charging model would also facilitate improved road investment and management decisions in the future.

The purpose of the HVRR reform is to implement a scheme whereby heavy vehicles are charged akin to the *long run marginal cost* of their road use, recognising that heavy vehicles share the road with the light commercial and passenger vehicle fleet and road damage from these vehicles as well as various environmental factors determines the total cost of maintenance. HVRR aims to make sure that road charges reflect the additional cost that road users impose on the road provider. Costs outside of the *long run marginal* road use costs, such as significant investments in improving or extending the road network, are not part of the scope of this reform and would continue to be funded out of general government revenue including road user charges, collected from all road users.

In November 2015, in response to the Harper Competition Policy Review, the Australian Government stated it would work with states and territories to accelerate HVRR, including identifying potential steps to transition to independent price regulation for heavy vehicle charges and to develop a forward looking cost base to underpin heavy vehicle charges. To support this, the Department of Infrastructure and Regional Development ('the Department') has requested DAE to update and extend the 2013 cost-benefit analysis to incorporate two additional end-states and assess all potential end-states based on updated evidence.

1.2 Possible end-states

Five potential end-states of the HVRR reform (the 'reform options') are appraised in this report, comprising of the three reform options considered in the 2013 report (Option 1, 2 and 3) plus two additional reform options (Options 1A and 2A):

- **Option 1** retains a fuel-based charging system with greater emphasis on the road user charges (RUC) as a charging mechanism. Incremental pricing would be available for vehicles travelling above prescribed mass limits.
- **Option 2** introduces a state-based distance charge (a distance charge that is differentiated by vehicle class and road type and is different across jurisdictions). It allows for flexible implementation options, including low technology approaches to charging and revenue collection.
- **Option 3** involves a full static mass distance location based charge and represents an efficient charging framework to deliver planning and expenditure outcomes.
- **Option 1A** retains a fuel-based charging system with greater emphasis on an excise-based road user charges (RUC) as a charging mechanism. Incremental pricing would be available for vehicles travelling above prescribed mass limits. Road charges will be subject to a light-handed price monitoring framework. Option 1A can be seen as a variation of Option 1.
- **Option 2A** introduces a state-based distance charge (a distance charge that is differentiated by vehicle class and is consistent across jurisdictions), with mass distance based charge for heavy vehicles. It allows for flexible implementation options, including low technology approaches to charging and revenue collection. All state and territory road related revenue and a proportion of fuel excise revenue will be hypothecated to a general road fund to improve road quality. The state-based distance charge will be subject to a tighter form of economic regulation. Option 2A can be seen as a variation of Option 2 and would place Australia in a similar position to New Zealand in terms of heavy vehicle charging.

All five reform options involve demand-side (through charging) and supply-side reforms (through influence on road service provision investment decision-making), though at different levels and involve different combinations of mechanisms, to achieve some degree of improved outcomes. Importantly, each option involves a form of independent regulatory regime by setting a forward-looking cost base to support more cost-reflective and transparent pricing and introduces expenditure accountability. In particular, except for Option 1A, all other options involve a more 'heavy-handed' form of economic regulation, to heavy vehicles, which includes revenue cap, incentive regulation and efficiency benchmarking to encourage road providers make prudent long-term investment decisions. A forward-looking approach to setting prices that are reflective of long run efficient costs of road service provision is important for achieving the recovery of efficient costs over the economic life of the road service, avoid distorted price signals and achieve prudent and timely investment decision-making.

However, it is worth noting that jurisdictions will be allowed to determine how far along the supply-side reform spectrum they wish to go. This recognises that there is a level of upfront investment and institutional and technical changes (for example; in terms of better data collection and monitoring system) required to implement the reform and that this investment decision will have to be made at the jurisdictional level.

Until the required supply-side changes are made at the jurisdictional level to address issues with current PAYGO heavy vehicle charges methodology, as identified by NTC (2016), the benefits of the reform and the ability of independent price and economic regulation to set heavy vehicle charges that are reflective of long run efficient costs of road service provision will not fully realise.

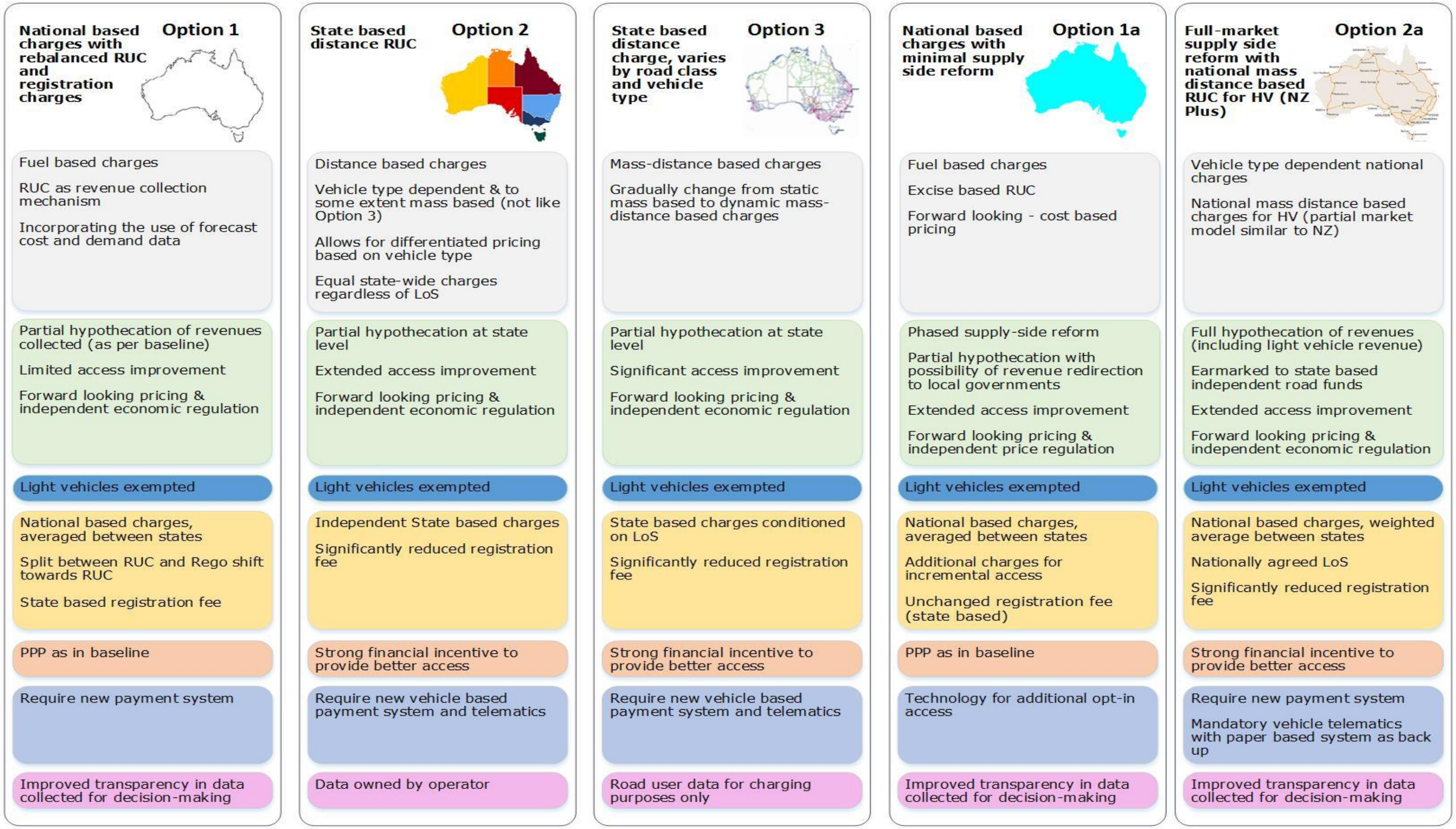
Independent price regulation can improve transparency in price-setting, minimise the potential for significant price fluctuations, and create stronger incentives for prudent investment decisions. Implementation of independent price regulation requires improvements to current baseline data and enforcement of better evidence base to support investment decision-making. It is easier to implement than economic regulation and can be considered as a lighter form of regulation. For example; there are common elements required in setting up price regulation and economic regulation (also addressed by the Transport and Infrastructure Council (2017)), this include:

- establishment of asset registers that collect information on heavy vehicle road network, including: access condition, functions, location, length, economic life and maintenance cost;
- establishment of nationally consistent asset maintenance and investment reporting standards;
- establishment of principles for preparing road expenditure investment and maintenance plans that covers consideration of expected demand and level of service;
- establishment of the technical systems and protocols required for collecting baseline information and record-keeping investment and maintenance expenditure plans; and
- development of pricing principles that outline the methodology that will be followed by the regulator in conducting price determinations.

Economic regulation is the key source of supply-side efficiencies. However, implementation of a successful economic regulation framework for heavy vehicles is harder to achieve due to the complexity of the task and the higher-level of risks to implementation. Setting up economic regulation of heavy vehicle charges and investment requires fundamental structural and behavioural changes to existing jurisdictional practices to ensure charges are efficiently set and appropriate to incentivises forward-looking prudent, efficient and timely road network investments. A range of factors will need to be considered in making forward-looking investment decisions when there are competing investment priorities. This includes consideration of the following at a national level: the different priority classes of roads important to heavy vehicle freight task, current and projected key transport nodes, current and projected major freight routes, urban planning and land use, and projected level of demand and service conditions.

A phased approach to the implementation of regulatory oversight could be considered. This would involve improving the baseline to step into independent price regulation before considering the feasibility of transitioning into independent economic regulation.

Figure 1.1 Overview of the five reform options



1.3 Purpose of this report

The purpose of this report is to provide an update to the cost benefit analysis that was produced for three potential reform end-states during the heavy vehicle road charging and investment reform process in 2013 and to analyse the likely impacts of two additional reform end-states. Results from this report should be read alongside other analysis that explores the design and practical feasibility of the HVRR reform elements.

This report follows the methodology framework that was developed in the 2013 analysis to assess benefits and costs. Where applicable, the evidence base that underpinned the 2013 analysis has been updated based on recent literature findings and statistical publications available to reflect current estimates of benefits and costs, changes in technology as well as findings from subsequent research and policy projects.

In line with treasury approaches to systematic evaluation of policy proposals, the impacts of proposed reform options have been assessed using a cost-benefit analysis (CBA) and a distributional analysis:

- the **CBA** compares all quantifiable economic, social and environmental impacts (benefits and costs) of the five reform options against the base case (no reform) – the incremental benefit of the reform options.
- the **distributional analysis** provides additional insight on the distribution of these impacts among the jurisdictions.

Each of the five reform options is assessed relative to the baseline, which is an estimate of the state of the world if the reforms were not to go ahead. In addition, the differences between the five options in terms of benefits, costs, risks and distributional effects are also analysed.

Fundamentally, the cost benefit analysis will aim to determine how a change in charging for and investment in roads will affect the behaviour of road users and road suppliers. This report aims to identify and investigate the outcomes of the most probable end-states, incorporating different combinations of appropriate price signals and reform to governance arrangements, particularly funding and investment decision-making.

Findings from this report will inform government decision-making on the relative costs and benefits of different end-states and the set of policies and charging mechanisms that would improve the overall supply and use of our road network.

1.4 Structure of this report

The remainder of this draft final report is structured as follows:

- **Chapter 2** outlines the methodology used to undertake the cost benefit analysis and the distributional analysis. It discusses our approach to establishing a baseline and to identifying and estimating the benefits and costs of the reforms.
- **Chapter 3** presents the baseline and key differences between reform options.
- **Chapter 4** presents our assessment of the overall impact of the proposed reforms.
- **Chapter 5** summarises our assessment of the overall impact of the proposed reforms based on risks and uncertainties.
- **Appendices A to I** provide additional detail such as, data sources, literature reviews and detailed data analysis.

2 Cost benefit analysis framework

This chapter outlines the methodology used to update the 2013 CBA and the distributional analysis, including:

- the benefits and costs that are likely to be realised under each potential end-state of the reform
- the inputs applied to estimate the benefits and costs and the inputs that have been updated relative to the 2013 CBA (findings from update to evidence base is summarised in Appendix B)
- the policy baseline based on current information
- how the behaviour of industry would change over time under each reform option and their associated net economic impact.

2.1 Identification of costs and benefits

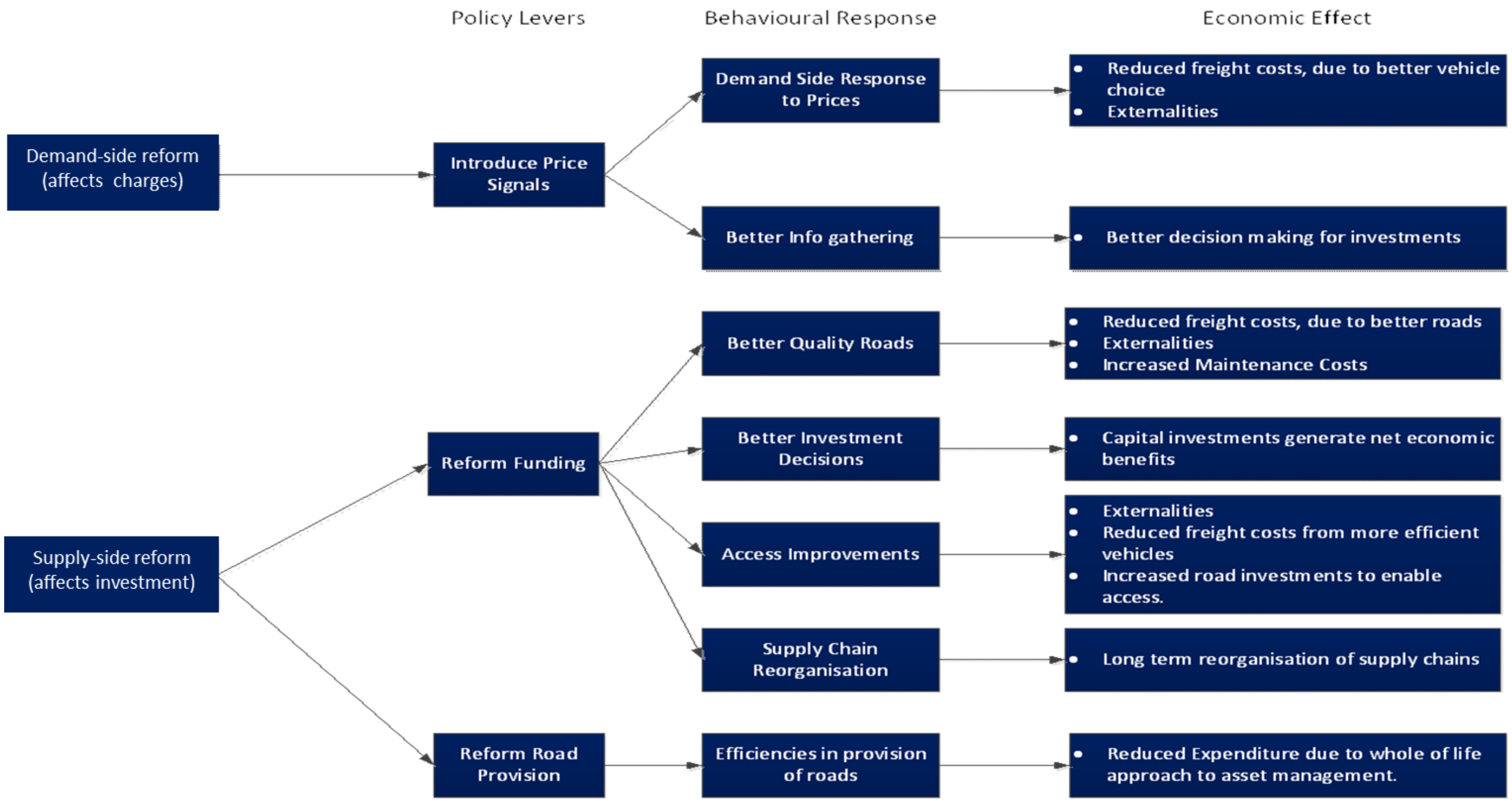
The proposed reforms have the potential to improve the signals which guide investment in and use of roads (through user charging), ultimately leading to:

- increased access to currently restricted roads for larger vehicles, reducing the total cost of road freight through encouraging a more efficient vehicle mix;
- increased scrutiny of road capital expenditure given that cost recovery will be based on regulatory approval;
- better, more timely upkeep of roads as funding is linked directly to road use, reducing vehicle operating costs and lifetime maintenance costs; and
- a more efficient use of the road network, where vehicles use certain roads only when the benefits of doing so outweigh the costs imposed.

In the long run these benefits for the freight transport sector could also result in benefits for the broader supply chain, resulting in lower costs for consumers and, potentially, increased trade and specialisation in the Australian economy. These could include, for example, moving distribution centres to more efficient locations if access restrictions in major urban areas are removed.

It is conceptually simplest to divide these potential impacts into those flowing from (i) the charging aspects of the reforms; and (ii) the investment aspects of the reforms. From there, the intermediate behavioural effects that are likely to ensue can be determined and the magnitude of the final effects can be estimated. This conceptual framework is illustrated in Figure 2.1 and is discussed further below.

Figure 2.1 Conceptual framework for estimating benefits



Considering the benefits in Figure 2.1 in order:

Charging → price signals → demand-side response

Although there have been significant improvements in recent years, the current heavy vehicle pricing system does not align costs paid by road users with the costs they generate for the road network (or society more broadly).

From an economic perspective, this results in an inefficient mix of heavy vehicles being used. That is, the current freight task is not being completed at minimal social cost when social costs take into account road wear and vehicle operating costs.

By more closely aligning prices with these social costs we will see a **more efficient mix of vehicles** being used. In this sense more efficient vehicles do not necessarily mean larger vehicles but **vehicles which are better matched to the particular task they are carrying ou**t. For high-quality interstate highways this could indeed result in larger vehicles being used. For lower-quality local roads this could see a reduction in vehicle size.

An additional benefit of rebalancing access charges more heavily towards RUC and MDL based charges is that it will likely reduce the level of registration charges. Some vehicle owners currently access debt financing to pay for vehicle registration fees and so this has the indirect benefit of potentially reducing any debt funding costs associated with vehicle registrations.

Charging → price signals → better information gathering

At the moment there is a great deal of dispersed data gathered on freight including Weigh-in-motion (WIM) and Culway data, vehicle surveys, detailed understanding of the engineering aspects of road wear and strength. This information is useful for the technical task of constructing roads and helps with monitoring road usage but it is not well suited to providing information to inform decision-making about investments.

Information for investment decision-making needs to understand both the current and potential demand as well as what the least cost response to this demand is. MDL data has the potential to provide up-to-date information on the current level of demand for particular routes as well providing enough detail to assess the lowest cost investment. For example, by analysing the origin and destination locations of freight, a set of investments could be identified which could complete an open access freight network for high productivity vehicles.

Investment → reform funding → better quality roads

In this context better quality roads are improvements in roads which reduce road user costs. This is a combination of both vehicle operating costs and driver preferences (such as a preference for ride smoothness). At the moment, although there is a genuine attempt to provide quality roads in each jurisdiction, there is no feedback loop for potentially translating road quality preferences to level of road use.

The negative effects of a lack of a feedback loop on road quality are compounded by the fact that the amount of expenditure on road maintenance and refurbishment is currently based on uncertain future funding levels, meaning road authorities are not able to make optimal lifecycle decisions as they would in a more certain funding environment.

More closely aligning funding to the use of roads will encourage provision of a level of road quality which takes close account of the demands of road users as well as the whole of life costs of maintenance. That is, the reforms could encourage an economically efficient level of road maintenance.

Investment → reform funding → better investment decisions

The pricing reforms will allow for better information to be gathered which will allow road providers to make better decisions about what to invest in. In addition to this, the funding reforms will introduce an economic regulator with power to approve or reject investment, capital and maintenance expenditure programs. This will introduce a level of discipline in road investment which has not been widely present before.

As in other regulated industries, the remit of the economic regulator would allow it to approve investments which meet a cost benefit test (as well as necessary investments for issues such as safety and CSOs). The economic regulator will therefore act as a check to ensure that investments in road infrastructure are beneficial from an economic perspective. This will mean that heavy vehicle road users are not paying for unproductive and uneconomic investments.

Investment → reform funding → Access improvements

At the moment there are significant last-kilometre problems in Australia (although these vary from state to state and from region to region) as well as mass and vehicle restrictions on some major highways.

Although community concerns about the presence of large vehicles on particular roads can play a role in reducing access, consultations indicate that the main cause of access restrictions is that road providers (particularly local governments) have no guarantee of receiving any benefits from allowing access for larger vehicles but are certain of bearing the costs from having to maintain their roads. This leads to an asset protection rather than asset utilisation mentality when considering whether to allow access for heavy vehicles.

The asset protection mentality is a consequence of road funding not being tied to road use. The proposed funding reforms will help ensure that the incentives of road providers are better matched to the needs of the freight sector by aligning funding flows to the provision of access. Once this funding gap has been bridged, it is likely that road providers will move from a defensive position where they try to protect their assets towards an open access regime where they encourage use of their asset in order to generate funds for further road provision and maintenance.

Ultimately, more open access will result in vehicle operators being able to choose a mix of vehicles and routes which minimises freight costs.

Investment → reform funding → supply chain reorganisation

Changes in the pattern of access will allow for long-term reorganisation of supply chains to take full advantage of the benefits offered by higher productivity vehicles. For example, if access for B-triples or A-Doubles is achieved on an Australia-wide network we could see the development of large scale, specialised distribution centres on the edges of this network. At these distribution centres, larger vehicles could be broken down into smaller vehicles which could be used for distribution within enhanced B-double networks.

This change would create benefits discussed above in terms of reduced vehicle operating costs flowing from access improvements but would also create further supply chain benefits. This is because newer, larger logistics facilities have the potential to operate at lower costs than existing facilities. This cost saving will then flow through the supply chain as logistics acts as an input into most businesses.

Investment → reform road provision → Efficiencies in the provision of roads

The final benefit identified from the reforms is the potential for efficiency in the provision of roads. The proposed reforms will allow greater flexibility in the supply of road infrastructure through a better governance structure to regulate prices and improve investment decision-making. Under the reforms, a forward looking cost base will be established to ensure prices are cost reflective and incentivise timely investment.

Revenue certainty enabled through setting efficient prices will allow greater flexibility in approaches for the supply of roads to allow more efficient practices to emerge over time and could result in cost savings.

This is a similar outcome to that anticipated in other areas of microeconomic reform (such as telecommunications, electricity and water). In these industries, one of the main perceived benefits of microeconomic reform has been an increased focus on minimising costs of providing services.

Costs of investment reform

A significant cost of the investment reforms relate to any capital expenditure which may have to be made to enable access. While details on the type of investments that would be made are unknown, an estimate of increased expenditure is included.

This estimate was developed by taking the estimated capital expenditure in the CRRP feasibility study (2011) of $50m a year as the initial annual capital expenditure under option 1. Expenditure was then increased at average annual rates seen historically (1.7%) and scaled for the relative difference in access improvements under each option.

The total investment is then split for each state based on their historical share of total road expenditure with an adjustment for the extent of change in vehicle use patterns that have been modelled.

While the diagram and discussion above presents a simplified, linear picture of the proposed reforms there is actually a complex relationship between access, road quality, road wear and maintenance expenditure. Specifically;

- allowing access can increase road wear costs and lead to a need for additional maintenance expenditure; and
- given current maintenance budgets and road quality there may be a hesitancy to allow access due to risks of increased road wear.

This complex relationship is the cause of 'asset protection' mentalities towards restricting access. The methodology below incorporates calculations covering the first point but the second point is not directly addressed. Instead, it is assumed that the HVRR reforms will bridge the gap between road use, road maintenance and funding. That is, under the reform, the second concern will be eliminated as the potential additional road wear from allowing access will be compensated with access charges paid by heavy vehicles.

The model that we have developed seeks to, from a bottom-up perspective, account for the complex interaction between current freight task, state of roads, vehicle share, price elasticity and provision of access on a street by street basis and how these factors would evolve and interact with each other under the different reform options. In doing this, our model is capable of informing the net and distributional impact of reform options.

In terms of parameterisation, the biggest uncertainty lies around the intermediate behavioural effects of the reform. Determining how road users, road providers and regulatory agencies across different jurisdictions and industries will respond to the policy levers is complex. Ultimately, however, the accuracy of the cost-benefit and distributional analyses depends on accuracy and validity of the information used to determine these effects. Our approach to estimating these parameters is detailed below.

2.2 Valuing costs and benefits

2.2.1 Benefits

Demand-side response

The benefits from the charging reforms are driven by the demand—side behavioural responses they provoke, both in operators switching between vehicle types in response to the mass pricing and in switching routes in response to the locational aspects of the pricing. These changes have the potential to lead to gains through:

- a shift in the composition of the heavy vehicle fleet to more efficient vehicles, reducing the combined maintenance and vehicle operating costs; and
- where alternative routes are available, a change in route patterns towards roads more able to carry heavy vehicles at low cost.

Different access charging mechanisms can lead to different behavioural responses to manage the transport tasks which influences the degree of substitution between road and vehicles types. The considered end-states represent scenarios where the access charges are gradually transformed from the current static average cost based charges (based on PAYGO annual registration fee and a fuel-excised based charge) to a dynamic pricing models where the charges are aligned with the actual network and social costs of the specific commodities, transported. It is expected that introduction of optimised heavy vehicle charging schemes will stimulate the transportation market towards use of more efficient vehicles types.

The key factors linking road user charges and behavioural responses are, in this case, elasticities of substitution between heavy vehicle types and road use. The elasticities of substitution measures the percentage change in heavy vehicle fleet, and road use resulting from a given percentage increase in charges, and this determines the demand-side response of the reforms.

The 2013 CBA used the elasticities of substitution estimates that were developed by the Institute of Transport and Logistics Studies (ITLS), University of Sydney, as part of the CRRP (2011) feasibility study that examined the state of the road freight task in Australia. The ITLS (2011) study analyses how changes in road user charges affect the choice of vehicles and roads. As these elasticities are estimated in a highly disaggregate manner through a stated choice survey, it gives a rather realistic view of how freight distribution and logistics companies might respond to alternative road user charging policies.

To calculate the benefits from demand-side behaviour response to alternative access charges, the elasticities of substitution estimated by ITLS (2011) was then combined with changes in price path under each reform option to allow for the calculation of the changing composition of heavy vehicles and therefore changes in road maintenance costs and vehicle operating costs.

The ITLS has since updated their elasticities of substitution estimates for road freight in Australia in 2013. This CBA uses the updated 2013 ITLS elasticities of substitution estimates. These elasticities are set out in Appendix B.

A flow on benefit from changing the approach to heavy vehicle charging is that it may reduce the use of debt funding for registration charges. This benefit has been estimated using the same approach as the 2013 study relying on information on average gearing levels, average registration costs and market interest rates. Together these sources suggest that elimination of debt funding of registration charges could result in a reduction in total vehicle operating costs of around 0.2%. As benefits from the elimination of debt funding to pay registration charges were found to be quite small in the 2013 CBA, for this model update we have maintained the 0.2% reduction in vehicle operating costs that was estimated previously.

Better information gathering and investment decision-making

At the moment there is a great deal of dispersed data gathered on freight including Weigh-in-Motion (WIM) and Culway data, vehicle surveys and detailed information on the engineering aspects of road wear and strength. This information is useful for the technical task of constructing and maintaining roads and helps with monitoring road usage but it is not well suited to providing information to inform decision-making about investments.

Information required for infrastructure investments however is essentially different and requires data on the type and magnitude of transported freight as well as the supplied level of service provided by the infrastructure network for the transport task. This information is necessary for solving challenges such as planning additions to the road network, prioritising maintenance, and determining access to key facilities such as intermodal terminals and ports.

In the 2013 CBA, benefits from better information gathering and improved investment decision-making were both qualitatively addressed. For this CBA, we apply the same treatment.

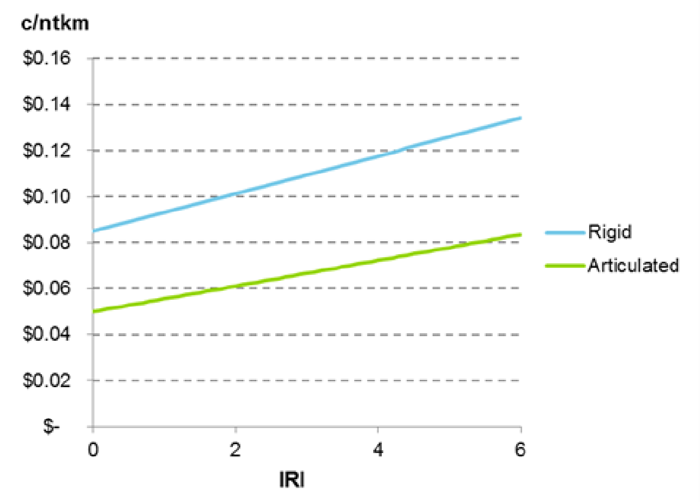
Better quality roads

Road quality has great influence on the cost of transport as it directly influences vehicle operating costs through the level of fuel consumption, vehicle speed and tire wear. Measurable indicators such as the International Roughness Index (IRI) are useful for assessment of road roughness and how that relates to vehicle operating cost.

The relationship between IRI and road vehicle operating costs is established in the Australian Transport Assessment and Planning (ATAP 2016) Guidelines. The ATAP Guideline sets a nationally consistent approach to estimating total vehicle operating costs with reference to vehicle type-specific coefficients, vehicle speed, IRI, and gross vehicle mass in tonnes. This Guideline represents the latest findings on the nature of the relationship between IRI and vehicle operating cost and replaces findings from Austroads

(1994) which was used in the 2013 CBA. Compared to research by Austroads which supports a strong non-linear relationship between road quality and vehicle operating costs, the ATAP Guideline supports a strong, linear relationship between road quality and vehicle operating cost.

Chart 2.1 Relationship between VOC and road quality



Source: ATAP Guideline (2016).

At the moment, there is a lack of incentive to provide a defined efficient level of road quality in each jurisdiction, as there is not an information feedback loop between road use and road quality. For example, if road users prefer a higher-quality road and are willing to pay for it, there is no formal way for road users and road providers to reach agreement on this mutually beneficial improvement. In 2014 the National Heavy Vehicle Regulator (NHVR) introduced the *Approved Guidelines for Granting Access* (2014). The Guidelines provide clarity on aspects of heavy vehicle access decision-making. However, as the guidelines do not provide additional incentives to grant access, anecdotal evidence suggests that they have not resulted in significant access improvements. The negative effects of a lack of a feedback loop on road quality are compounded by the fact that the quantum of expenditure on road maintenance and refurbishment is currently based on uncertain future funding levels, meaning road authorities are not able to make optimal lifecycle decisions as they would in a more certain funding environment.

More closely aligning funding to the use of roads will encourage provision of a level of road quality which takes close account of the demands of road users as well as the whole of life costs of maintenance. In response to this, the reform options are likely to result in a more economically efficient level of road quality being provided.

To determine the size of the economic benefit from improved road quality requires a view on:

- the degree to which vehicle operating cost reduces from improvements to road quality; and
- the optimal level of road quality based on the cost of road maintenance intervention.

To estimate the degree to which vehicle operating cost reduces from improvements to road quality, a simulation of potential road maintenance interventions to improve road quality, as measured by reduction in IRI, was undertaken to calculate the average reduction in vehicle operating costs from reduction in IRI of between zero to six units. This simulation is fully described in Appendix H of the 2013 CBA.

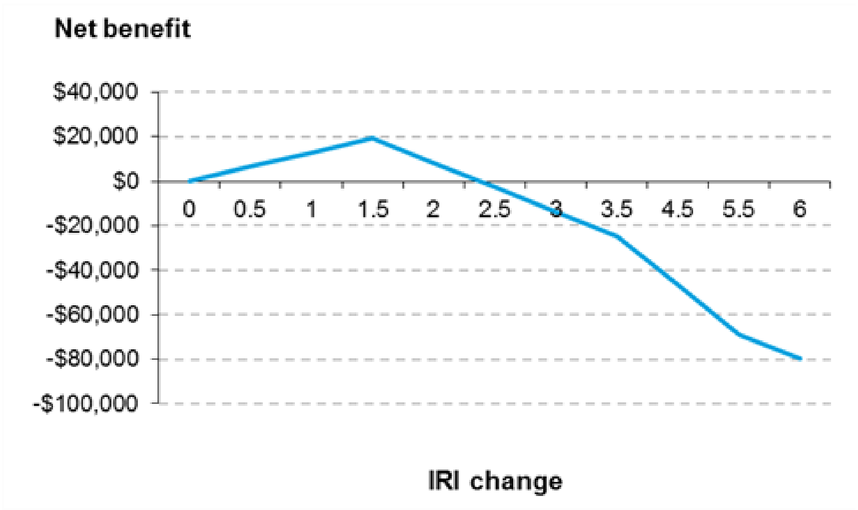
In the 2013 CBA, simulation of the average level to which vehicle operating cost reduces from improvements to IRI was undertaken on a sample of 29,000 road segments, based on data provided by states and using the non-linear relationship described in Austroads (1994). The optimal level of road quality was then determined by consulting with a range of stakeholders on the cost to improve road quality, expressed as cost per square metre to improve one unit of IRI. This cost was then compared to the benefits of a reduction in vehicle operating cost from reduction in IRI.

The 2013 analysis found that, for the most part, the road network was maintained at a level relatively close to the economically efficient level. However, there were particular segments of the road where quality improvements would generate net economic benefits. In most cases, the quality improvement was minor, usually zero to one IRI, to justify the cost of maintenance interventions. A literature review undertaken as part of the 2013 CBA supported this finding from the data (Austroads (2014), Hunt et al. (2004), Jeff Roorda and Associates (2010)).

For this CBA update, we maintained the same approach that was used in the 2013 CBA to determine the size of economic benefit from improved road quality but updated the statistical relationship used to run the simulation based on that set out in the ATAP Guideline. The sample size used to run the simulation and the state-level road maintenance intervention cost data that was used to determine the optimal level of road quality are unchanged in this CBA update.

We also reviewed recent literature and reached the same conclusion that improvements in road quality are beneficial in some specific parts of the road network but there is no significant economic value generated from improving road quality in all parts of the network (Office of Auditor General (2016), United States Department of Transportation (2004), Austroads (2016)). Literature review for this model update did not indicate any new reference sources on the costs of undertaking maintenance activity. There are, of course, situations where better quality roads can help reduce lifecycle costs of road maintenance but, in general, better quality roads are normally associated with higher costs. As an example of the results of this analysis, the figure below shows an illustrative example of the net benefits of IRI improvement for one segment of road. The results suggest that economic costs can be minimised by improving IRI by 1.5 unit. Similar analysis for other road segments indicate different results.

Chart 2.2 Net benefit of improving IRI on a particular road segment



Source: Deloitte 2017 analysis.

Based on the ATAG Guideline, a cumulative improvement of 8.5% (average reduction in IRI from 2.7 to 2.4 across states) over the period of the CBA analysis was applied to all reform options in this CBA update.

Access improvements

Access benefits accrue by allowing higher productivity vehicles to operate on existing roads. Changes in access can occur with roads in their current state, or may occasionally require upgrades that allow the movement of larger vehicles (this could include interventions such as strengthening bridges and widening turning areas). By allowing the use of higher productivity vehicles to use a wider range of roads where the benefits of doing so outweigh the costs, the total cost of the freight task is expected to decrease.

The difficulty in exhaustively mapping the potential access changes to Australia's road network precludes a complete reliance on a bottom-up approach to quantifying these benefits.

As a result, a top-down approach that estimates the likely extent of productivity gains was used, as the main input, to generate Australia-wide figures in the 2013 CBA. This top-down approach began with a forecast of potential productivity improvements from heavy vehicle road reform at a national level (BITRE

2011). This Australia-wide figure was then checked using a bottom-up approach and decomposed to a jurisdiction level based on a detailed data set of road access by different vehicle class for three states (NSW, VIC, and WA). This detailed analysis was extrapolated to other jurisdiction by analysing the rate of vehicle class adjustment that would have to occur in each jurisdiction to achieve the national results from BITRE (2011). This is the same approach that was used to establish the baseline in the 2013 CBA. For this CBA, we follow the same **top-down and then bottom-up approach** that was used in the 2013 study to establish the baseline forecasts of vehicle shares (discussed in detail in Section 3.1) and the potential access changes to Australia's road networks, and hence productivity gains that may potentially be achieved, under the five proposed reform options.

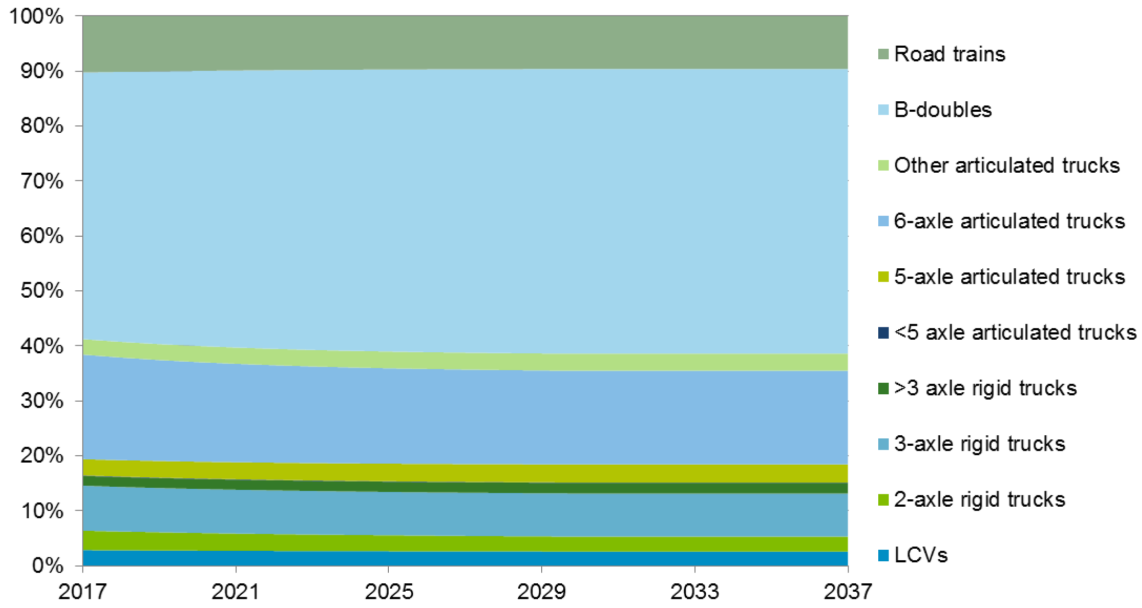
In the 2013 report, the degree to which the reform options would improve, at a high-level, the share of higher productivity vehicles used on roads was informed by work by BITRE (2011). In that report, BITRE analysed historical trends in road freight productivity growth, identifying major sources of productivity growth and explored the prospects for future productivity growth based on changes in the share of B-doubles and the introduction of PBS/HML policy mechanisms. The report is of particular interest as it focussed on the potential effects of improving access. In the forecasts, access was the major theme in informing future productivity growth, with predictions of future progress based on an analysis of the effects of Performance Based Standards (PBS) and Higher Mass Limits (HML) schemes on the use of higher productivity vehicles.

Put simply, from a **top-down perspective**, the maximum effect that access improvements could have on improving the efficient mix of heavy vehicles and road routes to reduce overall freight cost nationally was established by taking the baseline forecasts of vehicle use, vehicle type on roads and vehicle share and then apply the findings from the BITRE (2011) study by:

- assuming a higher share of B-doubles by extending the share of B-doubles in the baseline; and
- extending access to existing B-double network to B-triples, outside urban areas, and AB-triple access to road train routes on future truck-specific freight shares and fleet average loads to model the impact from introducing Performance Based Standards (PBS) and Higher Mass Limits (HML) schemes to encourage use of higher productivity vehicles.

A mixture of these two scenarios is appropriate for use in illustrating the maximum effect that access improvements could have on vehicle shares in Australian – under Option 3. This is because improvements in access could see a combination of a shift from B-doubles to B-triples on major routes and an extension of B-double operations on sub-arterial roads. This means that either scenario, on its own, will only capture part of the benefits of the reform. The assumed Australia-wide vehicle shares under a maximum change scenario are shown in Chart 2.3.

Chart 2.3 Forecast vehicle shares under Option 3 (Australia-wide)



Literature reviewed for this CBA update supported the direction and magnitude of economic benefits from access improvements estimated by BITRE (2011). In particular, the Austroads (2014) report assessed the direct and indirect benefits of increasing the mix of higher productivity vehicles from access improvements and the dispersion of direct benefits by State over the period of 2011-2030. The Austroads report found that direct benefits from use of higher productivity vehicles include: (1) reduced number of accident incidents (achieves 76% lower incidents than conventional trucks); (2) environmental benefit by reduced CO2 emissions (present value saving of $142 million on a carbon price basis); and (3) productivity savings (benefit defined in terms of number of trucks and kilometres reduced to undertake the equivalent articulated freight task).

Given this, this CBA modelling continues to use the BITRE (2011) estimates to establish the maximum level to which higher productivity vehicles will be used to 2030. Note that as forecasts of vehicle shares and freight task in the baseline extends only to 2030 (see Section 3), for years beyond 2030 we have assumed that vehicle shares remain fixed at the 2030 level.

A **bottom-up approach** is then used to test how the overall improved share of higher productivity vehicles from access improvements estimated under the top-down approach would likely be met at the jurisdictional level based on existing access requirements and freight use patterns. Specifically, the bottom-up analysis in the 2013 report involved the following steps:

1. using the Australian Bureau of Statistics (ABS) (2012) input output tables, identify the top road freight industries
2. gather a list of businesses in those industries and their locations
3. gather a list of roads with B-double (or higher) access in each jurisdiction
4. gather information on current freight use patterns in each jurisdiction using ABS Survey of Motor Vehicle Use (SMVU) (ABS 2016)
5. estimate a relationship between access and usage of B-double (or higher) vehicles
6. use this relationship to assess the level of access implied by BITRE’s overall vehicle share forecasts (from top-down approach described above)
7. re-allocate BITRE’s national vehicle share forecasts to each jurisdiction.

A critical assumption that underpins the bottom-up approach is that each state would transition gradually towards the vehicle composition seen in the later years of the Australian-wide forecast. The full details and conclusions of this bottom up analysis are set out in Appendix F.

For this CBA update, we continue to use the jurisdictional vehicle share forecasts that were established under a bottom-up approach for the 2013 CBA. However, we have updated the modelling with the most recent ABS SMVU to reflect detailed freight use patterns across jurisdictions to the 12 month period ending 30 June 2016 (ABS 2016). Note that the 2013 CBA had disaggregated freight use patterns across jurisdictions for the period from 2005 to 2007.

In relation to future efforts to map potential access changes to Australia's road network, it is worth noting efforts to improve road asset information. Heavy Vehicle Infrastructure Asset Registers (asset registers), published on the Transport and Infrastructure Council website provide information on key freight routes across Australia. The asset registers increase the transparency of service delivery to the heavy vehicle industry and enhance public understanding of the performance of the road infrastructure network. However, there are challenges in harmonising data across jurisdictions and gathering a breadth of data, for inclusion of a larger proportion of the road network.

Supply chain reorganisation

As road transport forms an input to many other industries, changes in the road industry have the potential to have widespread effects on supply chains. As with other areas of the analysis, there is only a small amount of empirical evidence to support parametrisation of the appropriate level of vertical scope and scale efficiency gains that could be achieved through the improved use of higher productivity heavy vehicles. Though the literature does support the positive impact a reduction in transportation costs has on supply chain efficiency gains. In a Transport for NSW (2015) report, it was found that overall economic benefits from transport cost reductions to passenger and freight transport due to transport program investments include: improved market access and agglomeration impacts, reduction in travel time and vehicle operating costs, efficiency gain from supply chain reorganisation and increase in inward investment.

In the 2013 CBA, the empirical evidence came from a review undertaken by the United States Department of Transport Federal Highway Administration (2004). This report found a 10% reduction in transport costs could be expected to result in an additional 2.4% reduction in supply chain costs. Benefits from supply chain savings was then captured in the CBA modelling by first estimating the annual reduction in vehicle operating cost that would be achieved under the reform options and then converting this into annual percentage reduction in vehicle operating costs to calculate the annual supply chain savings.

For this CBA modelling, updated empirical information on the size of supply chain savings that could be achieved from reduction in vehicle operating costs was available. In a study prepared for the Council of Supply Chain Management Professionals (CSCMP) it was found that investment in freight transportation infrastructure that reduces direct transportation costs by 10% will result in supply chain improvements in the form of reduction to company operating costs by 1% (Jacoby et al. 2008). This statistical relationship has been used in this CBA modelling.

Efficiencies in provision

Two types of efficiencies in road provision are likely to occur under the reform options: reduced expenditure from adopting a whole of life approach to pavement management, and, potentially, cost efficiencies from better governance and investment decision-making in the provision of roads.

Lifecycle road maintenance costs

The reforms are expected to bring increased certainty of funding to road providers by linking prices paid by road users to level of expected road use. In the 2013 CBA, consultation with stakeholders revealed that road providers currently face a high degree of uncertainty in funding for road maintenance with higher certainty available only over a single budgeting year or over a four-year budgeting cycle.

A demand-driven approach to funding would incentivise road authorities and road providers to make optimal lifecycle decisions in road maintenance planning and expenditure to minimise whole of lifecycle and road user costs instead of relying on uncertain funding cycles. That is, the reforms would encourage an economically efficient level of road maintenance.

In the 2013 CBA, road maintenance efficiencies from a whole of life approach were established in the theoretical literature and quantified using the benefits of pavement management systems. Pavement management systems allow road providers to monitor the state of their assets and to assess various approaches to maintenance. Using these systems to their full extent can deliver savings similar in nature to lifecycle approaches to maintenance. The literature on pavement management systems suggests savings in the order of 8.6-13.5% are possible.

In addition to the maintenance cost savings discussed above, maintenance expenditure was also adjusted for the mix of heavy vehicles using roads and the total amount of vehicle traffic that would occur. Having said this, the marginal road-wear cost is quite similar for different articulated vehicle classes. This means that there are relatively small savings in maintenance expenditure over time due to changes in the mix of vehicles. The 2013 CBA applied a 0.2% yearly reduction in maintenance expenditure from improved mix and volume of heavy vehicles.

For this CBA update, we found new information to support lowering estimated savings to a range of 5-13.5% from three sources. HoustonKemp (2016) estimated that adopting whole of life asset management strategies would generate savings of 5-13.5%. This lower bound is based on assumed improvements to funding certainty in which additional expenditure is available to address previous underspending in maintenance five years prior to commencement of the maintenance program. The World Bank's (2008) HDM-4 Queensland case study found that maintenance savings of 3.4 – 5.7% can be realised from whole of lifecycle approach to road maintenance. Tonkin Consulting (2015) estimated that for the City of Prospect in South Australia, a whole of life road management solution would result in a 24% reduction in surface asset depreciation and 30% reduction in pavement asset depreciation.

We therefore consider the range 5-13.5%, is the most reliable estimate of the benefits of pavement management systems. For this model update, we have incorporated information that the lower bound is likely to be at 5% and hence this has been included to update the percentage cost savings for Options 1A and 2A. For Options 1, 2 and 3 we have maintained the percentages cost savings used in the 2013 update to estimate the benefit of pavement management system. As a result, Option 1 uses 8.6%, Option 2 uses 10.23% (two-thirds weighting on the 8.6% value used for Option 1 and one-third weighting on the 13.5% value used for Option 3), Option 3 uses 13.5%, Option 1A uses the updated evidence and derives an estimate of 7.83% (two-thirds weighting on 5% and one-third weighting on 13.5%), Option 2A uses 13.5% (as it is assumed that the full hypothecation of revenues collected will be able to achieve improved lifecycle approach to maintenance of road quality).

Increased efficiency from better governance and investment decision-making

Improving the governance and mode of delivery of road supply, through establishing a forward looking cost base and a more predictable regulatory structure, can generate potential benefits in:

- achieving operating efficiencies;
- reduction in contractor mobilisation and demobilisation costs;
- reduced costs associated with delayed and cancelled projects;
- use of Longer-term contracting which will allow road agencies to plan more efficiently, and will also increase supply chain confidence in making investments with scope for greater private sector investment; and
- improved alignment of incentives between the supply and demand sides of the market.

In the 2013 CBA, a literature review of the operating efficiencies achievable with economic regulation (through establishing a forward-looking cost base), improved governance and privatisation internationally suggests that savings in the order of 7-38% could be achieved. However, the benefits of improved governance from aligning incentives to delivery of roads are less amenable to quantify, nonetheless, important to consider. The 2013 CBA did not specifically quantify the benefits from better governance and investment decision-making. Though a materially more conservative 15-25% efficiency gain from better governance and investment decision-making was tested in the sensitivity analysis.

For this CBA update, new information from the Productivity Commission (PC) Inquiry Report on Public Infrastructure (2014) supports the positive relationship better governance and investment decision-making has on efficiency gains in road provision. In particular, the Productivity Commission (PC) Report cites three studies where partial or full private involvement in infrastructure projects have achieved time and/or cost efficiencies. The case studies reviewed by PC include:

- Infrastructure Partnerships Australia examined 21 private public partnership (PPP) projects and 33 traditionally procured projects undertaken between 2000 and 2007. A combination of social infrastructure, transport, water and energy, and information technology projects were considered. PPP

projects were defined as a contracting arrangement in which private financing is involved, and traditionally procured projects were defined to include all non-PPP forms of contracting, including alliances and design-and-construct models. This study found that PPPs had an average cost overrun of 1.2% from contract stage to finalisation, compared to 14.8% for traditional methods, signifying a cost efficiency of 11.4% in favour of PPPs. Across the full period of the project from the original announcement, this cost efficiency was estimated at 30.8% (Allen Consulting Group 2007).
- the University of Melbourne examined 25 PPP projects and 42 traditionally procured projects between 2000 and 2007 in the categories of social infrastructure, transport, sustainability and information technology. PPPs were found to have an average cost overrun of 4.3% from the execution of contract compared to 18.0% for traditional projects, signifying a cost efficiency of 13.7% in favour of PPPs. This cost efficiency was estimated at 28.3% across the full period of the project (Duffield 2008).
- the UK National Audit Office examined 114 infrastructure projects between 2003 and 2008 spanning works in schools, hospitals, waste treatment, housing, prisons and roads. 65% of Private Finance Initiative (PFI) projects were completed to the contracted price compared to 54% of the non-PFI projects. In terms of time savings, 69% of PFI projects were delivered to the contracted timetable compared to 63% of non-PFI projects (United Kingdom National Audit Office 2009).

International examples provide further evidence of the potential benefits of 'supply-side' reform, including:

- early findings from a study of road cost drivers in New Zealand indicates a possible 20-25% efficiency gain across the NZ road network through better asset management data, modelling and management. This study is not yet finalised but will be watched closely by Australian Government officials. New Zealand has a direct charging system for heavy vehicle operators, with this revenue directly re-invested into roads in a fully transparent and accountable manner at arm's length from governments.
- in 1989 in the UK the provision of water and wastewater services was moved from the public to private sector. An economic regulator was created to control water bills and set service levels. Prior to reform the industry suffered from limited investments in assets, low quality standards and pollution incidents. Now consumers have improved standards of: water quality, drainage and sanitation.

For this model update, we follow the decision that was made in the 2013 CBA to not specifically quantify the benefit from better governance and investment decision-making in the economic modelling but consider the gain as part of sensitivity analysis, with the same range of 15-25% used.

2.2.2 Costs

The productivity benefits outlined above need to be weighed against the associated costs of the reforms, the main cost categories associated with implementing the reform options are:

- **vehicle monitoring costs** (i.e. the costs of installing/upgrading the technology required to implement the reforms);
- **user compliance costs** (i.e. the increased administrative burden associated with complying with the reforms);
- **government administration costs** (i.e. costs associated with additional administrative burden for government); and
- **capital investment costs** (i.e. the upfront capital expenditure required to enable access).

Vehicle monitoring and user compliance costs

In the 2013 CBA, the vehicle monitoring and user compliance costs were estimated based on figures produced in KPMG (2013) after adjustment for the vehicle stock estimated in the CBA model and were implemented in consultation with the heavy vehicle road charging and investment. For this CBA update, review of updated literature indicated findings in the KPMG (2013) study were similar to that observed in Germany, New Zealand and Switzerland.

It is worth noting that the KPMG (2013) estimate is likely a conservative estimate for the purpose of this update as technology has improved and vehicle monitoring and user compliance costs is likely to have decreased. However, without better and more recent data, this CBA update continues to apply the KPMG estimates that was applied in the 2013 study.

Government administration costs

Government administration costs were estimated using a bottom-up approach in the 2013 CBA, after taking into account the number of staff potentially required Australia-wide to implement the reform options and the implied additional administrative expenses these staff would generate. Administrative cost (such as buildings and technology) associated with employing each additional staff was based on the average overheads cost estimated by the Australian Public Service Commission (APSC) (2012). Updated 2016 overhead cost per staff estimates was available from the Australian Public Service Commission, and this new estimate has been applied in this CBA update (APSC 2016).

The total estimated number of additional staff that would be required under each reform option is presented in table below. For Options 1, 2 and 3, the same number of additional full time equivalent (FTE) positions around the country estimated in the 2013 CBA is applied in this model update. These figures were based on a bottom up estimate of FTE staff required for areas such as infrastructure investment decision-making, state transport agencies, local government and for economic regulation. While the total FTE staff required has been kept the same, the cost of these staff have been adjusted using current information on staff and agency costs from the Australian Public Service Commission.

For this model update, it is assumed that Option 1A and 2A will require a large increase in regulatory positions and so the same number of regulatory FTE is set to be the same as for Option 3. For Option 1A this is a conservative assumption as there is the possibility that regulation which only focuses on pricing and not broader economic performance may require fewer regulatory staff. For government administration and reform implementation, it is assumed that Option 1A will require the same number of FTE as Option 1 and Option 2A will require the same number of FTE as Option 2. Table 2.1 presents the number of additional FTE staff assumed for each reform option in the modelling.

Table 2.1 FTE required to implement reform options

	Estimated number of additional FTE required
Option 1	68
Option 2	138
Option 3	214
Option 1A	101
Option 2A	160

Source: DAE and HVCI

Capital investment costs

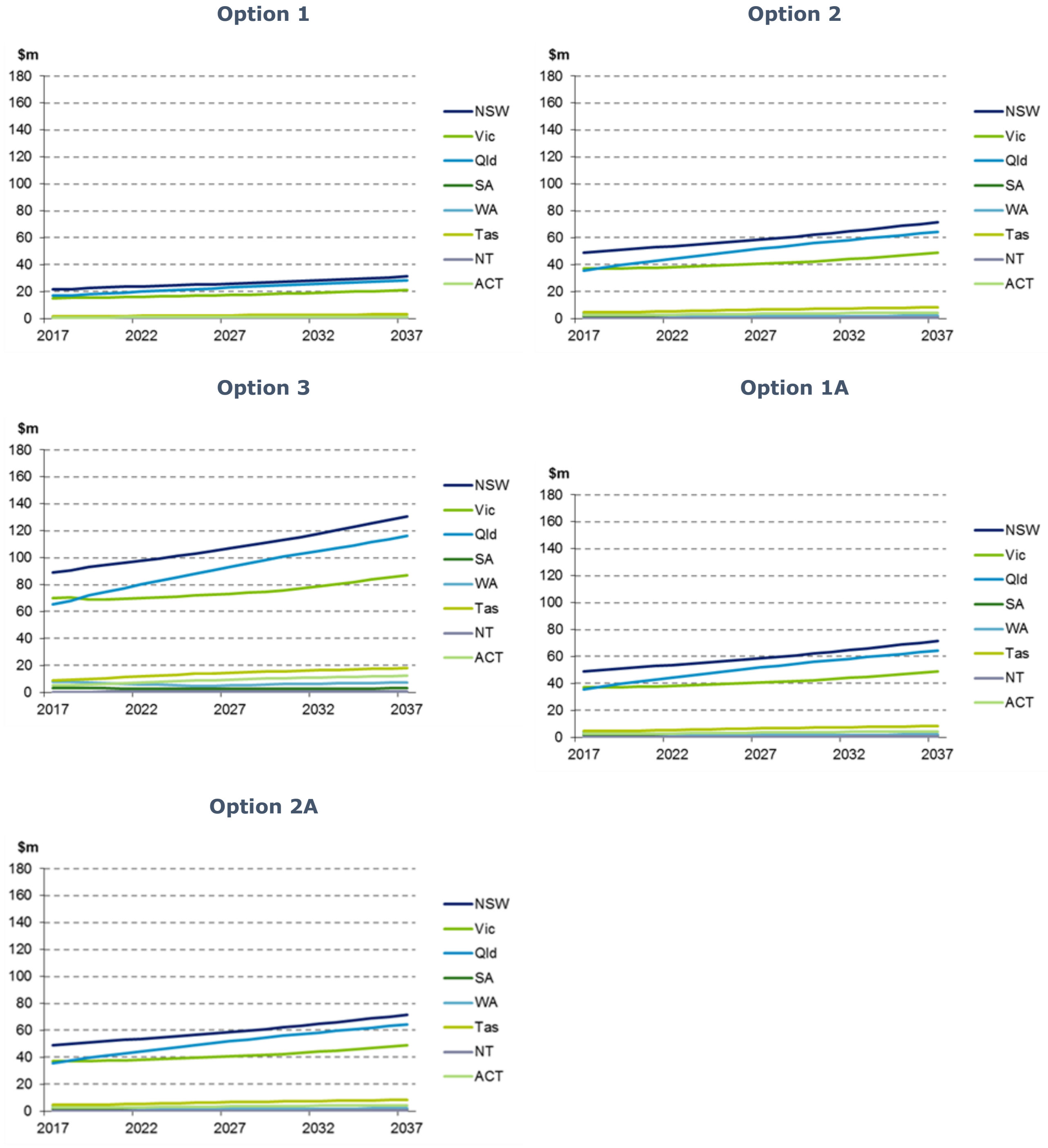
One of the main costs of the investment reforms relate to the capital expenditures, if any, which may have to be made to enable access. Without undertaking an in-depth engineering review of access restrictions on a case-by-case basis it is not possible to accurately estimate the precise costs of enabling access.

In the 2013 CBA, it was assumed that under Option 1, capital expenditure to enable access will be similar to that estimated in the CRRP feasibility study (initially around $50m a year Australia-wide). Expenditure was then increased at average annual rates seen historically (1.7%). Under Options 2 and 3 this expenditure was scaled up in line with the increased pace of vehicle share change (see Appendix G). The total investment was then split for each state based on their historical share of total road expenditure with an adjustment for the extent of change in vehicle use patterns relative to the national average.

For this CBA update, the same approach has been applied to estimate the amount of upfront capital investment that would be required to implement the supply-side reform required under each of the options. Specifically; capital expenditure required for reform implementation under Options 1 and 1A is similar to that estimated in the CRRP feasibility study, at around $50m a year Australia-wide initially, and then the expenditure increases at an average annual rate of 1.7%. Capital expenditure required under Options 2, 3 and 2A is then estimated by scaling up the capital expenditure level for Options 1 and 1A, by the relative pace of vehicle share change for Options 2, 3 and 2A.

A summary of the capital investment costs is set out in the chart below.

Chart 2.4 Additional investment in roads by states ($m)



Source: DAE (2017) analysis.

3 Comparing the baseline and reform options

3.1 Identifying the baseline

The first step of the CBA is to identify a realistic base case, what would occur in the heavy vehicle industry and broader economy if no regulatory reform was undertaken. Key aspects of the baseline include:

- the size of the freight task in terms of net tonne kilometres (NTK);
- the split of the freight task (by vehicle type);
- the size of the heavy vehicle fleet (by vehicle type);
- road maintenance expenditure;
- road quality;
- vehicle operating costs (VOC); and
- externalities.

A central part of estimating a reasonable baseline is to recognise that key aspects of the heavy vehicle industry and the road network are not fixed in time and will vary over the 20-year timeframe of the analysis. Accordingly, the baseline must not only estimate these dimensions in their current state, but also forecast them over the lifetime of the analysis.

For this modelling update, the approach used to establish the baseline has not changed from that used in the 2013 CBA. However, estimates underpinning the baseline has been updated based on recent publications.

Baseline estimates and forecasts in the 2013 CBA were mostly established based on infrastructure statistics and road freights estimates and forecasts from BITRE (2010) and BITRE (2012). Updated infrastructure statistics to 2015 is available from BITRE (2016a) for this CBA and the modelling has been updated with these estimates. In terms of road freight estimates and forecasts, BITRE (2016b) has released revised estimates to 2015. While this update does not change forecasts to 2030, it does change the baseline level estimates to 2015 used in the model. The modelling has been updated accordingly.

Detailed discussion of the methodological approach used to establish the baseline forecasts is presented in Appendix D.

3.2 Differentiating reform options

The approach outlined so far provides an estimate of the potential gains available to reform if it leads to the optimal management and use of the road network. To distinguish between options, it is necessary to identify the extent to which each option is able to achieve these benefits.

In principle, each option could allocate the same total quantum of funding to road management and hence the difference between options will depend on the mechanisms via which this funding is allocated efficiently and whether these mechanisms present decision makers with the optimal incentives. This is addressed against each of the key benefits below:

Efficient road use: requiring heavy vehicle operators to face the true marginal costs of their road usage will ensure that vehicles use selected routes only if the benefits of doing so outweigh the costs. This is expected to lead to a shift in routes and fleet composition, ultimately reducing maintenance costs and potentially affecting productivity. It is worth noting that, although governments have not agreed to light vehicle pricing at this time, efforts to transition to a more market based approach to road investment and charging would be expected to bring benefits for the entire road network over time. MDL pricing for heavy vehicles is the more effective mechanism to achieve this, and hence Options 2, 2A and 3 will see greater net benefits from the charging reforms, while Options 1 and 1A will confer some lesser benefits as appropriate. On the other end of the spectrum, in some cases, roads have the characteristics of a natural monopoly and so efficient pricing will require regulatory oversight to ensure only long run average costs for a forward looking cost base are recovered.

Optimal access decisions: under all options there will be some ability for road owners to better recover the costs associated with any changes to road access. However, large access benefits will require detailed information gathering and a close link between road use and road charges. This means that Options 2, 3, 1A and 2A will see greater access improvements while Option 1 will only see minor improvements.

Optimal maintenance and capital decisions: there is expected to be greater revenue certainty under all options and this will help ensure that maintenance decisions can be made based on optimal lifecycle management rather than current ad hoc revenue streams. The reduced VOC and road maintenance costs estimated will therefore be attributed to all options.

Administrative and compliance costs: there is likely to be an administrative burden of the reforms regardless of which option is pursued. However, the burden is expected to be higher under Option 3 than compared to other options. For this model update, it is assumed that Options 1A and 2A will require a large increase in regulatory positions and so the same number of regulatory FTE is set for Option 3. For Option 1A this is a conservative assumption as there is the possibility that regulation which only focuses on pricing and not broader economic performance may require fewer regulatory staff. In particular, Option 1 will use a low estimate of administrative costs while Option 3 will use a high estimate and Options 2, 1A and 2A will use estimates toward the middle of the range. The options are also differentiated based on the costs of vehicle monitoring.

Supply chain costs: as supply chain costs are estimated based on changes in vehicle operating costs, they will be higher when greater access improvements are achieved. That is, supply chain cost savings will be higher under all options except for Option 1.

In summary, the following approach has been used to differentiate between the options:

Table 3.1Approach to differentiating reform options

	Option 1	Option 2	Option 3	Option 1A	Option 2A
Access Prices	RUC	State-based distance charge differentiated by vehicle type (flexible mass distance pricing implementation)	Full static mass distance location based charge	Excise-based RUC	National-based distance charge with mass distance charge for heavy vehicles
Compliance costs	RUC based	As for Option 3 but without on-board technology	Cost to comply with full static mass distance location based charge	RUC based with on-board technology	Similar to Option 3 but require new payment system and telematics collection technology
Government Costs	$79 m (NPV)	$160 m (NPV)	$210 m (NPV)	$117 m (NPV)	$186 m (NPV)
Access benefits	Minimal departure from baseline	Initial step change with accelerated growth in access	Stronger initial step change with higher growth in access	Initial step change with accelerated growth in access	Initial step change with accelerated growth in access
Road investment	$567 m (NPV)	$1,309 m (NPV)	$2,428 m (NPV)	$1,309 m (NPV)	$1,309 m (NPV)
Maintenance efficiency	8.6%	10.2%	13.5%	7.83%	13.5%
Supply Chain benefits:	0.5% cost saving	0.9% cost saving	1.1% cost saving	0.8% cost saving	0.9% cost saving

Note: NPV presented in $2013 dollars. Source: DAE

Ultimately, the incentives faced by market participants largely determine the relative merits of these options. As a result, it is expected that total benefits will be higher under Option 3 as it better aligns the incentives of road users and road providers by providing and strengthening the incentives to both sides of the market to take into consideration the costs and preferences of the other side of the market, as cooperation can lead to more efficient outcome for both overtime.

4 Results

4.1 Modelling notes

There are a number of common modelling elements between the different reform options which are worth outlining before providing detail on the results:

- the analysis was performed over a 20 year time period, starting in 2017 when the proposed reforms would come into effect. This time period was selected to align the analysis with that undertaken for the National Heavy Vehicle Regulator RIS.
- real discount rates of 7% and 3% has been applied to derive the net present values (NPV) (see discussion below).
- NPV are presented in both $2013 and $2017 dollar terms. Note that presentation of modelling results in $2013 and $2017 dollar terms does not alter the relative benefits of costs of reform option but merely presents the net benefits based on the assumed year to which reform options are being appraised.
  - presentation of NPV in $2013 dollar terms is for ease of comparison to results from 2013 CBA; and
  - presentation of NPV in $2017 dollar terms is based on assumption that evaluation of reform options is undertaken in 2017.
- modelling was undertaken using 30 vehicle types but results are generally summarised into four vehicle types: light commercial, rigid, articulated and other.
- modelling was undertaken using three road types — local, arterial and highway — in line with the available data that has informed the development of indicative charging structures by MJA as a reasonable basis for modelling.
- two types of geographical location were modelled:
  - each jurisdiction was modelled separately; and
  - a rural and urban breakdown was incorporated for each jurisdiction.

Discount rate

The first set of results below uses a real discount rate of 7%; this is in line with requirements from the Office of Best Practice Regulation (2016) and Department of Finance (2006). The second set of results uses a real discount rate of 3%, more in line with social discount rates.

There is a strong case that discount rates for reforms such as those proposed by HVRR should be far below 7%. The proposed reforms are expected to generate a permanent transition in the use of heavy vehicles in Australia's economy. But, when using a discount rate of 7%, benefits of $1m in 2037 are valued at only $180,000 today. High discount rates therefore tend to make investments which generate a small level of ongoing benefits seem less appealing than investments which generate an initial, larger benefit but create no long term change to the economy.

The recommendation of using a 7% discount rate in Australia can be compared to recommendation in other countries. Hepburn (2007) reports the following recommended discount rates:

- Czech Republic: 1% for environmental projects;
- Denmark: 3% for environmental projects, 6% for other projects;
- USA: 3% up to 7%;
- UK: 3.5%, declining over time;
- European Commission: 4%;
- France: 4% declining to 2% for costs and benefits beyond 30 years;
- China: 4% for long term projects;
- Sweden 4%;
- Finland: 5%;
- Ireland: 5%;
- Slovak Republic: 5%;
- Spain: 5% for environmental projects;

- Canada: 10%; and
- New Zealand: 10%.

This research suggests that the requirements in Australia sit at the upper end of discount rates used internationally (only exceeded by Canada and New Zealand). This implies that the results below may understate the true nature of benefits from the reform as the use of OBPR's required discount rate, which is high in comparison to rates used internationally, gives little weight to reforms which generate ongoing benefits for the Australian economy.

4.2 Summary of net benefit

The overall net benefits from the reform options vary significantly but all five options present strong net benefits.

Table 4.1 Summary of costs and benefits ($2013 m) – 7% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	8,265	14,135	17,869	10,884	14,482
Costs (NPV)	1,814	3,193	4,613	2,545	2,938
Net Benefit (NPV)	**6,451**	**10,942**	**13,256**	**8,340**	**11,544**
Benefits					
Maintenance	4,377	5,562	7,691	4,378	7,212
Externalities	395	1,545	1,568	942	899
ATC Standard	173	1,054	541	387	864
Congestion and Accident	221	491	1,027	555	35
VOC	3,359	6,763	8,327	5,357	6,132
Supply chain	134	265	282	207	239
Total	**8,265**	**14,135**	**17,869**	**10,884**	**14,482**
Costs					
Data collection costs	41	343	548	0	219
Compliance & enforcement costs	371	624	671	371	477
Core system costs	323	323	323	313	313
Business support & administration	213	213	213	213	213
Road investments	567	1,309	2,428	1,309	1,309
Government Administration	79	160	210	117	186
Road quality improvements	221	221	221	221	221
Total	**1,814**	**3,193**	**4,613**	**2,545**	**2,938**
Periods of Analysis					
2017-2037	6,451	10,942	13,256	8,340	11,544
2038 and beyond	3,348	6,117	7,665	5,212	6,219
Total	**9,799**	**17,059**	**20,921**	**13,551**	**17,763**

Source: DAE (2017).

Table 4.2Summary of costs and benefits ($2017 m) – 7% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	10,834	18,528	23,422	14,267	18,983
Costs (NPV)	2,378	4,185	6,046	3,336	3,851
Net Benefit (NPV)	**8,456**	**14,343**	**17,376**	**10,932**	**15,132**
Benefits					
Maintenance	5,738	7,290	10,081	5,739	9,454
Externalities	517	2,025	2,056	1,235	1,178
ATC Standard	227	1,381	710	507	1,133
Congestion and Accident	290	644	1,346	728	45
VOC	4,403	8,865	10,916	7,022	8,037
Supply chain	176	347	369	271	314
Total	**10,834**	**18,528**	**23,422**	**14,267**	**18,983**
Costs					
Data collection costs	53	450	719	0	287
Compliance & enforcement costs	487	817	879	487	625
Core system costs	423	423	423	411	411
Business support & administration	279	279	279	279	279
Road investments	744	1,716	3,182	1,716	1,716
Government Administration	103	210	275	153	243
Road quality improvements	290	290	290	290	290
Total	**2,378**	**4,185**	**6,046**	**3,336**	**3,851**
Periods of Analysis					
2017-2037	8,456	14,343	17,376	10,932	15,132
2038 and beyond	4,389	8,018	10,047	6,832	8,151
Total	**12,844**	**22,361**	**27,423**	**17,763**	**23,283**

Source: DAE (2017).

In the results above, potential externality benefits from a reduction in road accidents and congestion are included as a separate item. This is because these externalities do not form part of the recommended externality values quoted in the ATC Handbook (2006). However, recent guidelines from Transport for NSW (2016) provide a basis for estimating congestion and accident externalities.

The tables below presents the results at a 3% discount rate:

Table 4.3 Summary of costs and benefits ($2013 m) – 3% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	15,019	25,738	32,667	20,343	26,217
Costs (NPV)	3,241	5,550	7,915	4,506	5,124
Net Benefit (NPV)	**11,778**	**20,188**	**24,752**	**15,838**	**21,092**
Benefits					
Maintenance	7,506	9,599	13,223	7,603	12,377
Externalities	838	2,986	3,229	2,011	1,774
ATC Standard	345	1,880	996	776	1,567
Congestion and Accident	493	1,106	2,232	1,235	207
VOC	6,417	12,662	15,693	10,334	11,617
Supply chain	258	491	523	396	449
Total	**15,019**	**25,738**	**32,667**	**20,343**	**26,217**
Costs					
Data collection costs	58	545	864	0	345
Compliance & enforcement costs	771	1,193	1,251	771	929
Core system costs	522	522	522	518	518
Business support & administration	425	425	425	425	425
Road investments	966	2,230	4,134	2,230	2,230
Government Administration	133	270	354	198	314
Road quality improvements	364	364	364	364	364
Total	**3,241**	**5,550**	**7,915**	**4,506**	**5,124**
Periods of Analysis					
2017-2037	11,778	20,188	24,752	15,838	21,092
2038 and beyond	20,251	36,997	46,362	31,523	37,613
Total	**32,029**	**57,184**	**71,114**	**47,361**	**58,705**

Source: DAE (2017).

Table 4.4 Summary of costs and benefits ($2017 m) – 3% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
20 year period of analysis					
Benefits (NPV)	16,903	28,968	36,767	22,897	29,507
Costs (NPV)	3,647	6,247	8,908	5,071	5,768
Net Benefit (NPV)	**13,256**	**22,721**	**27,859**	**17,826**	**23,739**
Benefits					

	Option 1	Option 2	Option 3	Option 1A	Option 2A
Maintenance	8,448	10,803	14,882	8,557	13,930
Externalities	943	3,361	3,634	2,263	1,996
ATC Standard	388	2,115	1,121	873	1,763
Congestion and Accident	555	1,245	2,512	1,390	233
VOC	7,223	14,251	17,663	11,631	13,075
Supply chain	290	553	588	446	506
Total	**16,903**	**28,968**	**36,767**	**22,897**	**29,507**
Costs					
Data collection costs	66	614	972	0	388
Compliance & enforcement costs	868	1,343	1,408	868	1,046
Core system costs	588	588	588	582	582
Business support & administration	478	478	478	478	478
Road investments	1,088	2,510	4,653	2,510	2,510
Government Administration	149	304	399	222	353
Road quality improvements	410	410	410	410	410
Total	**3,647**	**6,247**	**8,908**	**5,071**	**5,768**
Periods of Analysis					
2017-2037	13,256	22,721	27,859	17,826	23,739
2038 and beyond	22,792	41,640	52,180	35,479	42,334
Total	**36,048**	**64,361**	**80,039**	**53,305**	**66,073**

Source: DAE (2017).

Considering the source of benefits in each of the reform options:

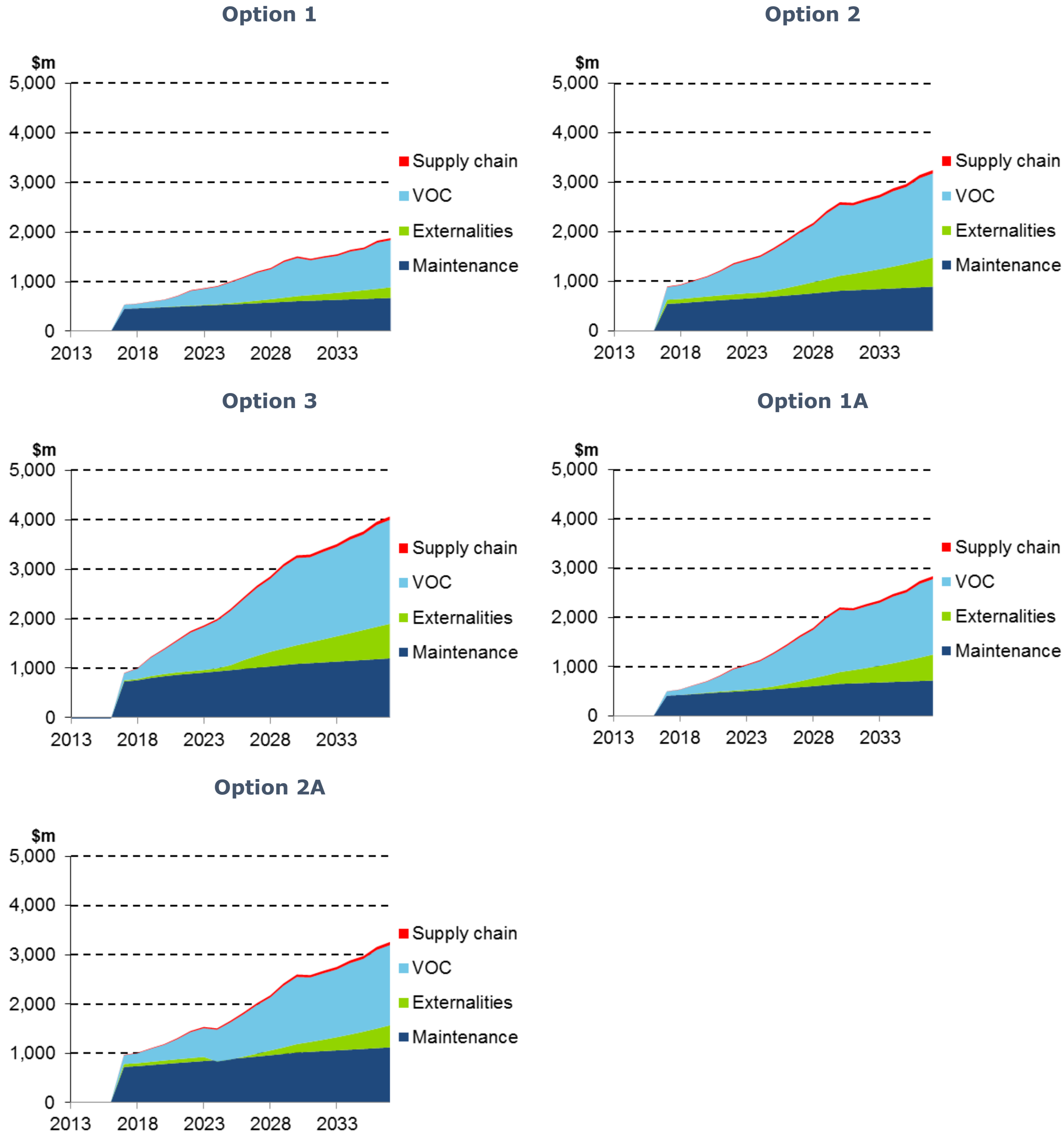
- in Option 1, the main source of benefits is from reduced maintenance expenditure. In particular, there are significant externality cost savings associated with Option 1 while it has relatively minor benefits in terms of supply chain cost reduction.
- in Options 2, 3, 1A and 2A, reductions in vehicle operating costs flowing from access improvements are significant and comparable in magnitude to maintenance efficiencies. Compare to Options 1, 1A and 2A, Options 2 and 3 achieve the highest benefit, on a relative basis, from reduced externality costs. Options 2, 3, 1A and 2A also see higher additional benefits in the supply chain compare to Option 1 as businesses re-organise to take advantage of higher productivity vehicles.
- Option 1 has lower source of benefit from vehicle operating costs for a combination of reasons. The charging arrangements in Option 1 mean that there is a looser link between road use, payments by road users and funding for road providers. On the supply-side this will not be able to create as strong incentives for improving access as are expected under the other options, in particular Option 3. On the demand-side this may create less incentive for efficient vehicle use patterns (such as ensuring that trailers are fully utilised).
- the difference in costs under each of the options is also significant. While the core systems and business support costs are estimated to be the same under each of the reform options, there is large variation in costs related to vehicle monitoring, user compliance and the level of investment in roads.

Considering how results from this updated modelling differ from results presented in the 2013 CBA:

- the results for Options 1, 2 and 3 are different from the results in the previous report and the results for Options 1A and 2A are different from the results for Options 1, 2 and 3. Understanding the reasons for these differences is complex due to a number of changes in inputs as well as interactions within the modelling. In terms of inputs, the main changes have been to values such as vehicle operating costs, the relationships between road quality and VOC, externalities, elasticities for vehicle use choices, current vehicle use shares and underlying cost assumptions (such as maintenance costs and administrative staff costs).
- comparing the results for Options 1, 2 and 3 to previous analysis, the main driver of changes comes through adjustments to current vehicle use patterns, this affects the benefits of increased access, as well as changes in vehicle operating costs. As a result of these changes there are flow on changes to the expected costs and benefits of the proposed reforms. For example, different vehicle use patterns result in changes to the level of capital expenditure required and also changes in the supply chain benefits. It's also important to note that the previous analysis presents values from the point of view of 2013 (where the reform was still four years away) while the current analysis presents results from the point of view of 2017 (where reform is expected to commence shortly). Tables are provided where updated results are presented in terms of dollars of 2013 to allow for a direct comparison between this report and the previous analysis (see Section 4). In particular:
    - comparing the results for Option 1 to the previous analysis (Option A), key changes to Option 1 are: higher benefits from reduction in vehicle operating cost, supply chain efficiency gains, reduction in congestion and traffic accidents, and lower government administration costs; and these are partially offset by higher capital investment cost and lower savings from lifecycle maintenance. Overall, net benefit for Option 1 increased in this update compared to the previous analysis.
    - comparing the results for Option 2 to the previous analysis (Option B), key changes to Option 2 are: higher benefits from reduction in vehicle operating cost, supply chain efficiency gains, and lower government administration cost; and these are partially offset by higher capital investment cost, lower savings from lifecycle maintenance and lower reduction in traffic externalities. Overall, net benefit for Option 2 increased in this update compared to the previous analysis.
    - comparing the results for Option 3 to the previous analysis (Option C), key changes to Option 3 are: higher benefits from reduction in congestion and traffic accident externalities, lower government administration and data collection cost. However, these are not sufficient to offset lower benefits from lifecycle maintenance, vehicle operating cost reduction and supply chain efficiency gains and higher capital investment costs. Overall, net benefit for Option 3 decreased in this update compared to the previous analysis.
- comparing the results for Options 1A and 2A to the results for Options 1 and 2, benefits in terms of improvements in access are the same for Options 1A, 2 and 2A. This suggests that access improvements under Option 1A are expected to be higher than under Option 1 and reflects improvements in the outlook for access since the previous analysis, including since the establishment of the National Heavy Vehicle Regulator. For Option 2A, maintenance benefits are expected to be greater than under Option 2 due to the fact that Option 2A would implement hypothecation more extensively. However, there is an offsetting force that Option 2A involves nationally averaged vehicle charges while Option 2 involves charges that are differentiated at the state level. A nationally averaged charge lowers the benefits from efficient use of vehicles as prices cannot be as accurately matched to costs. On net, the increased maintenance benefits more than offset the decreased vehicle efficiencies.

The sources of benefits for each reform option are shown in the diagrams below for the 7%discount rate case at $2013 dollar terms.

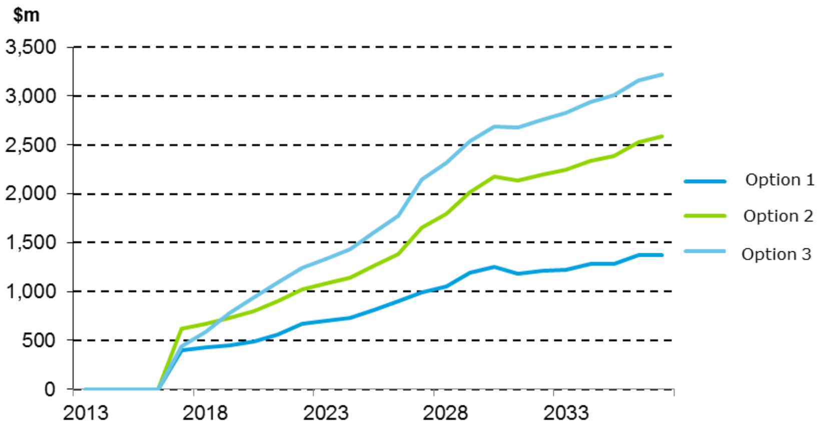
Chart 4.1 Sources of benefits (7% discount rate, $2013 dollars)

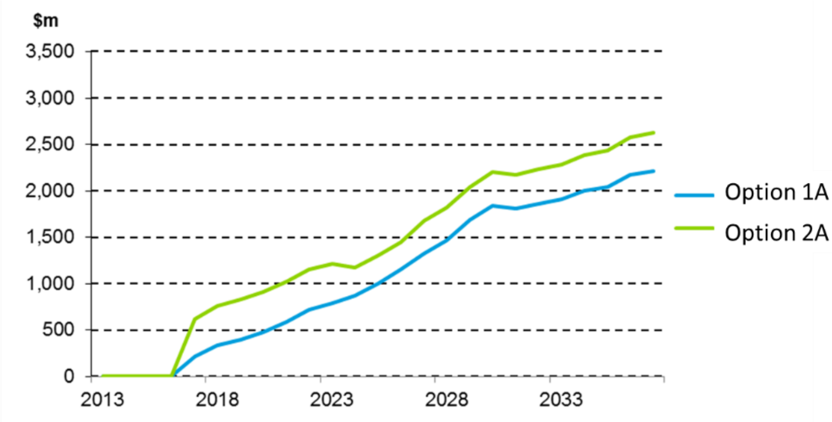


Source: DAE (2017).

Combining the costs and benefits gives the estimated net benefits of the reform options, shown below. The strong growth in net benefits in all options except for Option 1 during the period from 2018-2030 reflects the large changes in vehicle use patterns occurring in this period. In the period beyond 2030 benefits remain fairly stable as changes in vehicle use patterns are assumed to be constant – that is, the transition towards increased access and the use of more efficient vehicles that is induced by this has run its course to a new, stable level.

Chart 4.2Annual net benefits of reform (7% discount rate, $2013 dollars)





Source: DAE (2017).

Consistent with the theoretical framework of a CBA, this CBA has assessed the benefits and costs of the HVRR reform with reference to five potential end-states of the HVRR. This report provides a framework for evaluating the possible states of the world under the HVRR reform – with each associated with different levels and distribution of net impact across jurisdictions and varying capability in achieving the HVRR reform objective - improve the long run efficient provision and use of road services. Results from this CBA are useful in identifying the types of outcomes that may be achievable under each reform option and the elements of the reform that are more critical than others to achieving the overall objective of the HVRR reform.

It is also worth considering how these costs and benefits align with the implementation plan proposed by HVRR. Much of the costs to be faced by road users (such as compliance and administration) will not be made until supply-side changes have been committed and many of the supply-side changes are underway. This significantly reduces the risks for road users in meeting the costs associated with the reform as they essentially get to follow on a path of reform that is already well underway. The vast bulk of economic benefits will be achieved as supply-side are made with indirect externality benefits to be felt upon improvements to road quality and access.

Realisation of the net benefit estimated for each reform option rests heavily on the assumption that the supply-side reforms will be implemented successfully and in a logical and practical manner across jurisdictions over time to achieve the benefits at a national level. Under the current baseline, there are differences across jurisdictions in the definition of heavy vehicle revenue and expenditure, investment reporting standards, asset maintenance practices, methodology for translating heavy vehicle charges to investment expenditure, and derivation of average level of expenditure and revenue requirement. All of these differences will need to be addressed at a national level for the successful implementation of an economic regulation framework. These issues are critical in determining the role, objective, responsibility, and scope of the regulator's function and power.

As identified by the Transport and Infrastructure Council (2016), a phased approach to supply-side reform is required. The first stage of the reform will require improvements to data collection to improve transparency around expenditure, investment and service delivery. The second stage of the reform will require establishment of a formal approach for governments to develop a forward looking plan on road expenditure and investment, to ensure access and road service provisions on key freight routes are concurrently improved nationally. Each stage will involve a set of activities to understand and define the current issues and then to identify and test the optimal approach for addressing the current issues in alignment with the proposed reform. Maximisation of the benefits achievable under each reform option requires endorsement from governments and industry on each phase of the reform.

Having said this, analyses of the risks to implementation and the optimal sequencing of reform elements, in particular the supply-side reforms, proposed under each option are beyond the scope of this CBA. This CBA has not assessed the degree to which realisation of the net benefit measured for each option will be affected by reform complexity and the level of jurisdictional and organisation change required. As such, results from this CBA should not be interpreted as conclusive of the only optimal approach to implementing the HVRR. For example; there is potentially alternative cost-effective or lower risk reform options to achieving the same outcomes; and/or that as the HVRR reform is implemented, elements to a reform option may need to be changed or merged with components of other option(s).

Overall, there are clear benefits to reforming heavy vehicle road charging and investment, with the level of benefit and types of outcomes achievable dependent on the reform option selected. Ability to realise the full suite of benefits identified under each option is critically dependent on the reform being successfully implemented at the supply-side and that the industry actually takes up the reform and changes their behaviour overtime to meet the requirements of the reform at the demand-side.

4.3 Net benefit by jurisdiction

A data-driven approach has been used to disaggregate the CBA results, to estimate expected reform benefits by jurisdiction, based on current freight use patterns, stock and mix of vehicle types, road stock and use, maintenance expenditure and other demand—side and supply-side factors. The fundamental driving forces behind the estimated net benefits for each jurisdiction are the same as those discussed for the overall CBA. Estimated benefit for each jurisdiction is presented below.

Table 4.5 PV of net benefits of reform, by state ($2013 m) (7% discount rate)

State	Option 1	Option 2	Option 3	Option 1A	Option 2A
NSW	1,820	3,851	3,732	2,437	3,407
Vic	1,675	2,399	3,448	2,276	2,656
Qld	2,002	3,273	4,689	2,470	3,828
WA	437	626	402	482	709
SA	334	437	571	433	636
Tas	80	266	206	122	151
NT	87	74	145	96	137
ACT	16	16	63	22	20
Total	**6,451**	**10,942**	**13,256**	**8,340**	**11,544**

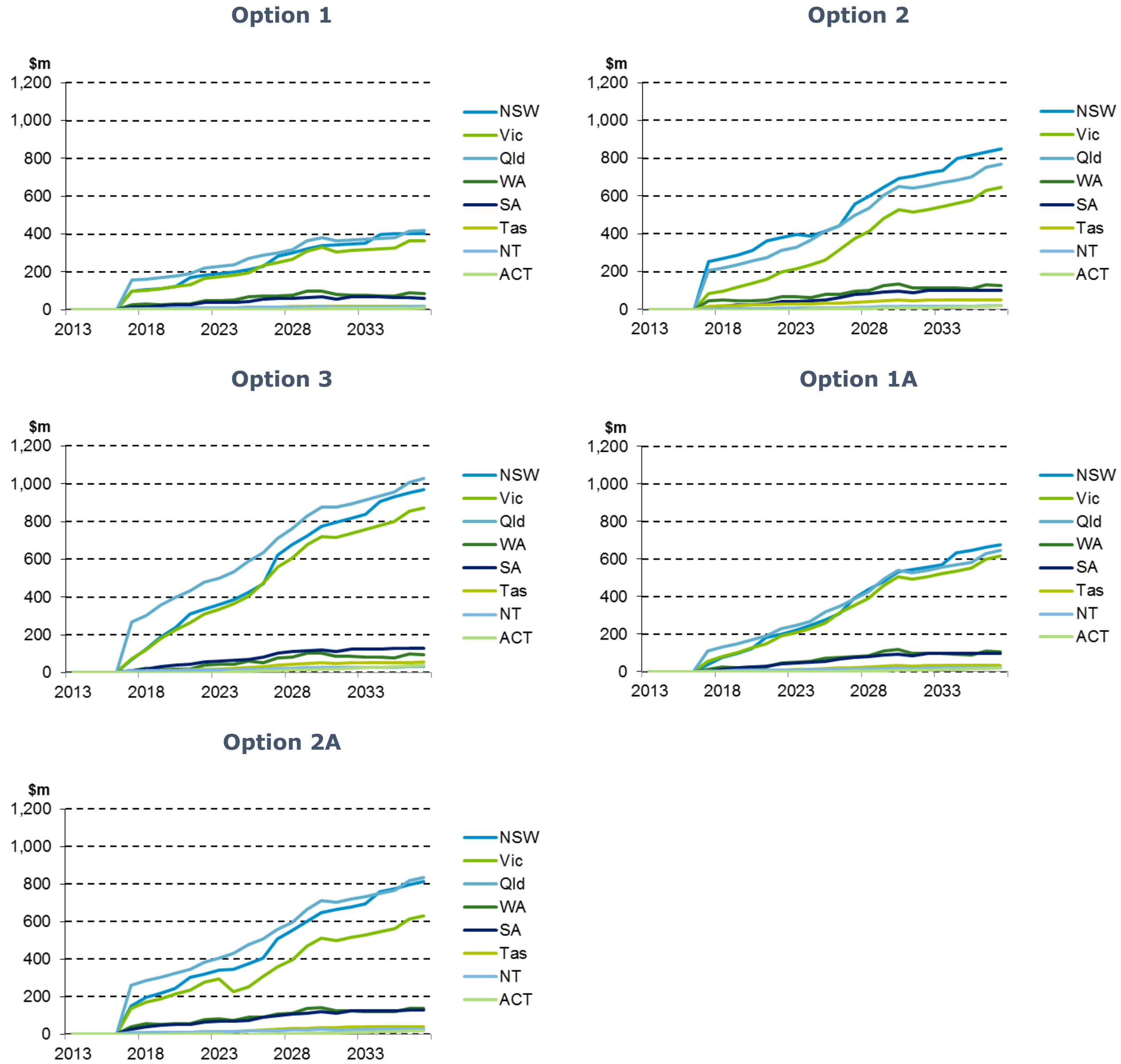
Source: DAE (2017).

Table 4.6 PV of net benefits of reform, by state ($2013 m) (3% discount rate)

State	Option 1	Option 2	Option 3	Option 1A	Option 2A
NSW	3,336	6,977	7,060	4,656	6,273
Vic	3,040	4,528	6,473	4,306	4,837
Qld	3,657	6,060	8,582	4,689	6,972
WA	798	1,134	763	897	1,268
SA	610	824	1,070	815	1,155
Tas	152	478	402	244	292
NT	154	139	261	176	246
ACT	31	48	142	54	49
Total	**11,778**	**20,188**	**24,752**	**15,838**	**21,092**

Source: DAE (2017).

Chart 4.3 Annual net benefits by jurisdiction (7% discount rate, $2013 dollars)



Source: DAE (2017).

There are large differences between the states but the driving factors of the different results can be roughly grouped as follows:

- **Queensland, New South Wales and Victoria**
  Qld, NSW and Victoria are responsible for the bulk of benefits estimated. This not only reflects the fact that they are responsible for a large portion of the nation's road freight task but also that they currently have lower levels of access and use less efficient vehicles than more northerly and westerly states.

  For these states there are maintenance benefits but the bulk of benefits come from shifts out of general access vehicles and into B-doubles and B-triples. In practice, this could be thought of as line-haul freight on the east coast moving more towards the use of B-triples on appropriate roads with distribution in metropolitan areas relying more heavily on B-doubles.

- **Western Australia, Northern Territory and South Australia**

Western Australia and the Northern Territory see lower levels of benefit from the proposed reforms. Both of these states currently sit above the average level of access and type of heavy vehicle use that occurs around Australia and so it is expected that the proposed reforms would mostly see a shuffling of vehicle use patterns between road-trains, B-Doubles, B-Triples and AB-Doubles rather than wholesale change in the type of vehicles that are being used. Both states do, however, see significant maintenance savings. Similar access and planning outcomes will be delivered in South Australia and Western Australia under the proposed reform. However, a slightly higher per capita benefit will be realised in South Australia. South Australia currently has a relatively good access framework and the proposed reforms will improve access level in South Australia further to that between NSW/VIC and WA.

These states are also likely to see benefits that are not captured in the figures given above. These benefits include the ability to make better investment decisions due to better information flow from road users to road suppliers. That is, under the reform options, road suppliers should face incentives that reward them for providing the level and type of service that their customers demand. This alignment of incentives can lead to a close alignment between the demand and supply side of the market in terms of investment decisions, service quality and the overall type of product supplied, creating benefits for road users.

- **ACT and Tasmania**
  ACT and Tasmania see little benefit from the propose reforms. Although these states have relatively low levels of access and so use relatively inefficient heavy vehicles, the modelling outlined in Appendix F suggested that it would be difficult for these two states to achieve the patterns of heavy vehicle use that are seen in larger states. As such, although there is a strong shift in these states towards more efficient vehicles, it is simply not as large as that seen in other states. This limits the total quantum of benefits that can be achieved from the reform in either state.

5 Sensitivity analysis

5.1 Variation tested

In the CBA itself we have normally attempted to take an average or conservative approach in order to provide a reasonable estimate of the scale of benefits expected from the reform. However, it is important to recognise that changes in some of these inputs could have consequences on the overall net benefits estimated from the reforms. For example, in the case of maintenance efficiency gains from better governance and investment decision-making, if significant efficiencies can be generated then this could make the reforms far more appealing. The range of sensitivity analyses undertaken are summarised in the table below:

Table 5.1 Sensitivity analysis inputs

	Baseline	Sensitivity 1	Sensitivity 2
Road train elasticity of substitution	As in CRRP study	Set to zero	
Maintenance efficiency gains	Lifecycle: Varies Corporatisation: 0% Total: Varies	Lifecycle: Varies Corporatisation: 15% Total: Varies%	Lifecycle: Varies Corporatisation: 25% Total: Varies%
Road quality in baseline	Deterioration of 0.015 IRI per year	Deterioration of 0 IRI per year	Deterioration of 0.03 IRI per year
Investment in roads and government costs	Varies by Option	Options 1,2,3 set to Option 1 Options 1A,2A set to Option 1A	Options 1,2,3 set to Option 3 Options 1A,2A set to Option 2A
Access benefits	Varies by Option	Options 1,2,3 set to Option 1 Options 1A,2A set to Option 1A	Options 1,2,3 set to Option 3 Options 1A,2A set to Option 2A

The motivation for these sensitivities is drawn from a number of different sources:

- elasticities: concern was raised about the reliability of this figure, removing it will provide an estimate of the over benefits without including benefits related to this figure.
- maintenance efficiency: there was considerable variability in the literature on maintenance efficiencies. This range reflects that seen in the literature.
- road quality in baseline: the baseline modelling included an assumption and this range tests the influence of this assumption on the results.
- investment in roads and government costs: these costs are estimates and so the range of possible estimates is tested.

5.2 Results from sensitivity analysis

The results of the sensitivity analysis based on inputs tested are presented in tables below.

Table 5.2 Sensitivity analysis results (NPV in $2013 m) at 7% discount rate

	Option 1	Option 2	Option 3	Option 1A	Option 2A
NPV - Baseline	$6,451	$10,942	$13,256	$8,340	$11,544
Road train elasticity of substitution					
NPV - Sensitivity 1	$6,453	$10,942	$13,256	$8,340	$11,544

Maintenance efficiency gains					
NPV - Sensitivity 1	$14,060	$18,492	$20,722	$15,886	$19,093
NPV - Sensitivity 2	$19,133	$23,525	$25,699	$20,916	$24,126
Road quality in baseline					
NPV - Sensitivity 1	$5,043	$9,526	$11,844	$6,930	$10,131
NPV - Sensitivity 2	$8,013	$12,512	$14,822	$9,904	$13,112
Investment in roads					
NPV - Sensitivity 1	$6,451	$11,765	$15,247	$8,340	$11,613
NPV - Sensitivity 2	$4,459	$9,774	$13,256	$8,271	$11,544
Access benefits					
NPV - Sensitivity 1	$6,451	$8,897	$6,666	$8,340	$10,797
NPV - Sensitivity 2	$13,123	$9,423	$13,256	$9,085	$11,544

Source: DAE (2017) analysis.

Overall, most of the detailed assumptions (such as road quality and elasticities) do not have a significant effect on the estimated net benefits. The largest movements are seen under the maintenance cost savings sensitivity and the access benefits sensitivity. In the case of maintenance savings, the NPV can increase by up to $13 billion while in the case of the access benefits sensitivity the NPVs become fairly different between the reform options, this suggests that the level of access benefits are the main differentiating factor between the Options.

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Appendix A Reform options

Table A.1 Attributes of reform options

	Option 1	Option 2	Option 3	Option 1A	Option 2A
Charging mechanism	National fuel based charges. • Greater emphasis on RUC rather than fuel-excise – • RUC as revenue collection mechanism, applying the charge not as a reduction in the fuel excise rebate but as an additional fuel charge in order to avoid the cap imposed by the fuel excise rate, incorporating the use of forecast cost and demand data, RUC at least equal to road wear and capacity increase. • Limited possibility to adjust RUC as it remains fuel based.	State-based distance charge, • Vehicle type dependent state charges (and mass to some extent but not like option 3), • Allowing a degree of differentiation of charges for different vehicle types	State-based mass distance charge, • Initially using static mass-based charging with the potential to move to dynamic mass-based charging as technology becomes cheaper.	National fuel-based charges • Excise based RUC. • Limited possibility to adjust RUC as it remains fuel based.	A partial market model with national-based distance charge: • Vehicle type dependent national charges (with mass distance based charges only apply to HV) • No dynamic weight to pricing: direct user charge for HV distributed by broad band of mass categories among vehicle classes
Supply-side reform	• Revenue held as it currently is by governments (partial hypothecation) • Limited access improvements • Independent economic regulator oversees prudent and efficient costs and sets charges based on forward looking cost base.	• Revenue hypothecated to state based road funds. • Extended access improvements • Independent economic regulator oversees prudent and efficient costs and sets charges based on forward looking cost base.	• Revenue hypothecated to state based road funds. • Significant access improvements • Independent economic regulator oversees prudent and efficient costs and sets charges based on forward looking cost base.	• Revenue held as it currently is with potential to direct some revenue back to local governments to encourage increased access • Extended access improvements • Independent price regulator sets charges based on forward looking cost base.	• All state territory road related revenue (including light vehicle revenues) hypothecated and earmarked to state based-independent road funds. • Extended access improvements • Independent economic regulator oversees prudent and efficient costs and agreed levels of service, and sets charges based on forward looking cost base.
exemptions	• Light weight vehicles exempted	• Light weight vehicles exempted	• Light weight vehicles exempted	• Light weight vehicles exempted	• Light weight vehicles are exempted, however light vehicle charges (fuel excise) are hypothecated to road funds.

	Option 1	Option 2	Option 3	Option 1A	Option 2A
Governance and spatial differences	National & Prices averaged, • Excise based RUC – split between RUC and Rego shifting towards RUC • Nationally averaged charges – i.e. cross subsidies across vehicle types, road types and jurisdictions. • Small regional fee charge.	State based & Prices averaged by state and no reflection of costs on other states. • Significant reduction of registration fee. • Charges averaged by jurisdiction - no difference in price paid on different road types within the jurisdiction.	State based & Prices reflects spatial LOS • Significant reduction of registration fee. • State-based charges conditioned to LOS.	National & Prices averaged • Excise based RUC – split between RUC and Rego as per current baseline. • With additional charges for incremental access. • Nationally averaged charges. • No change to proportion revenue from registration fee charge	National & Prices averaged • Significant reduction in registration charges. • Nationally averaged charges - no difference in price paid on different road types nationally. • A nationally agreed LOS • (Community Service Obligation).
PPP-aspects	• PPP as in baseline	• Strong financial incentive to provide better access	• Strong financial incentive to provide better access	• PPP as in baseline	• Strong financial incentive to provide better access
Technology need	• Require new general payment system	• Require new payment system (vehicle based) • Require vehicle telematics	• Require new payment system (vehicle based) • Require vehicle telematics	• Technology for vehicles that want to opt-in for additional access (this would already be available at the state level)	• Require new payment system (vehicle based) • Vehicle telematics promoted • Paper-based system as back-up
Data for planning	• Improved transparency in data collected for decision-making	• Usage data owned by operator	• Assurance that road user data will only be used for charging	• Improved transparency in data collected for decision-making	• Improved transparency and better data-collection for decision-making

Note: Options have been shaded based on level of benefit. Lighter shades reflect lower net benefit and darker shades reflect higher net benefit.

Appendix B Update to evidence base

This Appendix summarises findings from this literature review update and highlights the pieces of evidence included in the 2013 modelling which has been updated for this CBA modelling.

Table B.1 Summary of literature review findings

Model aspect	2013 Model treatment/input	2017 literature review findings
Establishing baseline		
Travel by type, travel by state, vehicle shares, road and vehicle stock	1. BITRE (2012) "Australian Infrastructure Statistics – Yearbook 2012". 2. BITRE (2010) "Road freight estimates and forecasts in Australia (1972 to 2030): interstate, capital cities and rest of state".	Baseline estimates updated in 2017 report based on following publications: 1. BITRE (2016) Australian Infrastructure Statistics Yearbook is available. 2. BITRE has released updates to estimates of road freight task in Australia to 2015-16. While this update does not change forecasts to 2030, it does change the baseline level estimates to 2015/16 used in the model.
Options benefits/costs estimation		
Demand-side response	Estimated potential benefits from pricing and funding changes (elasticities). Elasticities estimated used in model were from CRRP (2011) Feasibility Studies report.	Updated elasticity estimates available from a 2013 study prepared by the Institute of Transport Logistic Studies at The University of Sydney.
Better information gathering and investment decision-making	Qualitatively addressed the benefit from better information for decision-making on investments.	N.A.
Better quality roads	Economic impact modelled by making detailed assessment of optimal maintenance intervention based on data provided by jurisdictions. Inputs sourced from: 1. Austroads (1994), "Review and Enhancement of Vehicle Operating Cost Models Assessment of Existing Models" 2. Hunt, P. D. and Bunker, J. M. (2004). Roughness deterioration of bitumen sealed pavements. In Gordon, Ron and Robertson, Neil and Kazmierowski, Tom, Eds. Proceedings 6th International Conference on Managing Pavements, Brisbane, Australia. 3. Jeff Roorda and Associates (2010) The Local Roads Funding Gap – Study of Local Roads Funding in Australia 1999-2000 to 2019-2020, report prepared for the	Reviewed findings from literature and found that new research present results and findings that are similar in direction and magnitude to that incorporated in the 2013 study. 1. The 2017 report will not update 2013 inputs used but will update discussion of the benefits based on literature reviewed. 2. Relevant literature reviewed include: 3. Office of the Auditor General. (2016). Maintaining the state Road Network Follow-on Audit. Available online: https://audit.wa.gov.au/reports-and-publications/reports/maintaining-state-road-network-follow-audit/. 4. United States Department of Transportation. (2004). Freight Transportation Improvements and the Economy. 5. Austroads. (2016). Reforming Remote and Regional Road Funding in Australia.

Model aspect	2013 Model treatment/input	2017 literature review findings
	Australian Local Government Association.	
Access improvements	Economic impact modelled by making assessment of transition in vehicle shares based on BITRE (2011) forecasts and expenditure estimates developed from CRRP feasibility study. See; BITRE. (2011). Truck productivity: sources, trends and future prospects. Available online: http://www.bitre.gov.au/publications/2011/report_123.aspx	Reviewed findings from literature and found that new research present results and findings that are similar in direction and magnitude to that incorporated in the 2013 study. The 2017 report does not update 2013 inputs used but updates discussion of the benefits based on literature reviewed. Relevant literature reviewed include: 1. Austroads. (2014). Quantifying the benefit of higher productivity vehicles.
Supply chain reorganisation	Economic impact modelled by making assumptions of percentage reduction in supply chain cost due to investment in transport programs which lead to reduction in overall transportation cost. Input sourced from: United States Department of Transportation. (2004). Freight Transportation Improvements and the Economy.	Benefits from supply chain reorganisation will be updated in 2017 report based on: 1. Jacoby, D. & D, Hodge. (2008). Infrastructure investment: the supply chain connection. Council of Supply Chain Management Professionals.
Efficiencies in provision	Economic impact modelled by making assumption on whole of life management costs and pavement management systems and corporatisation benefit6s.	Reviewed findings from literature and found that new research present results and findings that are similar in direction and magnitude to that incorporated in the 2013 study. The 2017 report does not update 2013 inputs used but updates discussion of the benefits. Relevant literature reviewed include: 1. Harvey, M. (2016). Deriving benefit-cost ratios for road maintenance spending from an optimisation model, prepared for the Bureau of Infrastructure. 2. Tonkin Consulting. (2015). City of Prospect – Approach to whole of life road management. 3. HoustonKemp. (2016). Paving the way for road reform in Australia: High level assessment of benefits and costs. 4. Productivity Commission. (2014). Inquiry Report on Public Infrastructure.
Vehicle monitoring costs & user compliance costs	Economic impact modelled using KPMG (2013) estimates.	Reviewed findings from literature and found that new research present results and findings that are similar in direction and magnitude to that incorporated in the 2013 study. The 2017 report does not update 2013 inputs used but updates discussion of the benefits. For example; the total vehicle monitoring costs are similar to that observed in Germany, New Zealand and Switzerland.
Government administrative costs	Economic impact modelled by using a bottom-up approach to take account of the number of staff potentially required in each jurisdiction across Australian and level of administration costs involved.	The 2017 report does not update 2013 staff requirement inputs used but updates the level of administration cost involved per staff based on data from the Australian Public Service commission.

Model aspect	2013 Model treatment/input	2017 literature review findings
		See; APSC. (2016). Statement of Comprehensive Income, Labour cost as share of total 2015-16.

Appendix C Elasticities of substitution

Table C.1 Elasticities of substitution between vehicle class kilometres travelled (VKT) and access charges ($/km)

	Rail	R11	R12	R22	R11T11	R12T11	R12T12	R22T22	A112	A122	A123	A124	B12333	B1232	B1233	A123T23	A123T23T23
Rail	-0.00925	0.00022	0.00037	0.000825	0	0	0	0	0	0.000235	0.00018	0	0.00016	0.000275	0.00021	0.001615	0.00012
R11	0.000265	-0.14608	0.02409	0.000365	0	0	0	0	0.00124	0.00001	0.00092	0	0	0	0	0.001125	0
R12	0.00032	0.01774	-0.12782	0.009858	0.00001	0.00201	0.000095	0	0.000775	0.00426	0.002163	0	0	0	0.000065	0	0
R22	0.0003	0.000118	0.00431	-0.04632	0.00003	5.25E-10	0	0	0	0	0.000783	0	0	0.00001	0	0	0
R11T11	0	0	0	0.00002	-0.08508	0	0.0010425	0.012285	0	0	0	0	0	0	0	0	0
R12T11	0	0	0.000235	1.25E05 0		0.06085 0		0	0	0	0	0	0	0	0	0	0
R12T12	0	0	0.0000125	0	0.00038	0	-0.173975	0.025493	0	0	0.00003	0	0	0	0	0	0
R22T22	0	0	0	0	0.011083	0	0.0644475	-0.15381	0	0	0	0	0	0	0.000305	0.000605	0
A112	0	0.000195	0.000165	0	0	0	0	0	-0.3293	0.00588	0.000835	0	0	0	0	0.001328	0
A122	0.002115	0.00001	0.006108	0	0	0	0	0	0.038688	-0.1881	0.01527	0	0	0.01064	0	0.002143	4.25E-05
A123	0.00382	0.002085	0.006595	0.005473	0	0	0.00081	0	0.011815	0.025667	-0.2967	0.195175	0.005155	0.013913	0.025348	0.00618	0.01419
A124	0	0	0	0	0	0	0	0	0	0	0.024008	-0.80887	0	0.006233	0.00019	0.000443	0
B12333	0.04505	0	0	0	0	0	0	0	0	0	0.001163	0	-1.0363	0.00391	0.013923	0.04332	0.057605
B1232	0.025935	0	0	0.00003	0	0	0	0	0	0.005628	0.00524	0.018923	0.006508	-0.51624	0.01264	0.00064	0.01103
B1233	0.00618	0	0.000318	0	0	0	0	0.004958	0	0	0.039778	0.0024	0.09687	0.069067	-0.39744	0.052398	0.019828
A123T23	0.01383	0.001035	0	0	0	0	0	0.002463	0.007438	0.003953	0.002478	0.00147	0.076793	0.025397	0.013315	-0.78315	0.076043
A123T23T23	0.000285	0	0	0	0	0	0	0	0	0.00002	0.004758	0	0.08425	0.00902	0.00421	0.062868	-1.15296

Source: ITLS (2013).

Note: An example is that given a 1% increase in the price of a rigid 2 axle truck (R11), the VKT for this vehicle class will decrease by -0.14608% while the VKT for a 3 axle rigid (R12) will increase by 0.02409%.

Table C.2 Elasticities of substitution between vehicle class tonne kilometres travelled (TKM) and access charges ($/km)

	Rail	R11	R12	R22	R11T11	R12T11	R12T12	R22T22	A112	A122	A123	A124	B12333	B1232	B1233	A123T23	A123T23T23
Rail	-0.0116	0.00015	0.000255	0.000535	0	0	0	0	0	0.0002	0.00017	0	0.00016	0.0005	0.00025	0.002645	0.00007
R11	0.000175	-0.03486	0.005095	0.000218	0	0	0	0	0.000515	0	0.000398	0	0	0	0	0.000345	0
R12	0.000225	0.003745	-0.03924	0.0034	0	0.000735	2.25E 05	0	0.00016	0.001178	0.00116	0	0	0	0.00005	0	0
R22	0.0002	0.00007	0.001485	-0.02025	0.00001	0.00002	0	0	0	0	0.0005	0	0	0.00001	0	0	0
R11T11	0	0	0	0.00001	-0.07817	0	0.001003	0.01223	0	0	0	0	0	0	0	0	0
R12T11	0	0	8.75E 05	7.5E 06	0	-0.0229	0	0	0	0	0	0	0	0	0	0	0
R12T12	0	0	0	0	0.000363	0	-0.08756	0.012885	0	0	2.75E 05	0	0	0	0	0	0
R22T22	0	0	0	0	0.011013	0	0.032695	-0.12099	0	0	0	0	0	0	0.00036	0.001063	0
A112	0	8.25E 05	0.000035	0	0	0	0	0	-0.17879	0.002878	0.00056	0	0	0	0	0.000415	0
A122	0.00189	0	0.001693	0	0	0	0	0	0.01897	-0.11721	0.010345	0	0	0.007663	0	0.00081	1.25E 05
A123	0.00356	0.000895	0.003538	0.00349	0	0	0.000745	0	0.00792	0.017323	-0.31946	0.165255	0.006205	0.010323	0.039178	0.003728	0.031005
A124	0	0	0	0	0	0	0	0	0	0	0.020308	-0.94762	0	0.008418	0.000185	0.000453	0
B12333	0.04421	0	0	0	0	0	0	0	0	0	0.0014	0	-2.57755	0.003273	0.015193	0.09005	0.254815
B1232	0.03067	0	0	0.00002	0	0	0	0	0	0.00403	0.003918	0.025575	0.00545	-0.49291	0.013175	0.000823	0.023483
B1233	0.01153	0	0.000235	0	0	0	0	0.00592	0	0	0.061563	0.002395	0.10588	0.074408	-0.46486	0.075978	0.044215
A123T23	0.01294	0.000323	0	0	0	0	0	0.00435	0.002338	0.001265	0.001513	0.00152	0.160933	0.048797	0.0193	-1.36178	0.1744
A123T23T23	0.00018	0	0	0	0	0	0	0	0	6.67E 06	0.010475	0	0.373713	0.019038	0.009363	0.143718	-2.72523

Source: ITLS (2013).

Note: An example is that given a 1% increase in the price of a rigid 2 axle truck (R11), the TKM for this vehicle class will decrease by -0.03486% while the TKM for a 3 axle rigid (R12) will increase by 0.005095%.

Appendix D Establishing the baseline

Key aspects to establish the baseline include estimating:

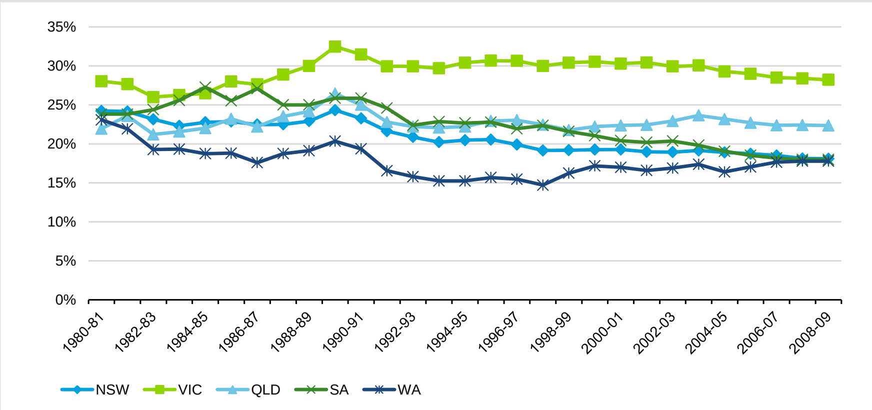
- the size of the freight task in terms of net tonne kilometres (NTK);
- the split of the freight task (by vehicle type);
- the size of the heavy vehicle fleet (by vehicle type);
- road maintenance expenditure;
- road quality; and
- vehicle operating cos.

D.1. Size of the freight task in NTK

Forecasts from BITRE have been used for the overall freight task, particularly NTK. For example, NTK by state and vehicle type has been modelled to 2030 based on BITRE's publication *'Road freight estimates and forecasts in Australia'*. That publication provides a forecast of road freight broken down by geographic area. The forecasting methodology is based, primarily, on growth in gross state product (GSP) as well as historical shares between different geographic regions. In previous projects we have undertaken a thorough review of this forecasting methodology and consider that it provides reasonable forecasts which are internally consistent. The BITRE forecasts also seem to align well to implied freight task estimates from other forecasting exercises undertaken by other agencies (such as port throughput).

Note on urban vs. rural travel

There appears to some recent trends in the nature of urban vs. rural travel, measured in NTK. For example, in South Australia, the last 15 years have shown a gradual decline in urban versus rural travel:



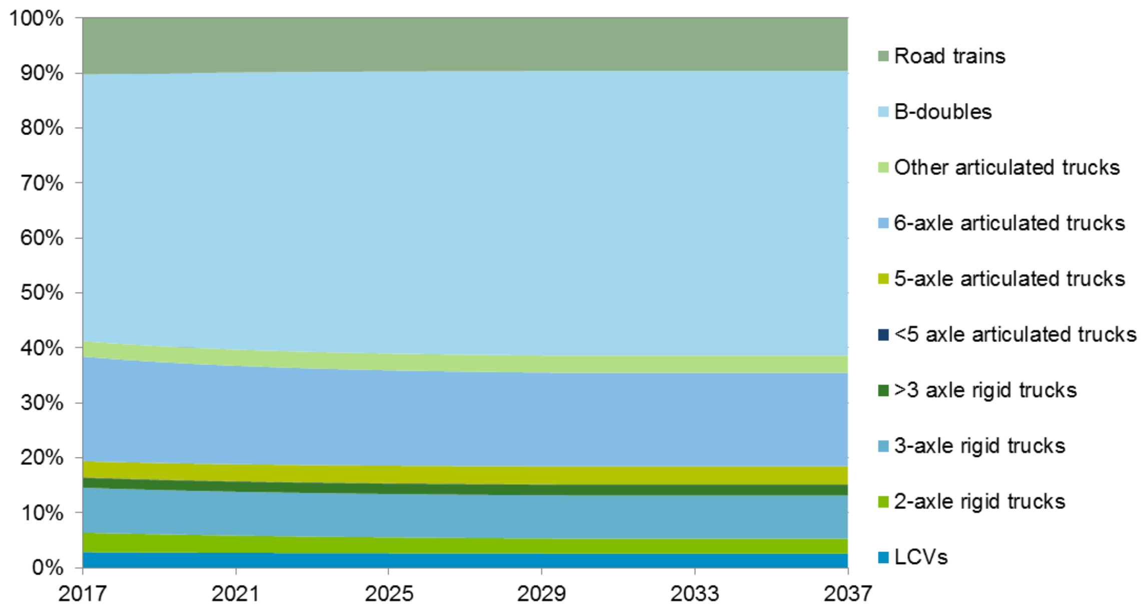
In cases such as this, historical trends were extrapolated but greater weight was given to more recent years. This was done in order to better capture recent trends.

D.2. Split of the freight task between vehicle types

An additional BITRE (2011) report *'Truck Productivity: Sources, trends and future prospects'* was used as a starting point to estimate baseline vehicle shares over the forecast period. That report is largely based on a detailed econometric analysis of historical vehicle shares, vehicle operating costs and regulatory controls. We have reviewed the underlying results of BITRE's econometric analysis and consider them to be sound, for example BITRE's empirical analysis finds that an increase in mass limits leads to increased mass but not generally by as much as the limit is increased. The approach also produces forecasts of vehicle shares which match *a priori* expectations. For instance, the share of B-doubles is forecast to increase in coming years but to level off over time as the market becomes saturated. From a practical point of view, the analysis undertaken by BITRE is ideally suited to the current task as it presents forecasts of vehicle shares at a highly disaggregated level. The assumed Australia-wide vehicle shares under the base case are shown in Chart D.1.

It is important to note that the BITRE forecasts extend to 2030. For years beyond 2030 we have assumed that vehicle shares remain fixed at the 2030 level.

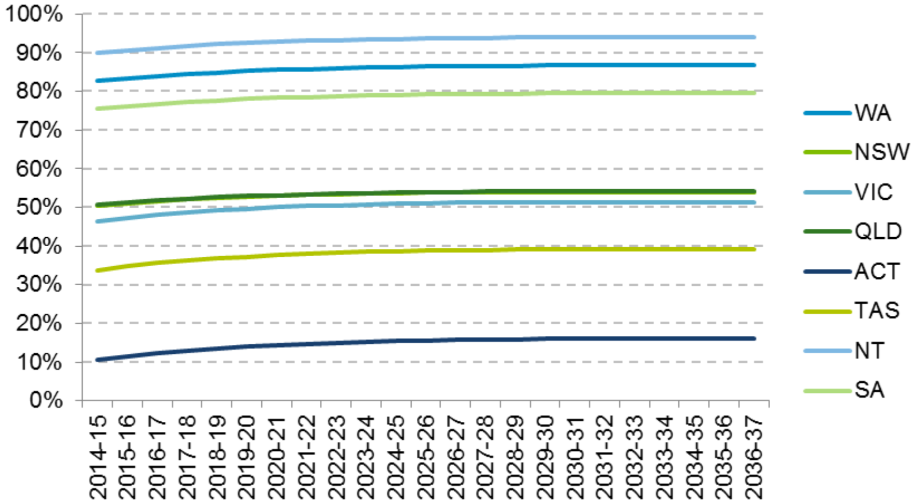
Chart D.1 Forecast Australia wide vehicle shares under an optimal access scenario (NTK)



Source: BITRE (2010) (2016) and DAE

The BITRE report was able to provide Australia wide shares for each vehicle type. These were then broken down into more detailed forecasts for each state and at a more disaggregated vehicle class using data from the ABS Survey of Motor Vehicle Use (SMVU). In essence, the methodology took data on average vehicle shares and the total freight from 2005-2007 for each state from the SMVU. For each state, this base was then grown at a rate which allowed the overall national shares from the BITRE report to be achieved. The critical assumption in making this calculation was that each state transitioned gradually towards the vehicle composition seen in the later years of the Australia-wide forecast. As an example, the chart below demonstrates the modelled transition path for vehicles below B-double and B-double or greater in size.

Chart D.2 Modelled transition paths for each state to achieve overall baseline BITRE forecasts



This approach allowed us to develop detailed vehicle share forecasts for each state. These are shown in Appendix G.

D.3. The size of the heavy vehicle fleet

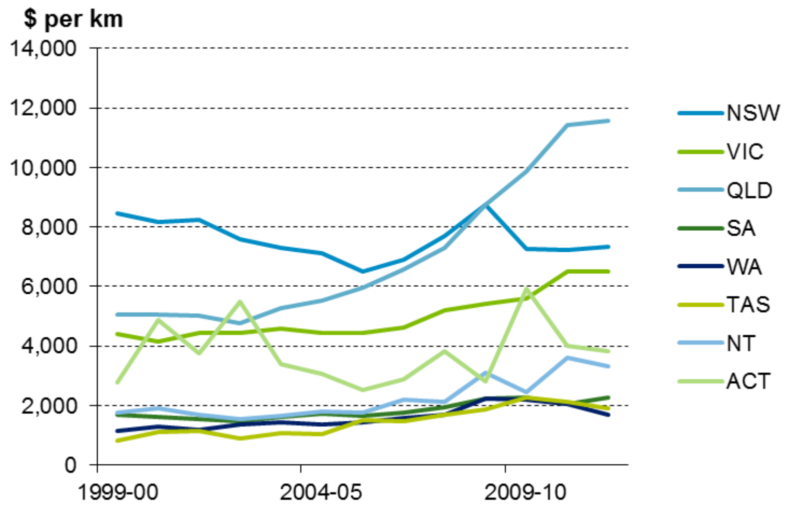
Many other modelling parameters can then be forecast from the state and vehicle level NTK figures. For example, the vehicle stock is forecast by taking current vehicle registration data and extrapolating it based on projected NTK and the average travel per vehicle type.

D.4. Road maintenance expenditure

Some historical data analysis was undertaken on average maintenance expenditure per kilometre of road in each jurisdiction. This analysis was based on NTC data on road maintenance expenditure, which covers routine maintenance, periodic surface maintenance, bridge maintenance and rehabilitation, and road rehabilitation. That NTC data is available in a complete form for each year since 1999-00. Road stock data was taken from BITRE's transport statistics yearbook.

With the exception of Queensland, where an upward time trend was present, there was no statistically significant trend in road maintenance expenditure over the past ten years.

Chart D.3 Historical average maintenance expenditure

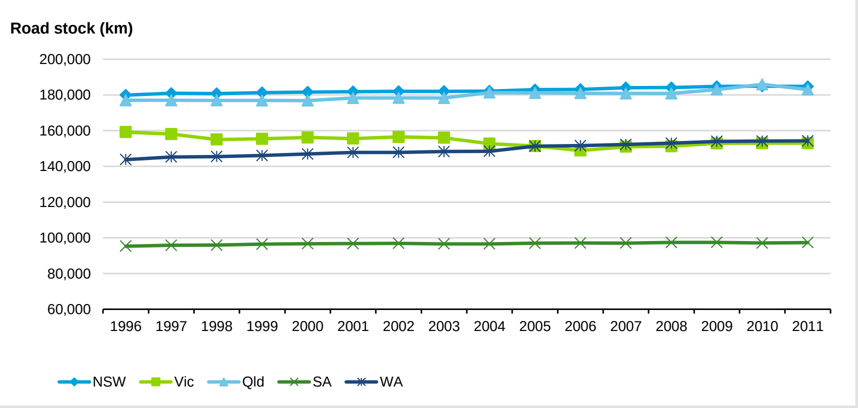


Source: DAE analysis

As a result of this analysis, road maintenance expenditure has been linked to the increase in road stock. The increase in road stock itself has been estimated based on historical trends, see the box below. Maintenance expenditure per kilometre of road has then been kept constant. Overall, this results in a gradual increase in maintenance expenditure over time under the base case.

Note on road stock

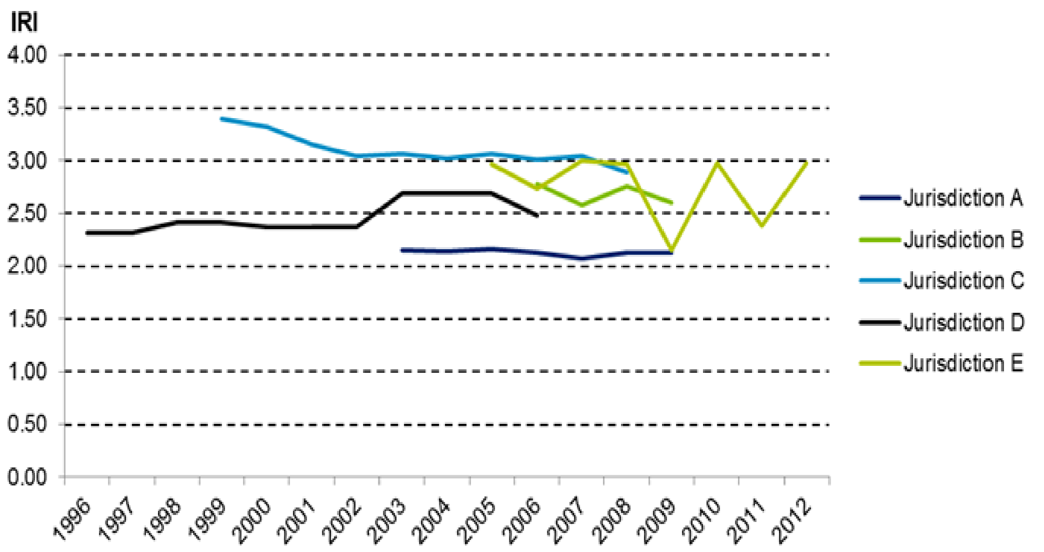
For road stock, the forecasts have been developed from historical growth rates. This is due to the fact that the data generally shows a gradual and consistent growth over time, with limited spikes or troughs from year to year.



D.5. Road quality

We undertook a detailed analysis of historical road quality. The best data available to us covered NSW, Victoria, South Australia and Tasmania and encompassed the years 1994-2012. However, no state had data covering all the years. This data was extremely detailed totalling around 450,000 road segments – each of which had observations over a number of years. Initial investigation of this data focussed on analysing how the distribution of road quality changed over time. It is preferable to consider the distribution of road quality rather than its average due to the sharp increase in vehicle operating costs that go along with poor quality roads. The results of this analysis are shown in Appendix E. The main finding of this analysis is that the overall distribution of road quality has been fairly stable over time in most states. That is jurisdictions have been able to maintain road quality under historical funding and weather conditions. This trend can be seen in the following chart, which just shows average road quality.

Chart D.4 Average observed road quality



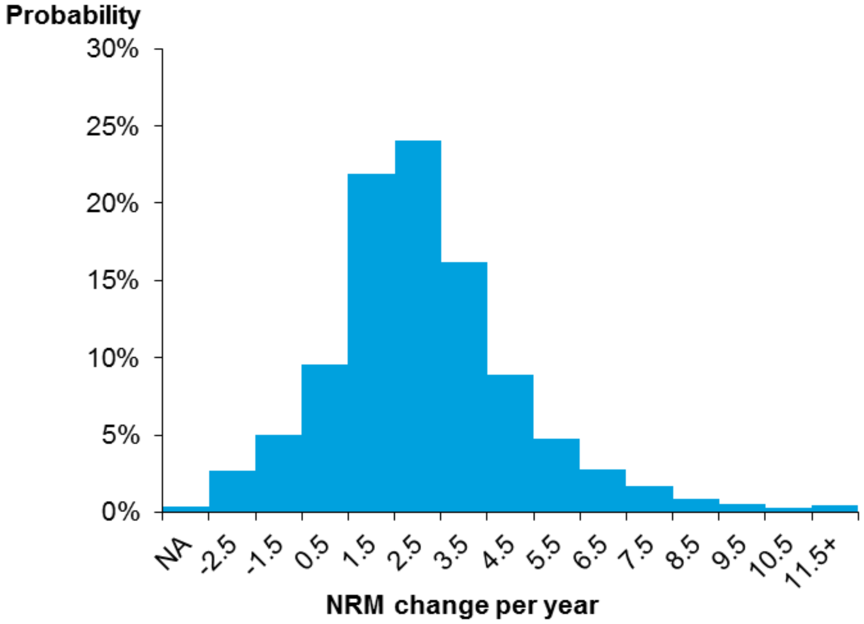
Note: time series have been intentionally de-identified

Source: data provided by NTC and jurisdictions

However, feedback from the consultations undertaken in 2013 to develop the CBA modelling framework suggested that several jurisdictions were concerned about their ability to maintain current road quality with the likely budget available to them in the future. This feedback is supported by research into the maintenance backlogs at the local government level. For example, a report from PwC (2006) estimated that the aggregate backlog for all 700 Australian local councils was approximately $14.5 billion, with 10% to 30% of councils facing sustainability challenges. The estimated funding gap per annum to cover the backlog and the annual underspend was estimated at $2.0 billion.

In light of this feedback we investigated the potential for decreases in road quality due to deterioration over time. The best available data on this was covered in Hunt and Bunker (2004). This paper used regression analysis to estimate the average annual deterioration rate in road segments in Queensland. A distribution of average deterioration rates was found, as shown in the figure below, the average rate in this distribution was 2.6 NAASRA Roughness Meter Counts (NRM) per year which translates to 0.15 IRI. To recognise that there is the potential for reduced maintenance funding in the future (given the increasing asset base), in the base case we have assumed that the average road quality deteriorates by 0.015 IRI units per year. This would be the average expected rate of deterioration if 10% of the network was allowed to deteriorate at its natural rate each year without intervention.

Chart D.5 Distribution of road quality deterioration, per year



Source: Hunt and Bunker (2004)

This result is supported by a report from Jeff Roorda and Associates (2010) which indicated that future current levels of expenditure would need to increase by an average of $1.2 billion per year to avoid deterioration of the local road network. This compares to an annual expenditure of almost $14 billion (based on 2007-08 data). Further support is brought by another report from Jeff Roorda and Associates (2012) which found that 16% of road assets (by value) were regarded as being in poor or very poor quality (i.e. requiring significant renewal/rehabilitation or being physically unsound and/or beyond rehabilitation). In particular, a substantial share of unsealed roads (25%) and timber bridges (31%) were considered to be of poor or very poor quality.

D.6. Vehicle operating costs

Initial vehicle operating costs by vehicle type have been sourced from the NTC's heavy vehicle operating cost model. These costs have been assumed to remain constant, in real terms, over the forecast period. This is a conservative assumption as there is the possibility for increases in the real costs of both labour and fuel over time.

Vehicle operating costs are then adjusted based on average road quality. In the base case this involves an upwards adjustment over time to account for the assumed slow deterioration in road quality. This upwards adjustment is made based on information from Austroads (1994).

D.7. Externalities

There are a range of externalities associated with transport investments, including:

- Road congestion;
- Traffic accident;
- air pollution;
- climate change;
- noise;
- water;
- nature and landscape; and
- urban separation.

Increased use of higher productivity vehicles and better access for these vehicles under the proposed reform is expected to reduce the overall number of vehicles used to carry out the equivalent freight task. This will lower road congestion[1], number of traffic accidents, air pollution and carbon emissions, and noise impacts. Improved governance and investment decision-making of transport investment projects will mitigate the negative impact transport investment project has on water, nature and landscape and urban liveability.

The 2013 CBA estimated externality costs using recommended externality values estimated by a number of sources, including:

- the Australian Transport Council (ATC) (2006) estimated the environmental externality costs (including; air pollution, climate change, noise, water, nature and landscape and urban separation) and derived a total cost of externality ranging from a high of around 5c/NTK for medium sized vehicles in urban areas to a low of around 0.25c/NTK for medium sized vehicles in rural areas;
- BITRE report estimated total social cost of accidents of around 4.8 cents per vehicle km for rigid trucks and 4 cents per vehicle km for articulated trucks;
- The NSW handbook estimated congestion externalities at 0.13 cents per passenger car unit (PCU) km. Heavy vehicles are equivalent to a variable number of PCUs; for example, B-doubles are estimated to be equivalent to 8 PCUs and so generate $1.02 per km in congestion externalities. Congestion externalities were limited to urban travel and an estimate for the proportion of heavy vehicle travel during peak (29%) times was also applied. This figure was based on DAE's previous experience in analysis of heavy vehicle movements.

For this model update, updated externality parameter values for road congestion and traffic accident, associated with transport investments, are available from the Transport for NSW (2016), which are estimated in accordance with the 2016 Australasian Transport Assessment and Planning (ATAP) Guidelines (Australian Transport and Infrastructure Council (ATIC) 2016). The ATAP Guideline provides a nationally consistent approach to the inclusion of accident and congestion externalities in the evaluation of transport projects.

The marginal road congestion cost estimated for Sydney, by Transport for NSW, for different vehicle types is shown in table.

Table D.1 Marginal road congestion cost in Sydney

Vehicle type	Passenger car equivalency (PCE) factors	Marginal congestion cost in Sydney ($cents/VKT)
Passenger vehicles & LCVs	1	36
Rigid trucks	3	108
Trailers	6	216
Articulated trucks	5	180
B doubles	8	288

[1] It is worth noting that congestion charging is not an element of the HVRR.

Vehicle type	Passenger car equivalency (PCE) factors	Marginal congestion cost in Sydney ($cents/VKT)
Double road train	8	288
Triple road trains	10	360
2 axle buses	2	72
3 axle buses	3	108

Source: Economic Evaluations Transport for NSW.

In addition, Transport for NSW estimates the total social cost from car traffic accidents to be $0.04 per vehicle km for cars and $0.02 for larger vehicles (such as buses).

This CBA modelling updates estimates of road congestion and traffic accident, associated with transport investments, with reference to the estimates provided by Transport for NSW.

D.8. Summary on establishing the baseline

The variables discussed above were the key inputs into the baseline. With these variables we were able to construct a model which can calculate the total economic cost of completing Australia’s freight task over the forecast period under the baseline. This total economic cost is primarily composed of vehicle operating costs, road maintenance costs and externalities (such as accidents and injuries). The next step in the methodology was to develop a clear picture of the range of costs and benefits expected to be generated by the reform and how these costs and benefits flow through into behavioural change.

Appendix E Historical road quality

Distributions of road quality found in the data are provided on the following pages. The important features to note are that:

- Most jurisdictions have very stable distributions of road quality over time, suggesting that average road quality has not been deteriorating historically.
- In all jurisdictions, there is a long tail on road quality. This implies that there may be particular roads of poor quality which could be targeted as part of the HVRR reforms.

These distributions were fitted using a kernel density approach. In the case of jurisdiction C, there were some errors in the data resulting in an overestimate of the density of the distribution around zero.

Chart E.1 Historical IRI distribution – Jurisdiction A

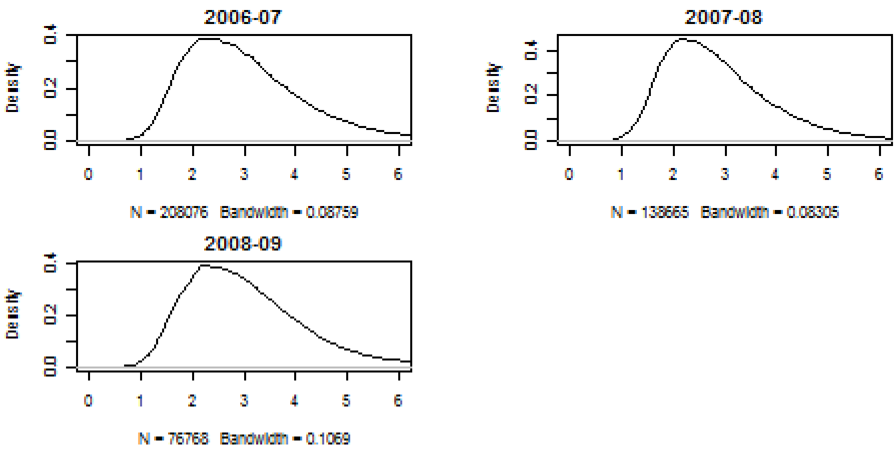


Chart E.2 Historical IRI distribution – Jurisdiction B

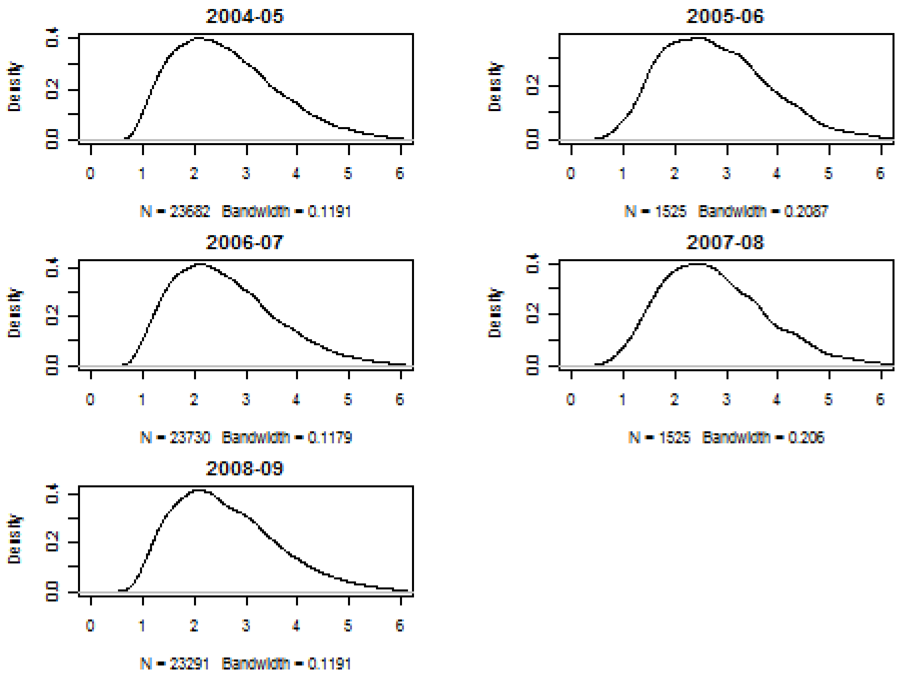
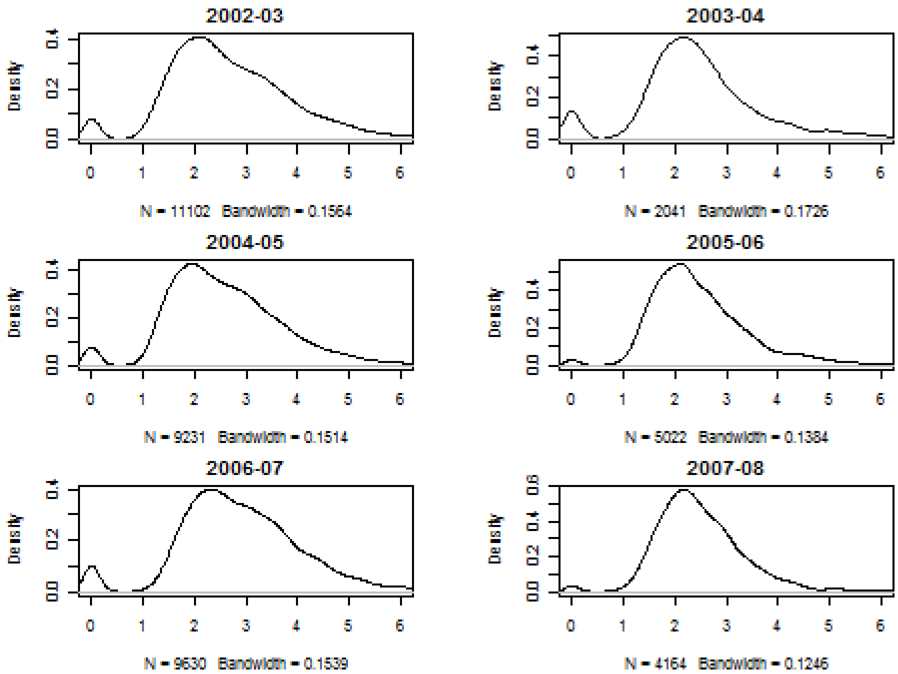


Chart E.3 Historical IRI distribution – Jurisdiction C



Note: positive density at 0 indicates erroneous data that was excluded in further analysis

Chart E.4 Historical IRI distribution – Jurisdiction D

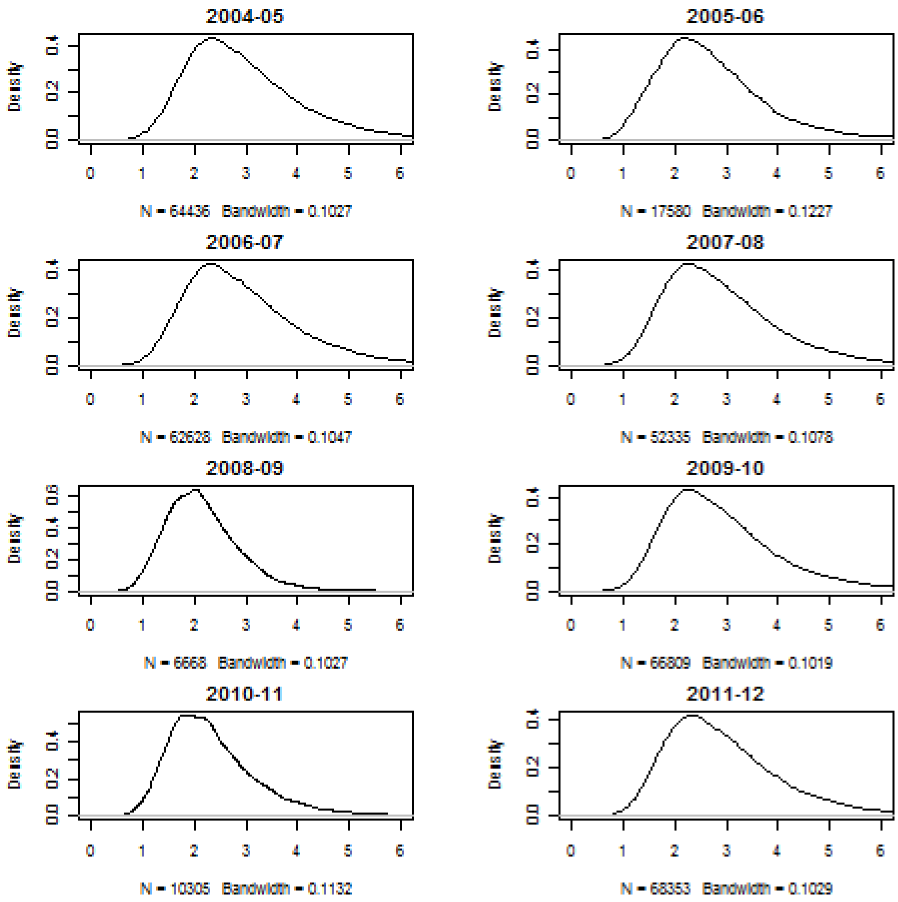
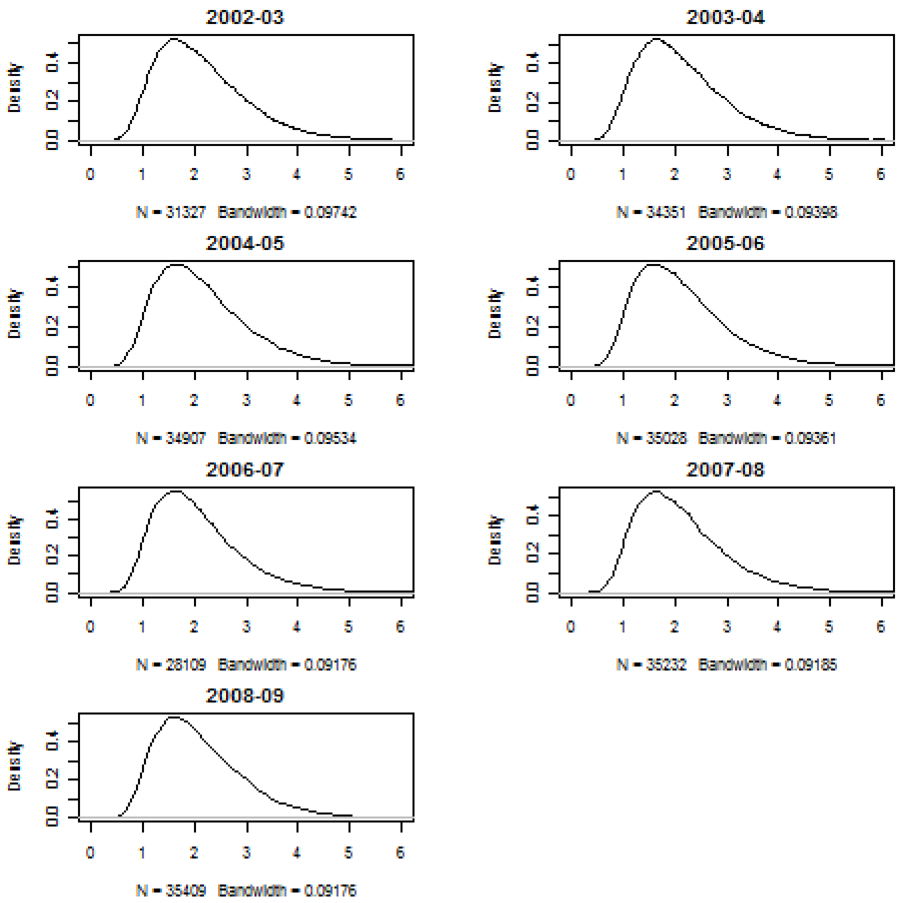


Chart E.5 Historical IRI distribution – Jurisdiction E



Appendix F Bottom-up analysis of access improvements

In the 2013 CBA, we undertook a bottom-up approach to modelling the potential benefits of the HVCI reforms for access. The goal of this bottom-up modelling was to verify the top-down figures generated by BITRE and ground these against real world action: providing access to businesses.

The modelling involved the following steps:

1. Using the ABS input output tables, identify the top road freight industries
2. Gather a list of businesses in those industries and their locations
3. Gather a list of roads with B-double (or higher) access in each jurisdiction
4. Gather information on current freight use patterns in each jurisdiction using ABS Survey of Motor Vehicle Use (SMVU)
5. Estimate a relationship between access and usage of B-double (or higher) vehicles
6. Use this relationship to assess the level of access implied by BITRE's overall vehicle share forecasts (from top-down approach described in section 2.2.1 under access improvements)
7. Re-allocate BITRE's national vehicle share forecasts to each jurisdiction.

Some detail is provided for each of these steps below.

Note on interpreting the results of this Appendix:

The modelling of businesses with access presented in this appendix is indicative only and was used as a sense check against the Australia-wide BITRE figures and the disaggregation of these figures for each state.

The change in business with access does not form an input into the CBA, only the estimated vehicle shares do.

F.1. Identify top road freight industries

The ABS input output tables (2012) provide information on use of output from the road freight industry by all other industries in Australia. Using this data, there are two ways in which an industry could be considered an important user of road freight. Either that industry could purchase a large amount of output from the road freight industry (level of demand) or output from the road freight industry could form a large part of total inputs to that industry (intensity of demand).

To identify the set of top road freight industries, we have given each of these factors an equal weighting. This approach identifies the following sets of industries as the most important road freight users in the Australian economy.

Table F.1 Most significant road freight industries in the Australian economy

	Level of demand	Intensity of demand	Averaged
1	Road freight transport	Cement, Lime and Ready-Mixed Concrete Manufacturing	Road Transport
2	Construction Services	Sawmill Product Manufacturing	Cement, Lime and Ready-Mixed Concrete Manufacturing
3	Wholesale Trade	Other Non-Metallic Mineral Product Manufacturing	Meat and Meat product Manufacturing
4	Meat and Meat product Manufacturing	Tanned Leather, Dressed Fur and Leather Product Manufacturing	Sawmill Product Manufacturing
5	Residential Building Construction	Fruit and Vegetable Product Manufacturing	Fruit and Vegetable Product Manufacturing
6	Sheep, Grains, Beef and Dairy Cattle	Pulp, Paper and Paperboard Manufacturing	Sheep, Grains, Beef and Dairy Cattle
7	Basic Non-Ferrous Metal Manufacturing	Grain Mill and Cereal Product Manufacturing	Grain Mill and Cereal Product Manufacturing
8	Food and Beverage Services	Meat and Meat product Manufacturing	Dairy Product Manufacturing
9	Cement, Lime and Ready-Mixed Concrete Manufacturing	Road Transport	Other Food Product Manufacturing
10	Public Administration and Regulatory Services	Plaster and Concrete Product Manufacturing	Iron and Steel Manufacturing
11	Retail Trade	Textile Manufacturing	Other Wood Product Manufacturing
12	Health Care Services	Beer Manufacturing	Plaster and Concrete Product Manufacturing
13	Iron and Steel Manufacturing	Other Wood Product Manufacturing	Food and Beverage Services
14	Heavy and Civil Engineering Construction	Veterinary Pharmaceutical and Medicinal Product Manufacturing	Basic Chemical Manufacturing
15	Non-Residential Building Construction	Oils and Fats Manufacturing	Beer Manufacturing

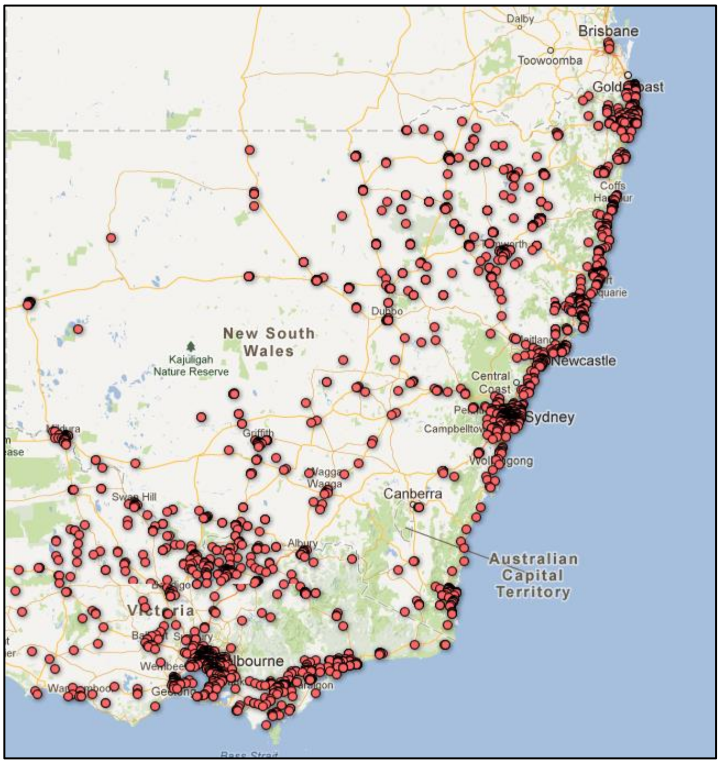
Source: ABS (2012)

Note: Important freight users were identified based on assessment of level of demand of road transport in the Input-Output table. Intensity relates to the share of road transport in that business' immediate inputs, it shows how important road transport is important to a business in terms of generating outputs.

F.2. Identify businesses in these industries

The next step in the analysis was to identify a list of businesses in Australia operating in these important freight industries. A list of current Australian businesses, their addresses and industry of operation was sourced from Yell123. The industries in the Yell123 database are more detailed and so differed from those in the ABS input-output tables. As such, a concordance between listings in the Yell123 database and the IO tables was constructed and data on around 127,000 businesses was extracted as shown in the image below.

Figure F.1 Location of some of the businesses in south-east Australia included in the bottom-up sample



Source: DAE analysis based on data from Yell 123 (2012) presented using Google Maps

The businesses selected were listed as operating in the following industries:

Abattoir Machinery & Equipment

Abattoirs

Bakers

Bakers & Pastry cooks Supplies

Bakery Equipment

Balsa Wood

Balustrading

Banana Growers

Beekeepers

Beekeeping Supplies

Biscuits

Bitumen Products

Bitumen Spraying

Bottle Closures

Breweries

Brewery Equipment & Supplies

Butchers--Retail

Butchers--Wholesalers

Butchers & Smallgoods Manufacturers Supplies

Can Manufacturers

Car & Truck Cleaning Equipment &/or Products

Car & Truck Cleaning Services

Cargo & Freight Containers &/or Services

Carriers--Car Transporting

Carriers--Light

Carriers-Heavy

Carriers Depots

Catering--Industrial & Commercial

Cement Rendering

Cement Supplies-Wholesalers & Manufacturers

Cheese &/or Cheese Products

Chemical Engineers

Chemical Processing Equipment

Chemical Suppliers

Chemicals-Agricultural

Chemicals-Industrial

Chemists-Consulting & or Industrial

Chocolate & Cocoa

Coffee-Wsale

Coffee Brewing Equipment & Supplies

Concrete--Pre-Mixed

Concrete Additives

Concrete Aggregates

Concrete Block Making Equipment

Concrete Contractors

Concrete Formwork Form Ties & Accessories

Concrete Kerbs or Gutters

Concrete Mixing Equipment & or Vibrators

Concrete Pre-Cast Panels

Concrete Products

Concrete Pumping Services

Concrete Pumps & Equipment

Concrete Reinforcements

Concrete Sawing, Drilling, Grinding & Breaking

Concrete Slab Floors

Concrete Treatment &/or Repair Services

Confectionery--Retail

Confectionery--Wholesalers & Manufacturers

Confectionery Manufacturers Equipment & Supplies

Coopers

Copper & or Brass Products

Crane Hire

Crane Manufacturers & Distributors

Dairies

Dairy Equipment & Supplies

Dairy Products--Wsalers & Mfrs

Doughnuts, Equipment & or Supplies

Emu Farmers & Products

Engine Reconditioning

Engine Reconditioning Equipment

Farm and Agricultural Advisory Service

Farm Contracting Services

Farm Equipment & Supplies

Farmers

Feedlots

Fertilisers

Fertilizer &/or Insecticide Spreading

Flour Wholesalers & Manufacturers

Food &/or General Store Supplies

Food &/or General Stores

Food Brokers &/or Agents

Food Processing, Canning &/or Packing Machinery

Food Products- Manufacturers and Processors

Frozen Foods--Wholesalers & Manufacturers

Frozen Foods-Retail

Fruit & Vegetable Packing &/or Packs

Fruit & Vegetables-Wholesale

Fruit Juice Merchants & or Processors

Fruit, Vegetable & or Grain Exporters

Fruiterers & Greengrocers

Fuel and Oil Additives

Fuel Injection-Diesel

Fuel Injection-Petrol

Fuel Merchants

Galvanising & or Tinning

Game Farmers & or Dealers

Grain & Produce--Wholesalers

Grain & Produce-Retail

Graziers

Grocers--Wholesale

Halal Products

Hotels--Pubs

Liquor Stores--Retail

Livestock Buyers

Livestock Transport Services

Maltsters

Meat Exporting and or Packing

Metal Cutting Equipment

Metal Cutting Services

Metal Finishers Equipment and Supplies

Metal Merchants

Metal Polishers

Metal Powder Fabricators

Metal Rolling and Forming

Metal Spinners

Metal Sprayers

Metal Spraying Equipment

Metal Stamping & Pressing

Metal Workers

Metallurgists

Metals-Expanded

Motor Engineers & Repairers

Motor Oils and Spirits

Motor Radiator Services

Motor Radiator Wholesalers & or Manufacturers

Motor Replacement Parts

Motor Vehicle Inspection and Testing

Mufflers &/or Exhaust Systems

Mushroom & or Spawn Suppliers

Olives & Olive Oil

Pallets & Platforms

Pasta Products & or Equipment

Pies, Pasties & Sausage Rolls-Wholesalers & Manufacturers

Pig Breeders & or Dealers

Plaques

Plaster & Plasterboard Supplies

Plasterers-Plasterboard Fixers

Plastering Supplies & Equipment

Plasters--Plasterboard Fixers

Polystyrene Products

Polyurethane Products

Potato Chips & or Crisps

Potato Growers

Poultry-Retail

Poultry Equipment & Supplies

Poultry Farmers & Dealers

Poultry Processing & Supplies

Road Transport Vehicles & Equipment

Rubber Products--Wholesalers & Manufacturers

Sawmillers

Sawmilling & Logging Equipment

Saws

Seed Cleaning, Drying & Grading Services

Sheep Shearing Equipment & Supplies

Sheet Metal Workers

Sheet Metal Workers Machinery

Stainless Steel Products & Equipment

Steel Fabricators &/or Manufacturers

Steel Merchants

Steel Rolling Mills

Steel Wool Wholesalers & Manufacturers

Stevedores

Stock Feed & Supplements

Stock Feeds & Supplements

Stockyards & Equipment

Stud Breeders-Cattle & Sheep

Vegetable Growers

Wood Carvers

Wood Chippers

Wood Turners

Woodworking Machinery & or Service

Wool Brokers

Wool Buyers & Merchants

Wool Processing Equipment & or Services

Wool Stores

Yeast Wholesalers & Manufacturers

F.3. Gather a list of roads with B-double (or higher) access

Given time constraints, the quality of available data and the fact that this exercise was a validation of BITRE's data source we have limited data gathering for this stage of the analysis to Western Australia, NSW and Victoria.

The stage of the analysis involved sourcing a list of roads in each of these jurisdictions where B-double (or above) vehicles are able to operate. The data was sourced from publicly available information._These data sources identified around 7000 roads in Western Australia, 5000 roads in NSW and 1600 roads in Victoria as having at least B-double access.

Restricting attention to Western Australia, NSW and Victoria reduces the number of businesses in the dataset to around 81,000.

F.4. Gather information on current freight use patterns in each jurisdiction

This data was sourced from a highly detailed version of the SMVU provided to us by NTC (ABS 2008). This SMVU data aggregates results from 2005, 2006 and 2007 and provides use of heavy vehicles by industry, jurisdiction and NTC vehicle class.

Considering the split between sub-B-double and B-double (and above) vehicles classes, this data suggested the following level of heavy vehicle use among the jurisdictions:

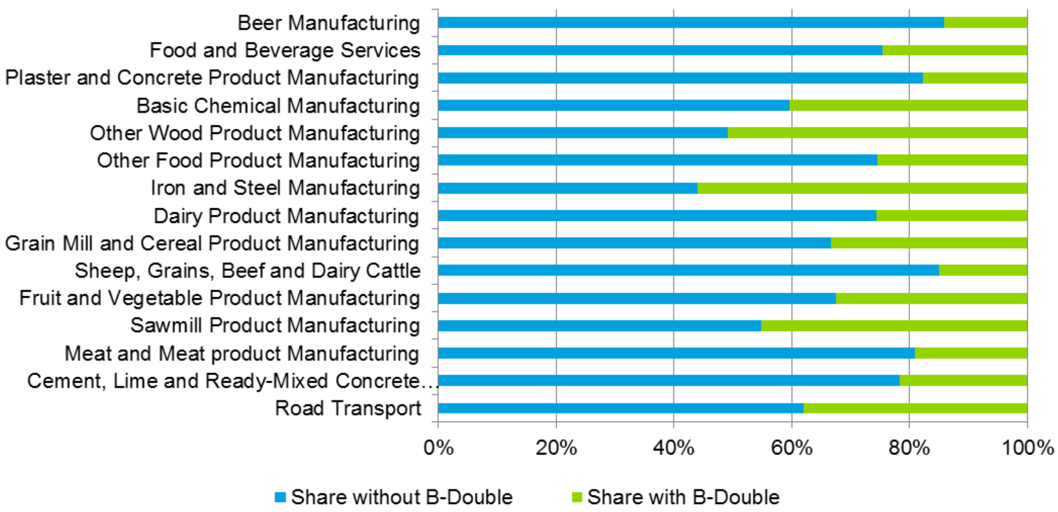
Chart F.1 Share of heavy vehicle use in jurisdictions (NTK)

Source: ABS (2017)

F.5. Access and usage of B-double (or higher) vehicles

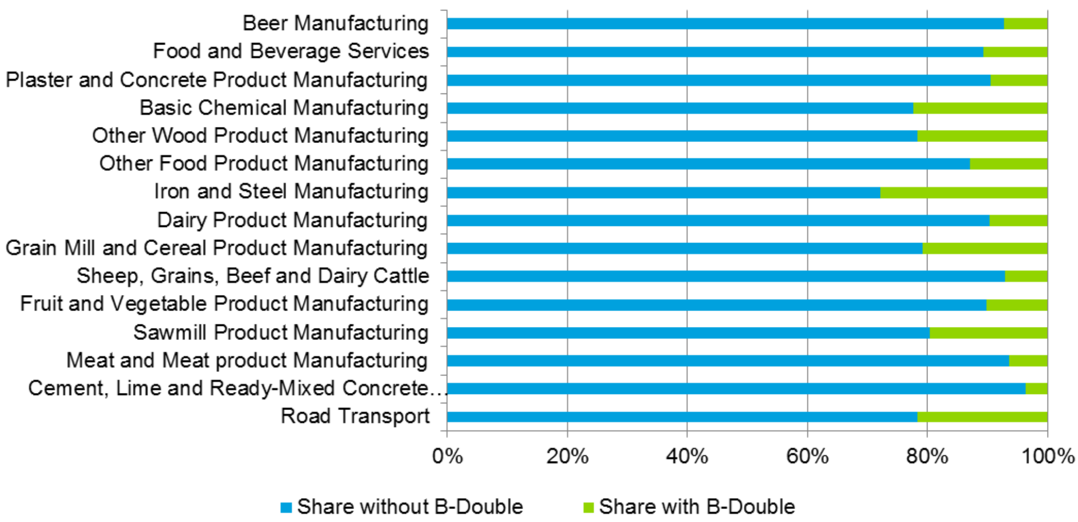
The first stage of this part of the analysis was to estimate the share of businesses in each jurisdiction located on a road with at least B-double access. This involved a comparison of addresses in the business listing database to addresses in the database of roads with B-double access. Addresses provided in the database commonly reflects the location of operational facility for industry sectors. However, it is worth noting that the operational facility address for small businesses can sometimes be the same as their head office address. The following charts show the results of this estimate for WA, NSW and Victoria.

Chart F.2 Businesses with at least B-double access, Western Australia



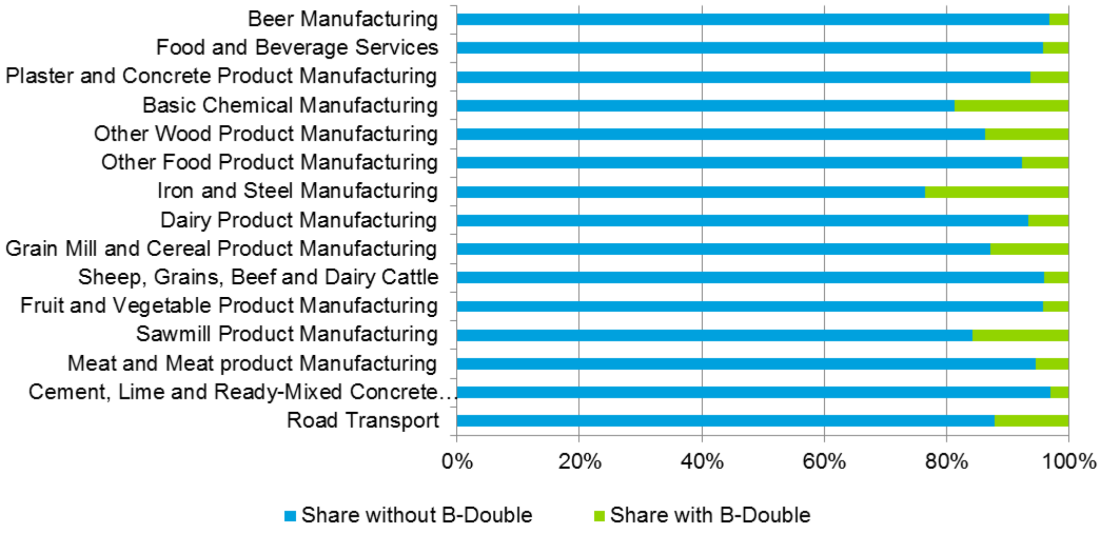
Source: DAE analysis

Chart F.3 Businesses with at least B-double access, NSW



Source: DAE analysis

Chart F.4 Businesses with at least B-double access, Victoria



Source: DAE analysis

Appendix G Vehicle shares

Note on charts and tables in this appendix:

The modelling of vehicle shares is ultimately based on forecasts developed by BITRE. These forecasts only extend to 2030.

The CBA covers the period to 2037. Beyond 2030 we have assumed that vehicle shares remain fixed at their 2030 level.

Details on the conversion between vehicle classes is provided in Appendix H.

Chart G.1 Vehicle shares of NTK, WA – Baseline

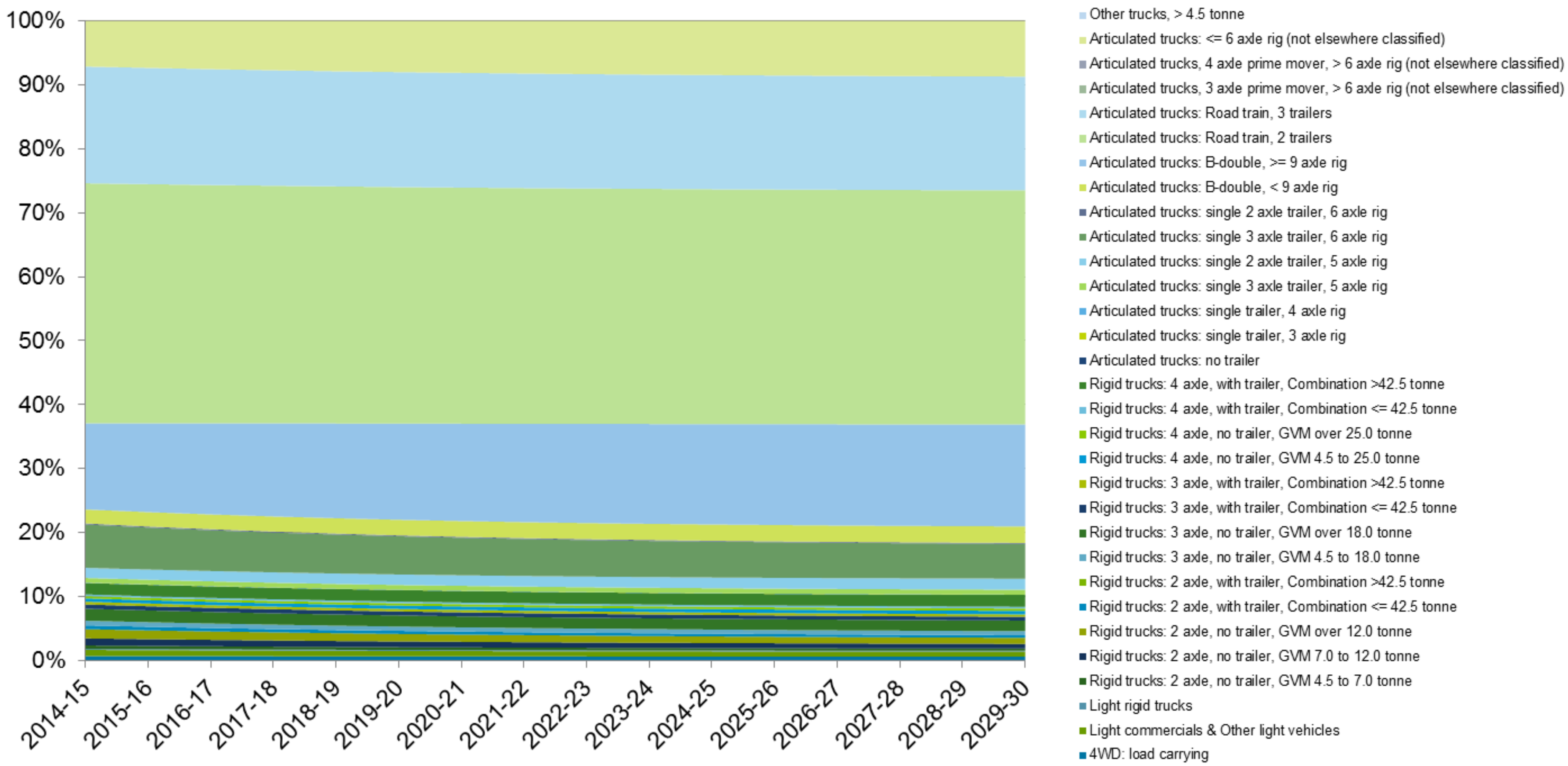


Chart G.2 Vehicle shares of NTK, WA – Option 1

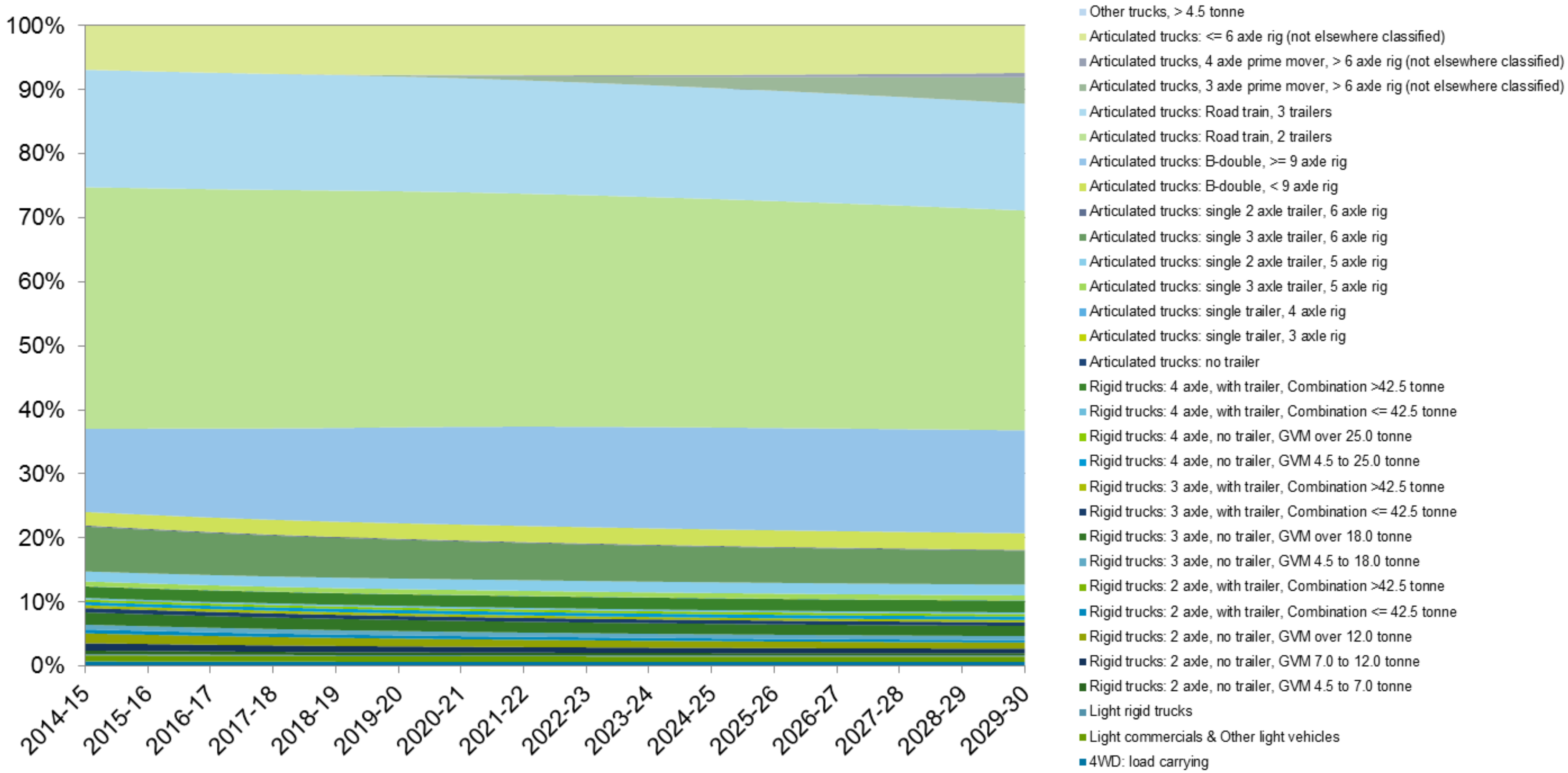


Chart G.3 Vehicle shares of NTK, WA – Options 2, 1A and 2A

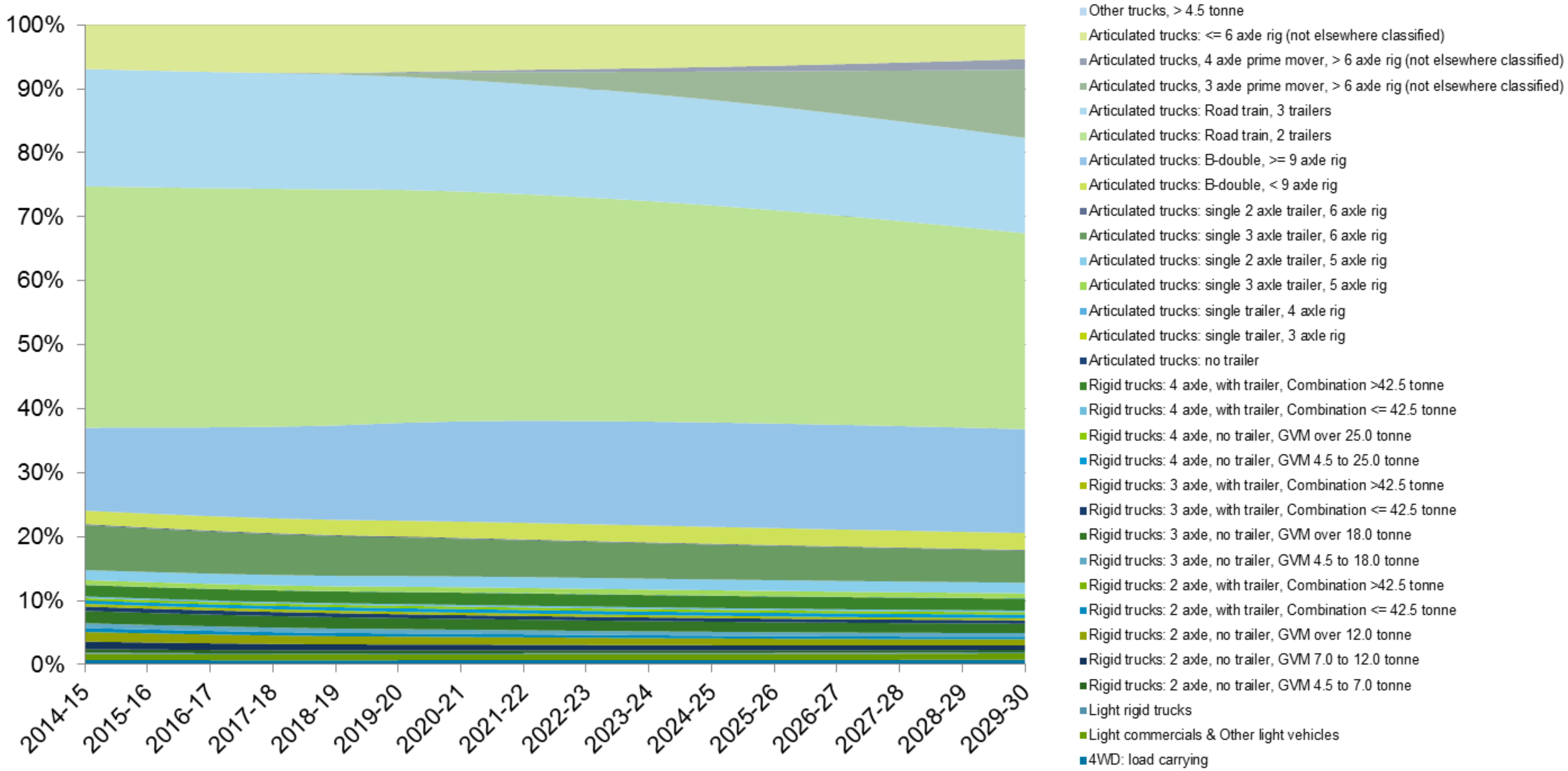


Chart G.4 Vehicle shares of NTK, WA – Option 3

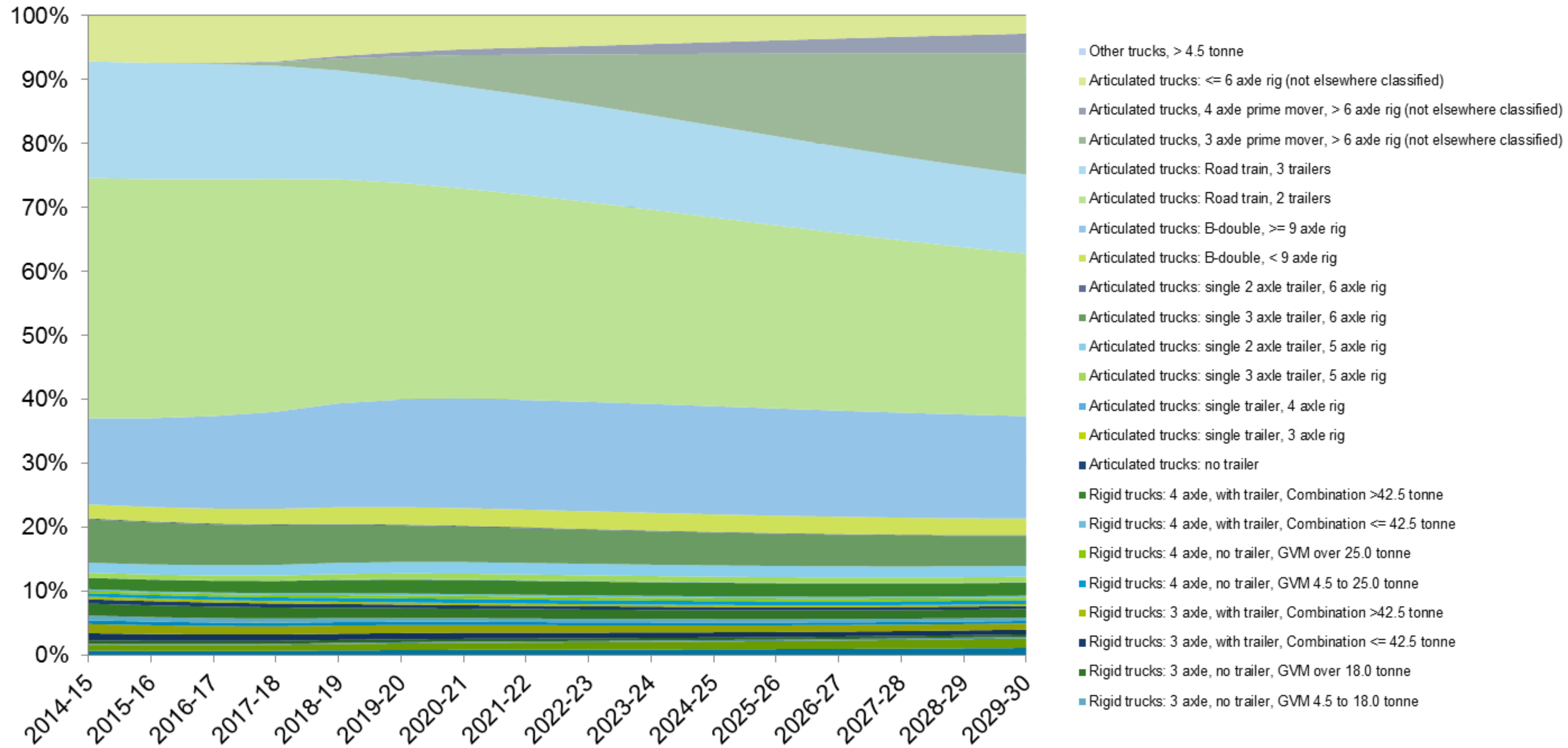


Table G.1 Vehicle shares of NTK - WA

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	0.8	0.6	0.6	0.8	0.7	0.7	0.8	0.7	0.8	0.8	0.9	1.2
Light commercials & Other light vehicles	1.0	0.8	0.8	1.0	0.9	0.8	1.0	0.9	1.0	1.0	1.2	1.5

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.6	0.4	0.3	0.6	0.4	0.3	0.6	0.4	0.3	0.6	0.4	0.4
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	1.3	0.8	0.7	1.4	0.8	0.7	1.4	0.9	0.7	1.3	0.9	0.7
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	1.6	1.1	1.0	1.8	1.1	1.0	1.8	1.1	0.9	1.6	1.1	1.0
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	0.7	0.4	0.4	0.7	0.5	0.4	0.7	0.5	0.4	0.7	0.5	0.4
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	0.8	0.7	0.6	0.8	0.6	0.6	0.8	0.6	0.6	0.8	0.6	0.5
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	2.0	1.7	1.7	2.1	1.7	1.6	2.1	1.6	1.5	2.0	1.4	1.3
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	0.7	0.6	0.6	0.8	0.6	0.6	0.8	0.6	0.5	0.7	0.5	0.5
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.4	0.3	0.4	0.3	0.3
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.6	0.6
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	1.8	1.8	1.9	1.8	1.8	1.8	1.8	1.9	1.9	1.8	2.2	2.0
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 4 axle rig	-	-	-	-	-	-	-	0.1	-	-	0.1	0.1
Articulated trucks: single 3 axle trailer, 5 axle rig	0.7	0.8	0.8	0.7	0.8	0.8	0.7	0.8	0.8	0.7	0.8	0.8
Articulated trucks: single 2 axle trailer, 5 axle rig	1.6	1.7	1.7	1.6	1.7	1.7	1.6	1.7	1.7	1.6	1.8	1.7
Articulated trucks: single 3 axle trailer, 6 axle rig	7.4	5.7	5.4	7.9	5.7	5.3	7.9	5.6	5.0	7.4	5.3	4.7
Articulated trucks: single 2 axle trailer, 6 axle rig	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1
Articulated trucks: B-double, < 9 axle rig	2.0	2.5	2.6	1.9	2.5	2.6	1.9	2.6	2.6	2.0	2.8	2.6
Articulated trucks: B-double, >= 9 axle rig	12.3	15.5	16.0	11.6	15.7	16.1	11.6	16.1	16.2	12.3	17.1	16.0
Articulated trucks: Road train, 2 trailers	37.7	36.8	36.6	37.8	36.2	34.3	37.8	35.0	30.6	37.7	31.2	25.4
Articulated trucks: Road train, 3 trailers	18.3	17.9	17.8	18.4	17.6	16.7	18.4	17.0	14.9	18.3	15.2	12.4

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	1.0	4.1	-	2.6	10.7	-	7.9	19.0
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.2	0.7	-	0.5	1.7	-	1.3	3.0
Articulated trucks: <= 6 axle rig (not elsewhere classified)	6.6	8.3	8.7	6.2	7.7	7.4	6.2	6.9	5.3	6.6	4.7	2.8
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.5 Vehicle shares of NTK, NSW – Baseline

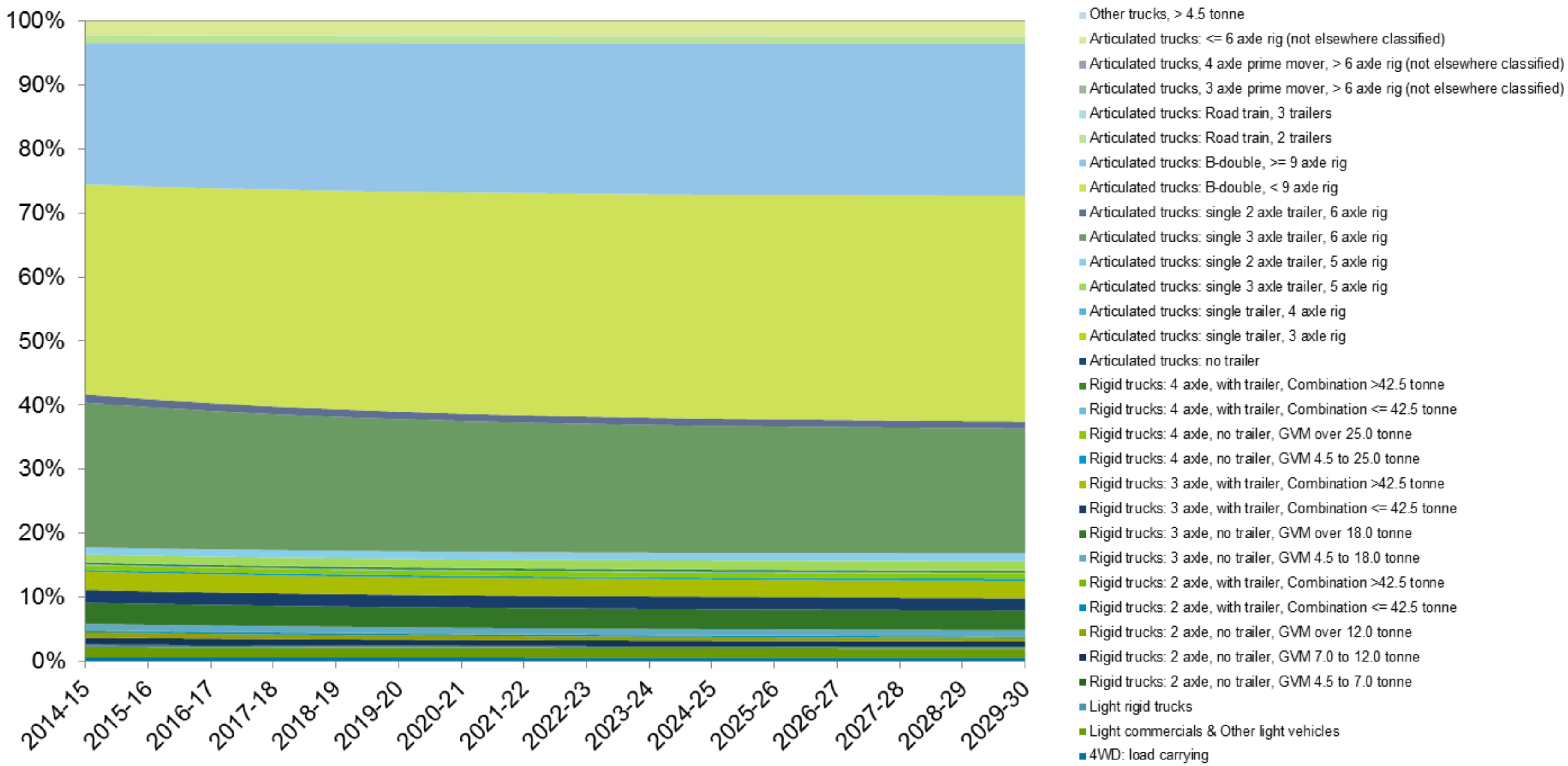


Chart G.6 Vehicle shares of NTK, NSW – Option 1

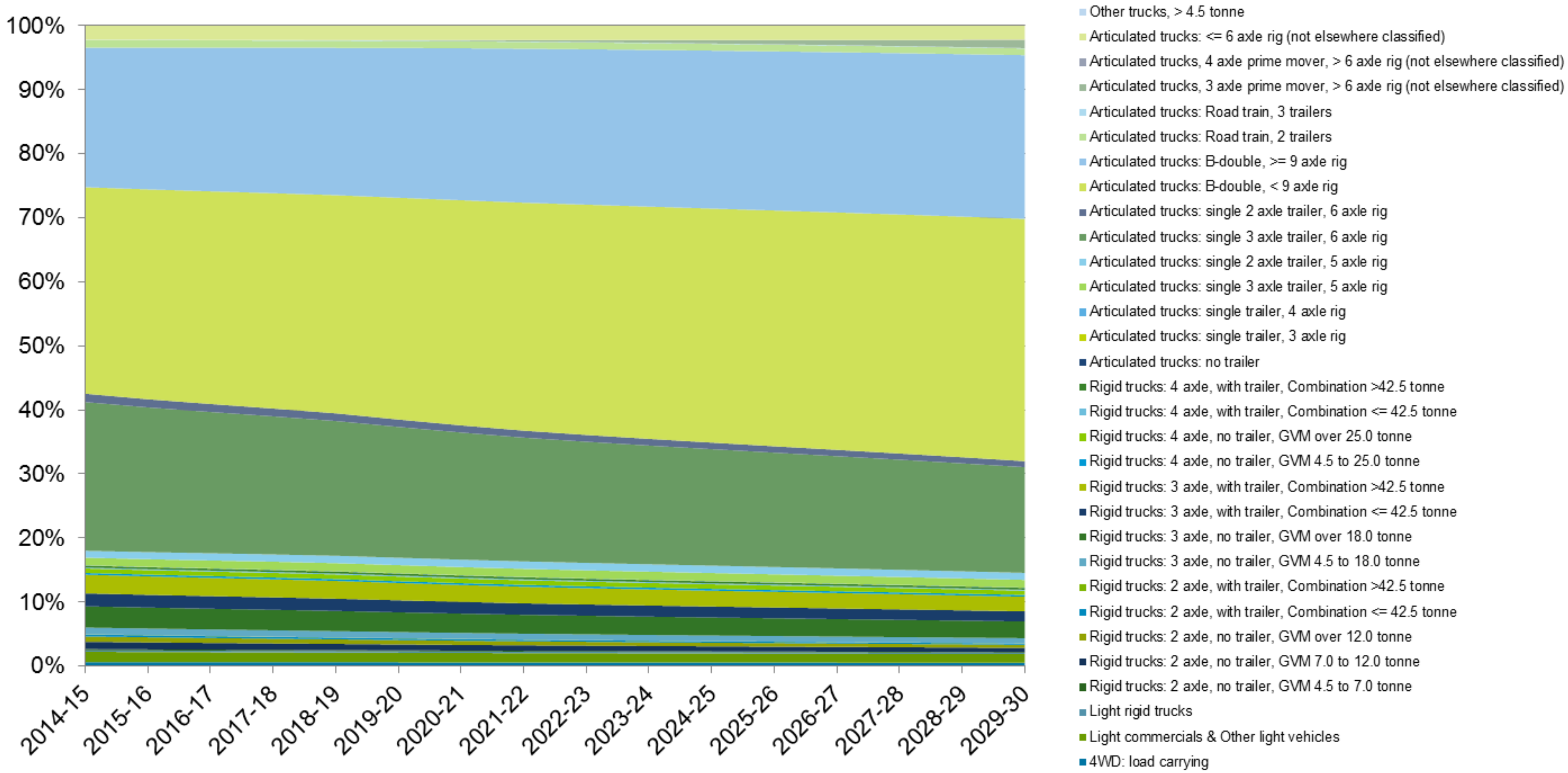


Chart G.7 Vehicle shares of NTK, NSW – Options 2, 1A and 2A

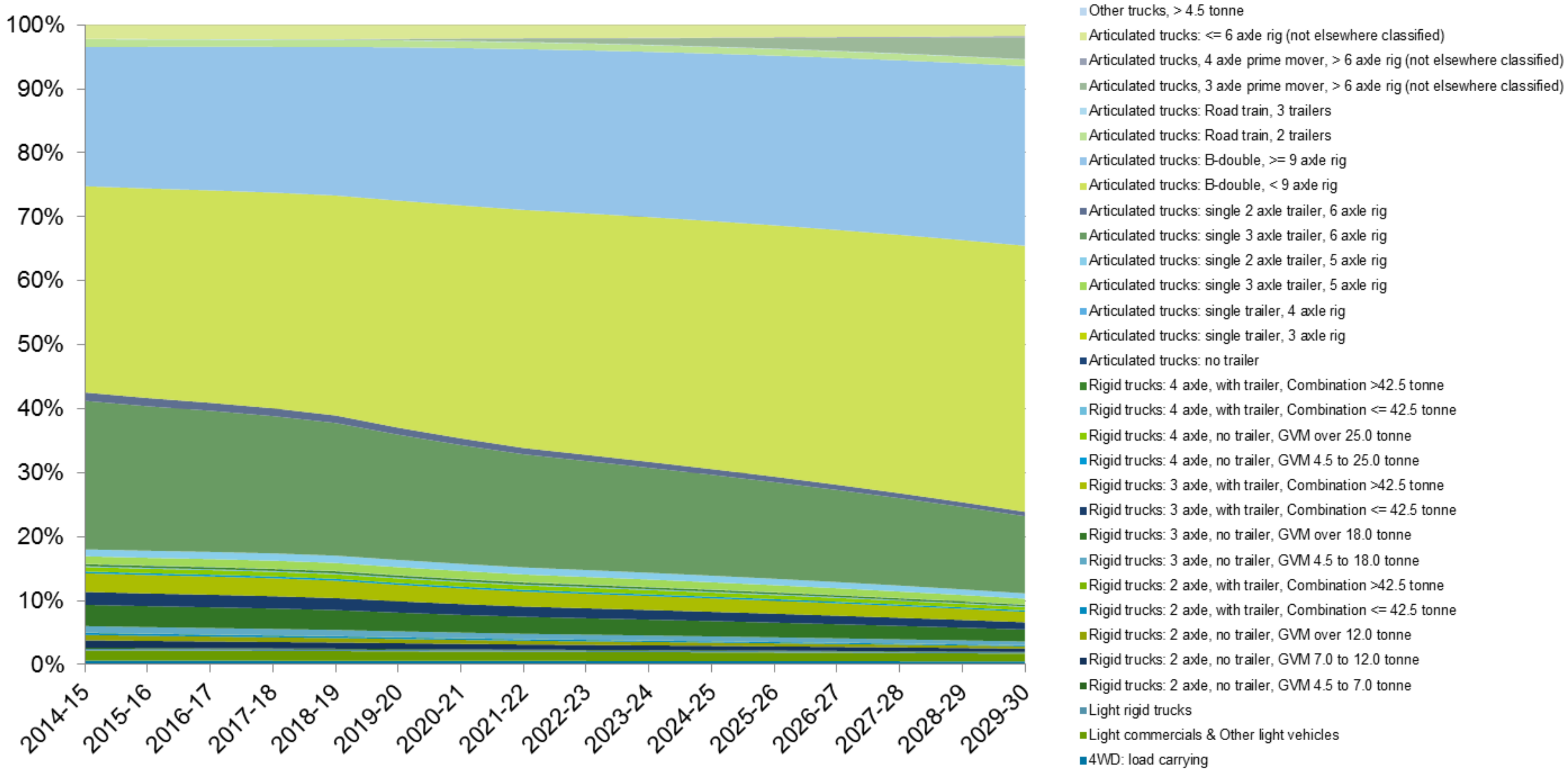


Chart G.8 Vehicle shares of NTK, NSW – Option 3

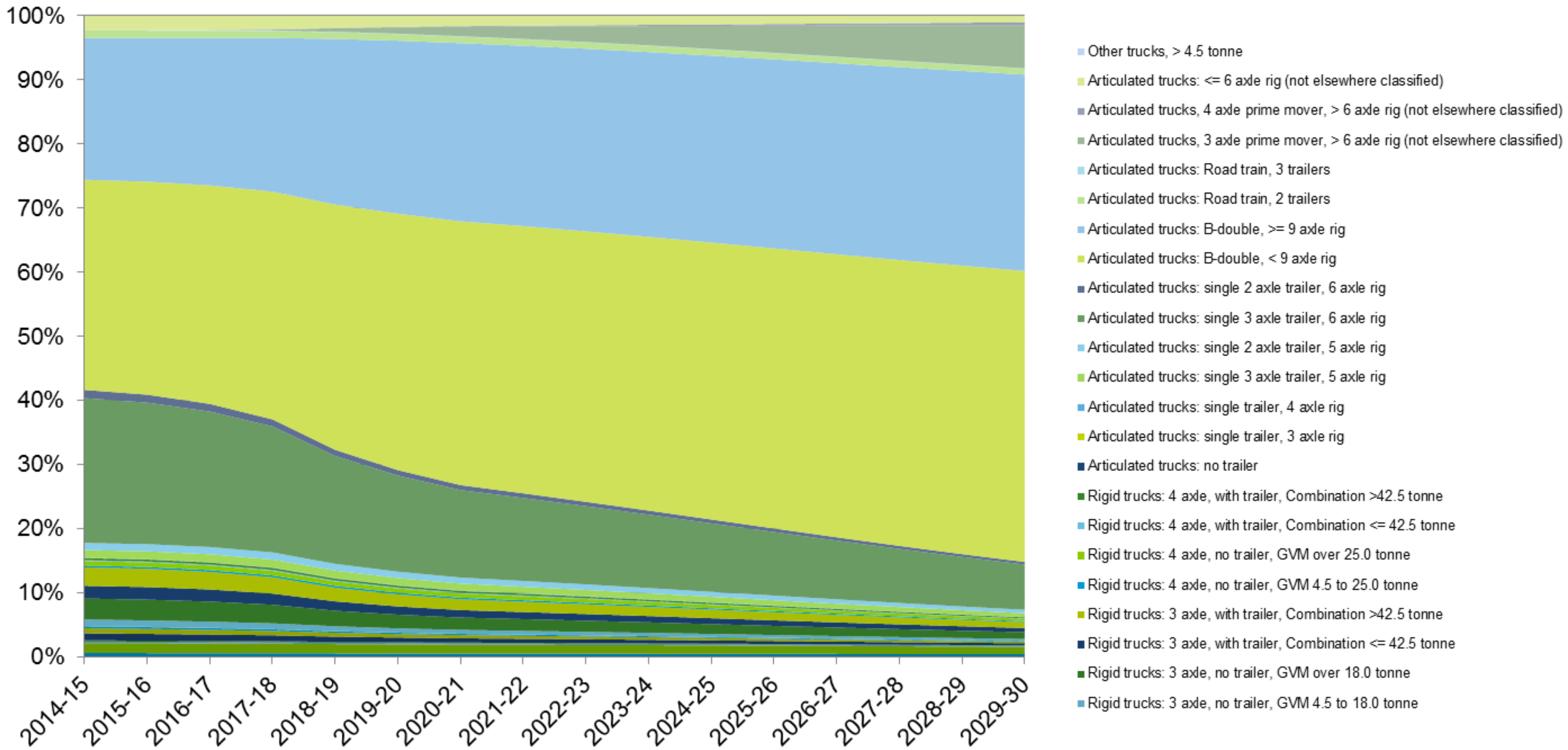


Table G.2 Vehicle shares of NTK - NSW

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	0.7	0.6	0.6	0.7	0.6	0.5	0.7	0.6	0.5	0.7	0.5	0.5
Light commercials & Other light vehicles	1.6	1.5	1.4	1.7	1.4	1.3	1.7	1.4	1.2	1.6	1.3	1.1

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	1.2	0.9	0.8	1.3	0.8	0.7	1.3	0.8	0.5	1.2	0.6	0.3
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	0.9	0.6	0.6	0.9	0.6	0.5	0.9	0.6	0.4	0.9	0.4	0.2
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	0.3	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.1	0.3	0.2	0.1
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	1.1	1.0	1.0	1.1	0.9	0.8	1.1	0.8	0.6	1.1	0.5	0.3
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	3.4	3.1	3.1	3.5	2.9	2.6	3.5	2.6	1.9	3.4	1.7	1.1
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	2.1	1.9	1.9	2.1	1.8	1.6	2.1	1.6	1.1	2.1	1.1	0.6
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	3.0	2.7	2.7	3.1	2.6	2.3	3.1	2.3	1.6	3.0	1.5	0.9
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.1
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.5	0.7	0.6	0.4
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 4 axle rig	-	-	-	-	-	-	-	-	-	-	0.1	-
Articulated trucks: single 3 axle trailer, 5 axle rig	1.2	1.3	1.4	1.1	1.3	1.2	1.1	1.2	0.9	1.2	0.9	0.6
Articulated trucks: single 2 axle trailer, 5 axle rig	1.1	1.2	1.3	1.1	1.2	1.1	1.1	1.1	0.8	1.1	0.9	0.5
Articulated trucks: single 3 axle trailer, 6 axle rig	24.2	20.1	19.5	25.3	18.9	16.5	25.3	17.0	12.1	24.2	12.2	7.1
Articulated trucks: single 2 axle trailer, 6 axle rig	1.4	1.1	1.1	1.4	1.1	0.9	1.4	1.0	0.7	1.4	0.7	0.4
Articulated trucks: B-double, < 9 axle rig	31.4	34.8	35.2	30.4	35.9	37.8	30.4	37.7	41.6	31.4	42.2	45.4
Articulated trucks: B-double, >= 9 axle rig	21.2	23.5	23.8	20.5	24.3	25.6	20.5	25.5	28.1	21.2	28.5	30.6
Articulated trucks: Road train, 2 trailers	1.2	1.1	1.0	1.3	1.1	1.0	1.3	1.1	1.0	1.2	1.0	0.9
Articulated trucks: Road train, 3 trailers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.3	1.2	-	0.8	3.4	-	2.5	6.8
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	-	0.1	-	0.1	0.2	-	0.2	0.4
Articulated trucks: <= 6 axle rig (not elsewhere classified)	2.1	2.4	2.4	2.1	2.2	2.2	2.1	2.0	1.7	2.1	1.5	1.0
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.9 Vehicle shares of NTK, VIC – Baseline

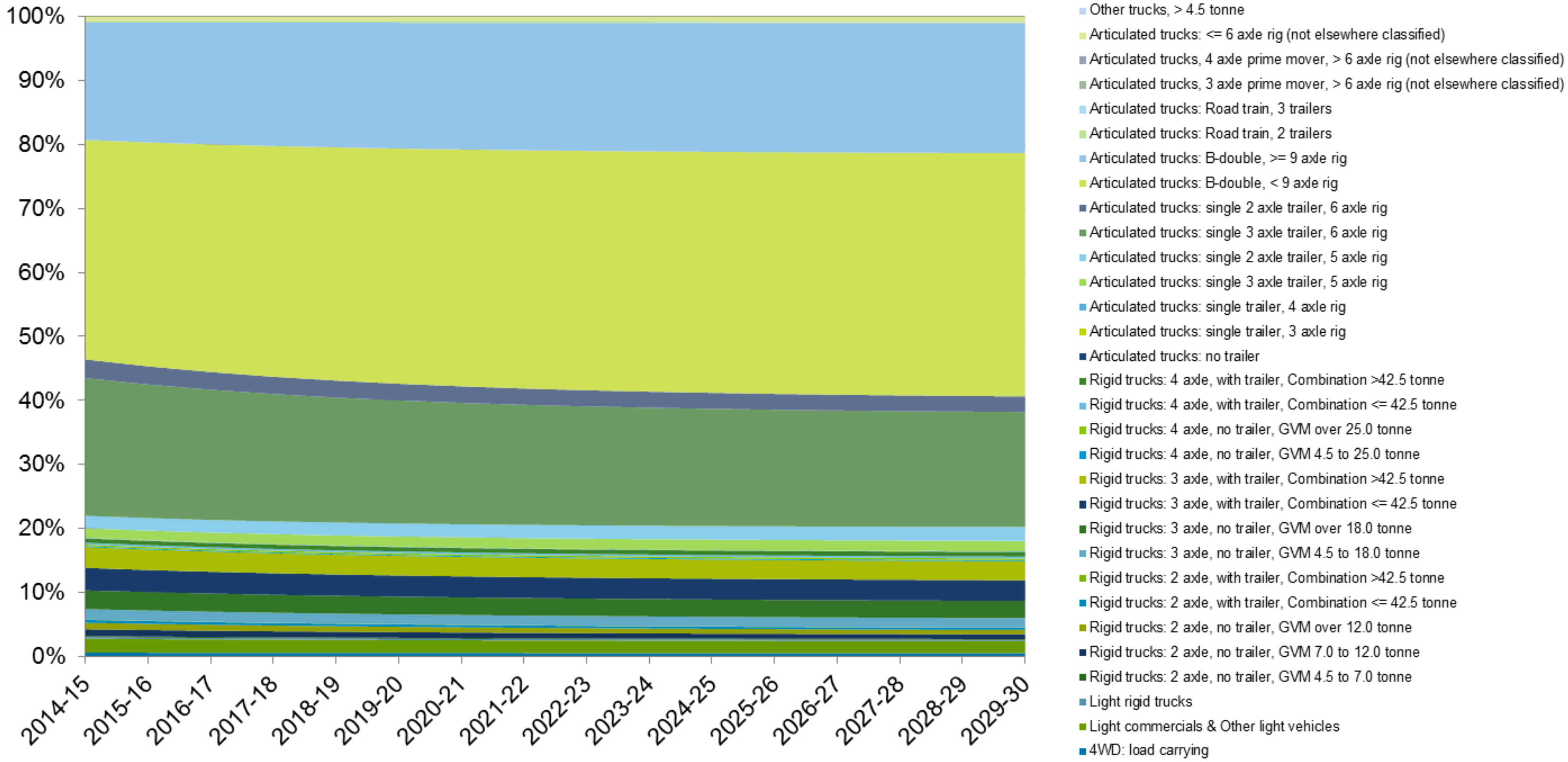


Chart G.10 Vehicle shares of NTK, VIC – Option 1

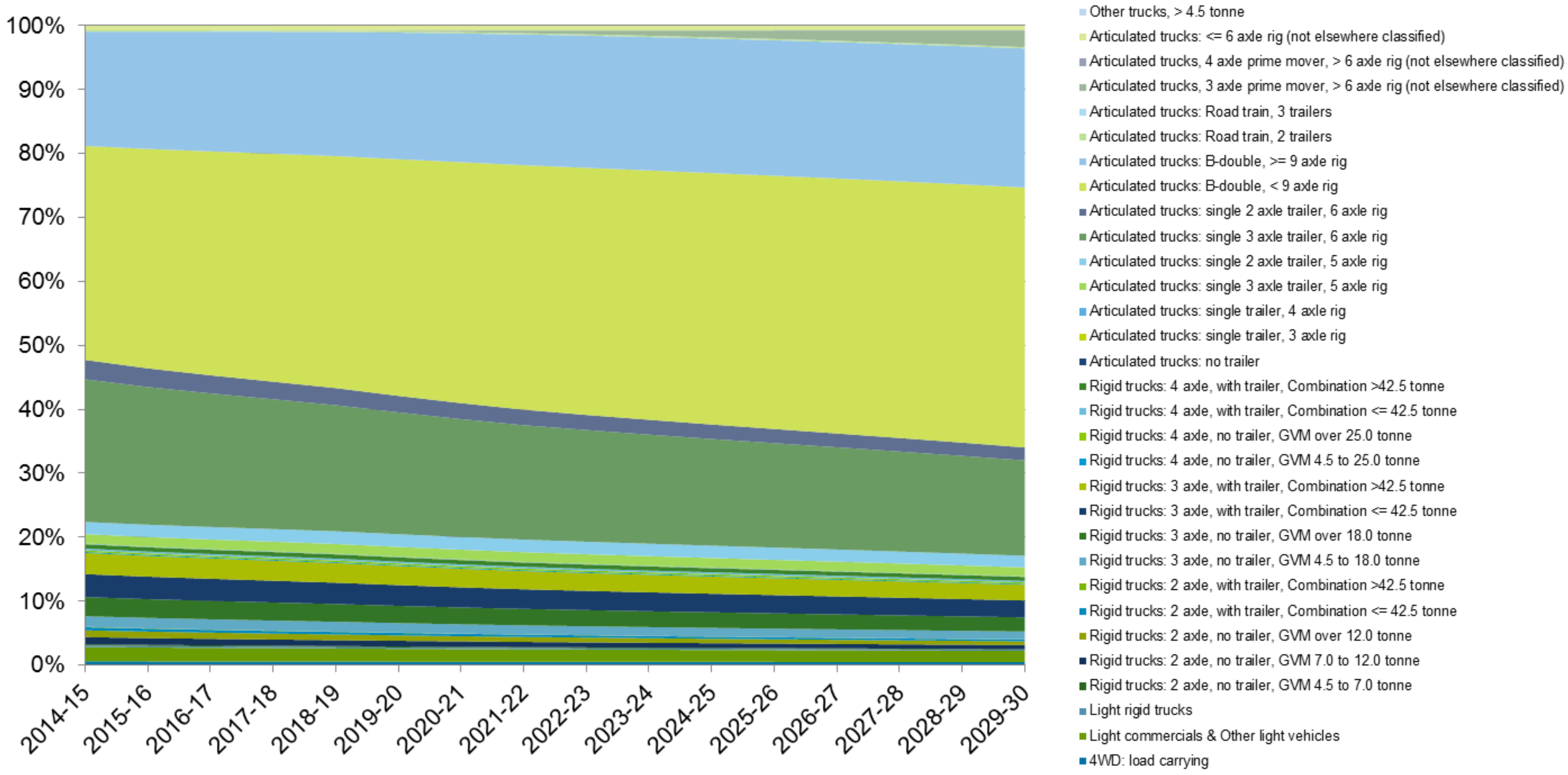


Chart G.11 Vehicle shares of NTK, VIC – Options 2, 1A and 2A

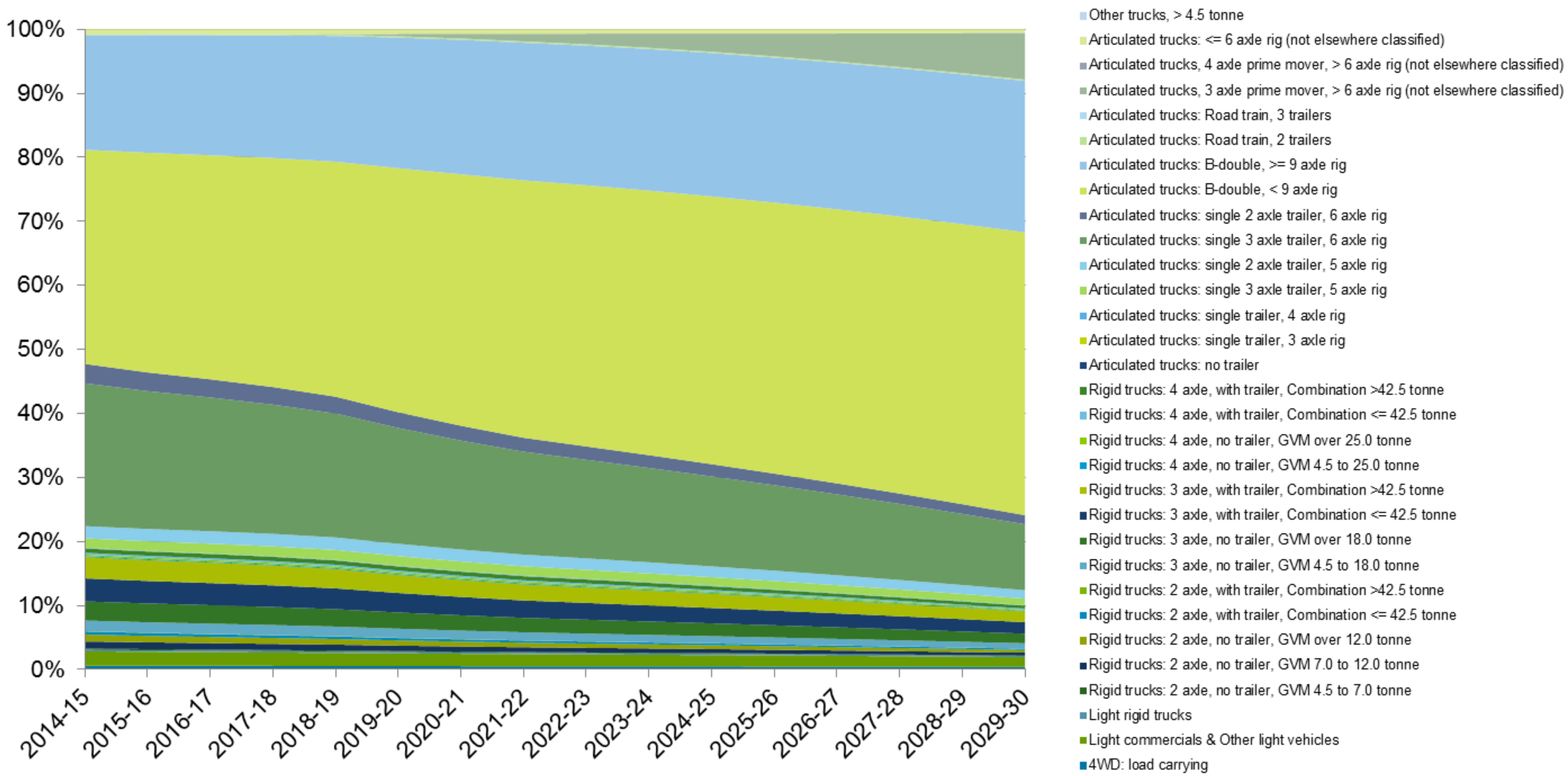


Chart G.12 Vehicle shares of NTK, VIC – Option 3

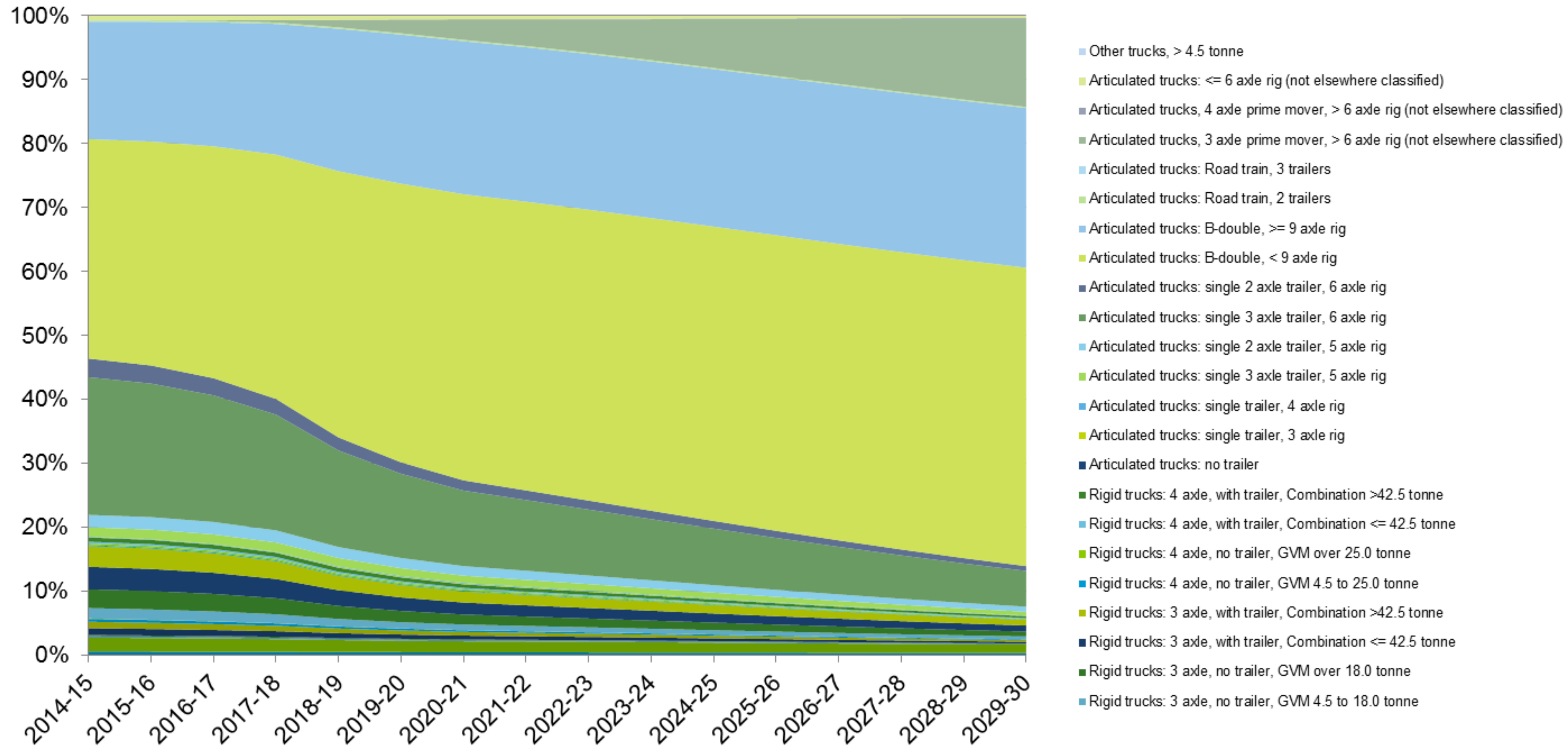


Table G.3 Vehicle shares of NTK - VIC

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	0.6	0.5	0.5	0.6	0.5	0.5	0.6	0.5	0.4	0.6	0.5	0.4
Light commercials & Other light vehicles	2.3	1.9	1.9	2.4	1.9	1.7	2.4	1.8	1.5	2.3	1.7	1.3

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.1
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	-
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	1.2	0.8	0.7	1.3	0.8	0.6	1.3	0.7	0.4	1.2	0.5	0.3
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	1.1	0.8	0.7	1.2	0.7	0.6	1.2	0.7	0.4	1.1	0.5	0.3
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	0.5	0.4	0.3	0.5	0.3	0.3	0.5	0.3	0.2	0.5	0.2	0.1
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	0.1	-	-	0.1	-	-	0.1	-	-	0.1	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	1.7	1.5	1.5	1.7	1.4	1.2	1.7	1.2	0.8	1.7	0.8	0.4
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	3.1	2.7	2.7	3.1	2.5	2.2	3.1	2.2	1.5	3.1	1.4	0.8
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	3.7	3.3	3.2	3.8	3.0	2.7	3.8	2.6	1.8	3.7	1.7	0.9
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	3.4	3.0	3.0	3.5	2.8	2.4	3.5	2.4	1.7	3.4	1.5	0.9
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.1
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.6	0.4	0.7	0.5	0.3
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	0.1	-	-	0.1	-	-	0.1	0.1	-	0.1	0.1	-
Articulated trucks: single trailer, 4 axle rig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Articulated trucks: single 3 axle trailer, 5 axle rig	1.4	1.6	1.7	1.4	1.5	1.4	1.4	1.4	1.0	1.4	1.0	0.6
Articulated trucks: single 2 axle trailer, 5 axle rig	1.9	2.1	2.2	1.8	2.0	1.8	1.8	1.8	1.3	1.9	1.3	0.8
Articulated trucks: single 3 axle trailer, 6 axle rig	23.2	18.6	18.0	24.1	17.5	14.9	24.1	15.4	10.3	23.2	10.3	5.6
Articulated trucks: single 2 axle trailer, 6 axle rig	3.1	2.5	2.4	3.3	2.4	2.0	3.3	2.1	1.4	3.1	1.4	0.8
Articulated trucks: B-double, < 9 axle rig	32.5	37.4	38.0	31.4	38.6	40.6	31.4	40.8	44.2	32.5	45.5	46.7
Articulated trucks: B-double, >= 9 axle rig	17.4	20.0	20.4	16.8	20.7	21.8	16.8	21.8	23.7	17.4	24.3	25.0
Articulated trucks: Road train, 2 trailers	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Articulated trucks: Road train, 3 trailers	-	-	-	-	-	-	-	-	-	-	-	-

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.6	2.6	-	1.6	7.2	-	5.2	13.8
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	-	-	-	-	0.1	-	0.1	0.2
Articulated trucks: <= 6 axle rig (not elsewhere classified)	0.7	0.8	0.8	0.6	0.7	0.7	0.6	0.7	0.6	0.7	0.5	0.3
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.13 Vehicle shares of NTK, QLD – Baseline

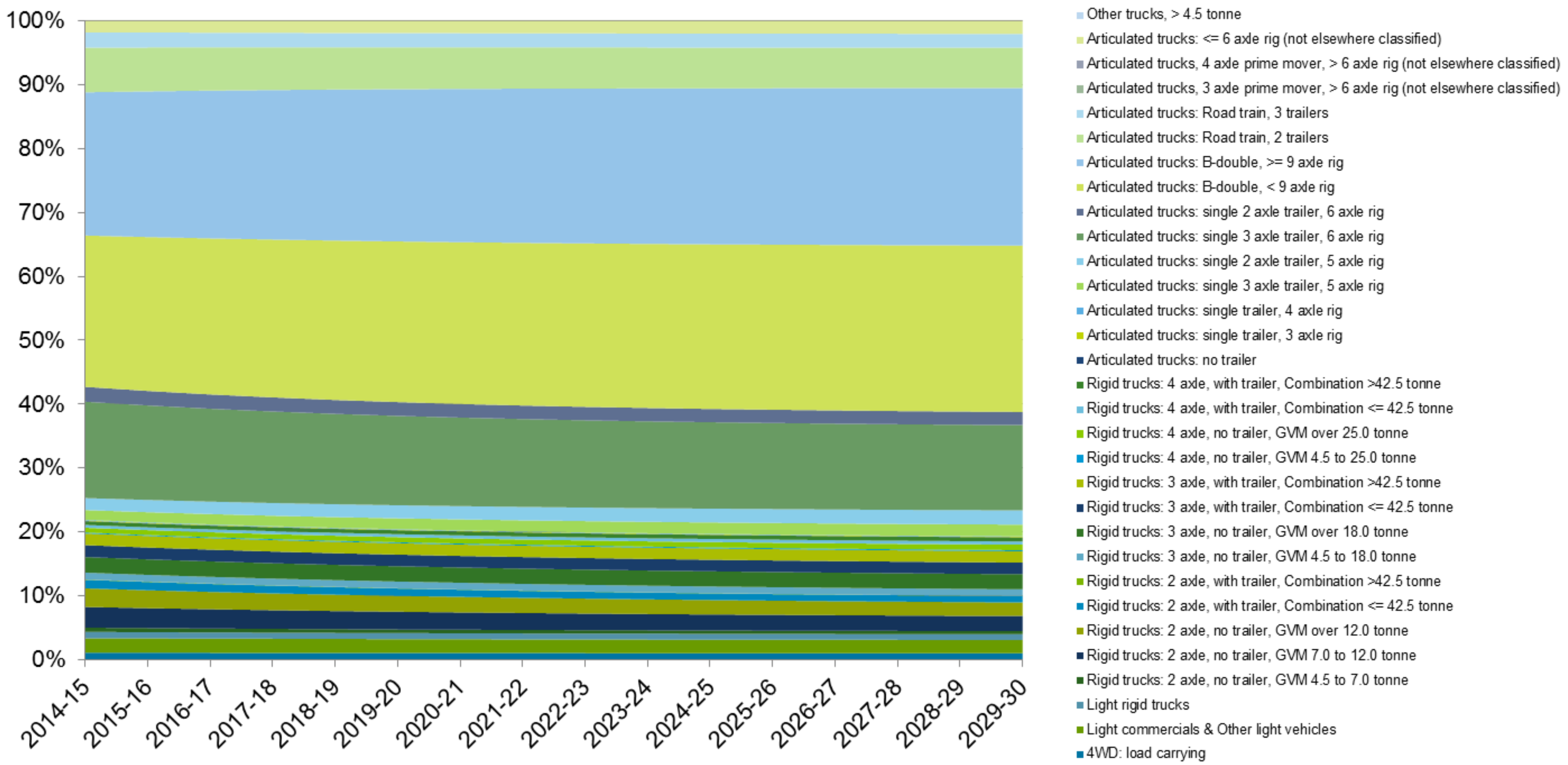


Chart G.14 Vehicle shares of NTK, QLD – Option 1

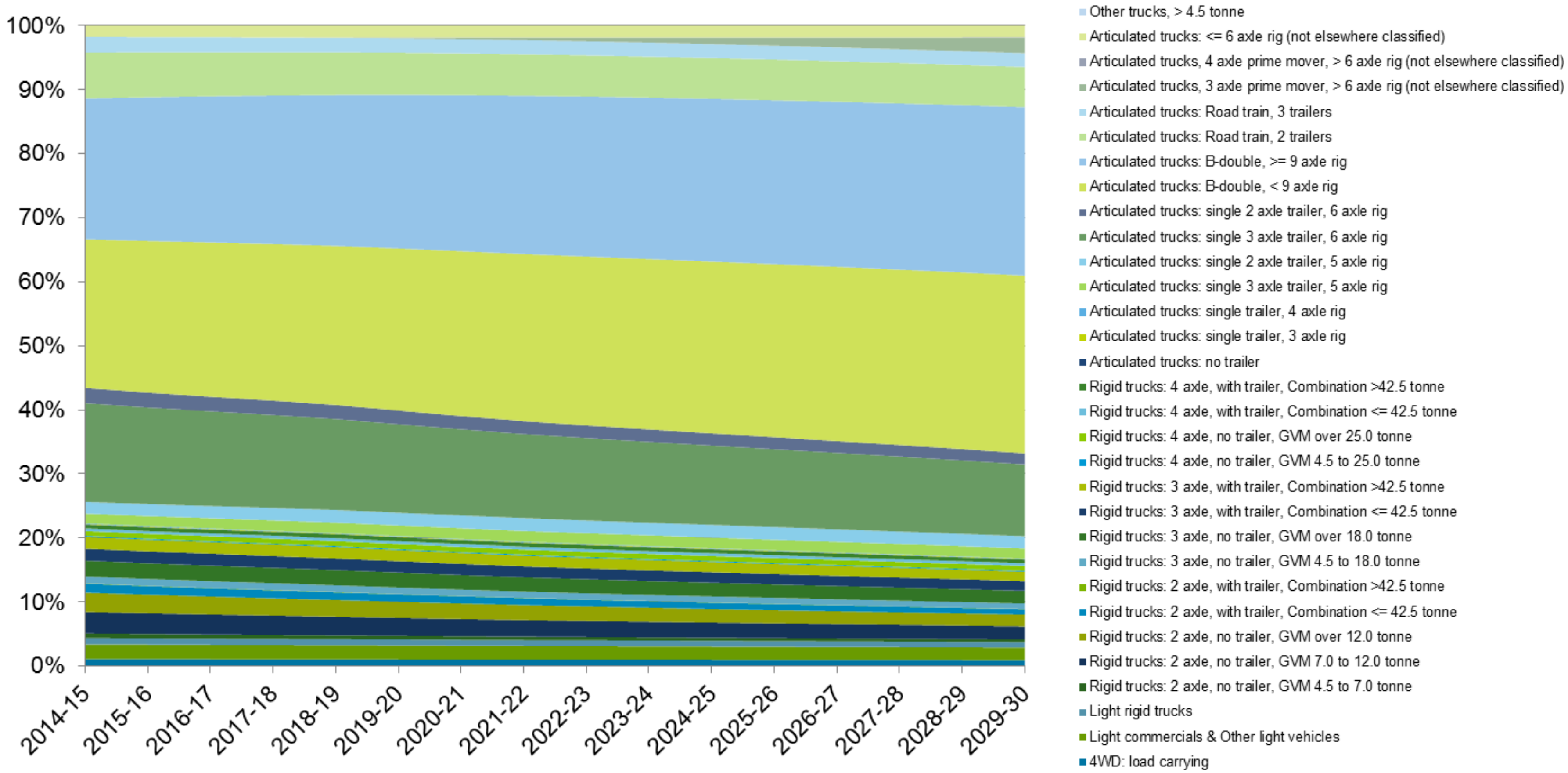


Chart G.15 Vehicle shares of NTK, QLD – Options 2, 1A and 2A

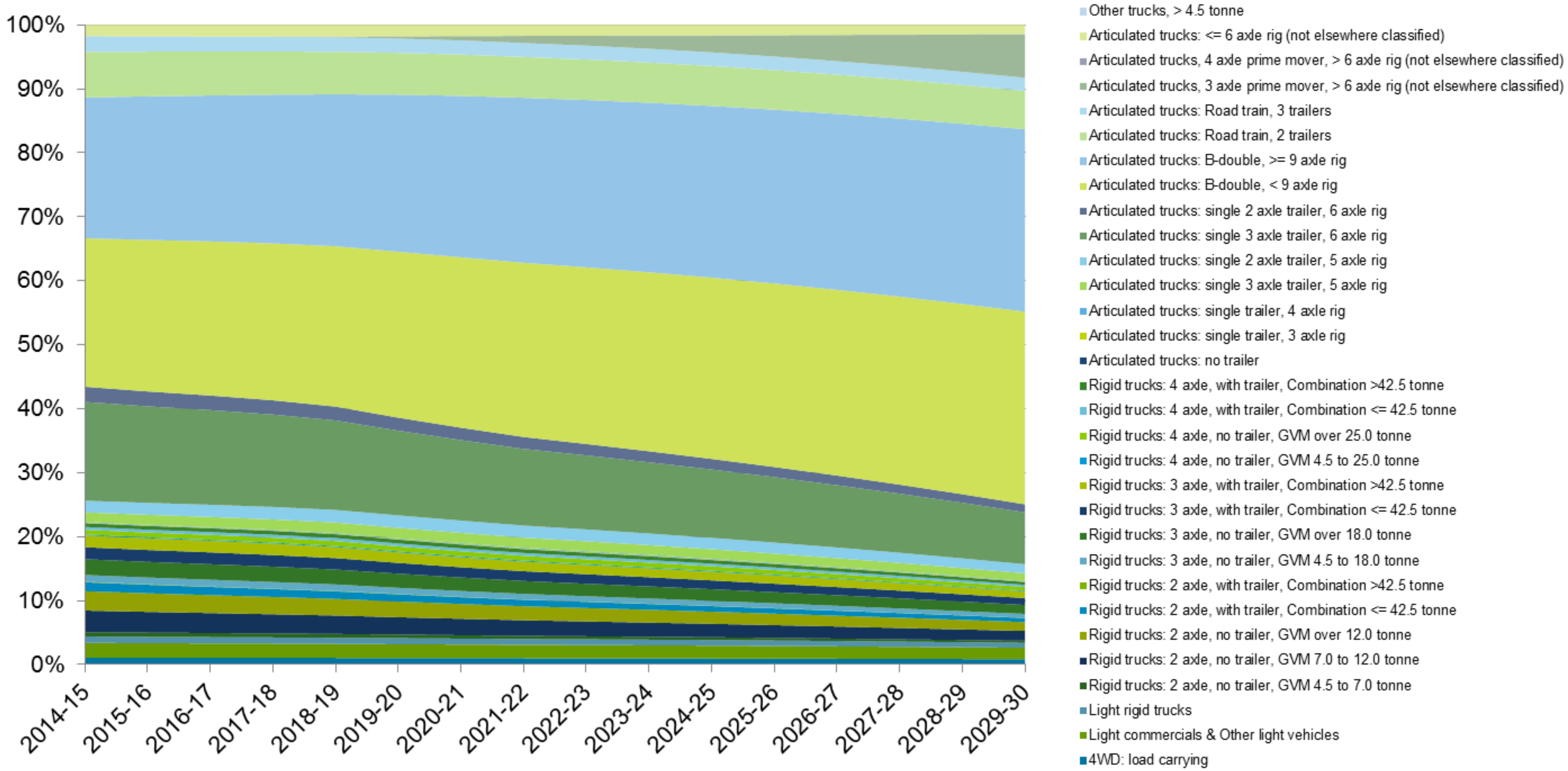


Chart G.16 Vehicle shares of NTK, QLD – Option 3

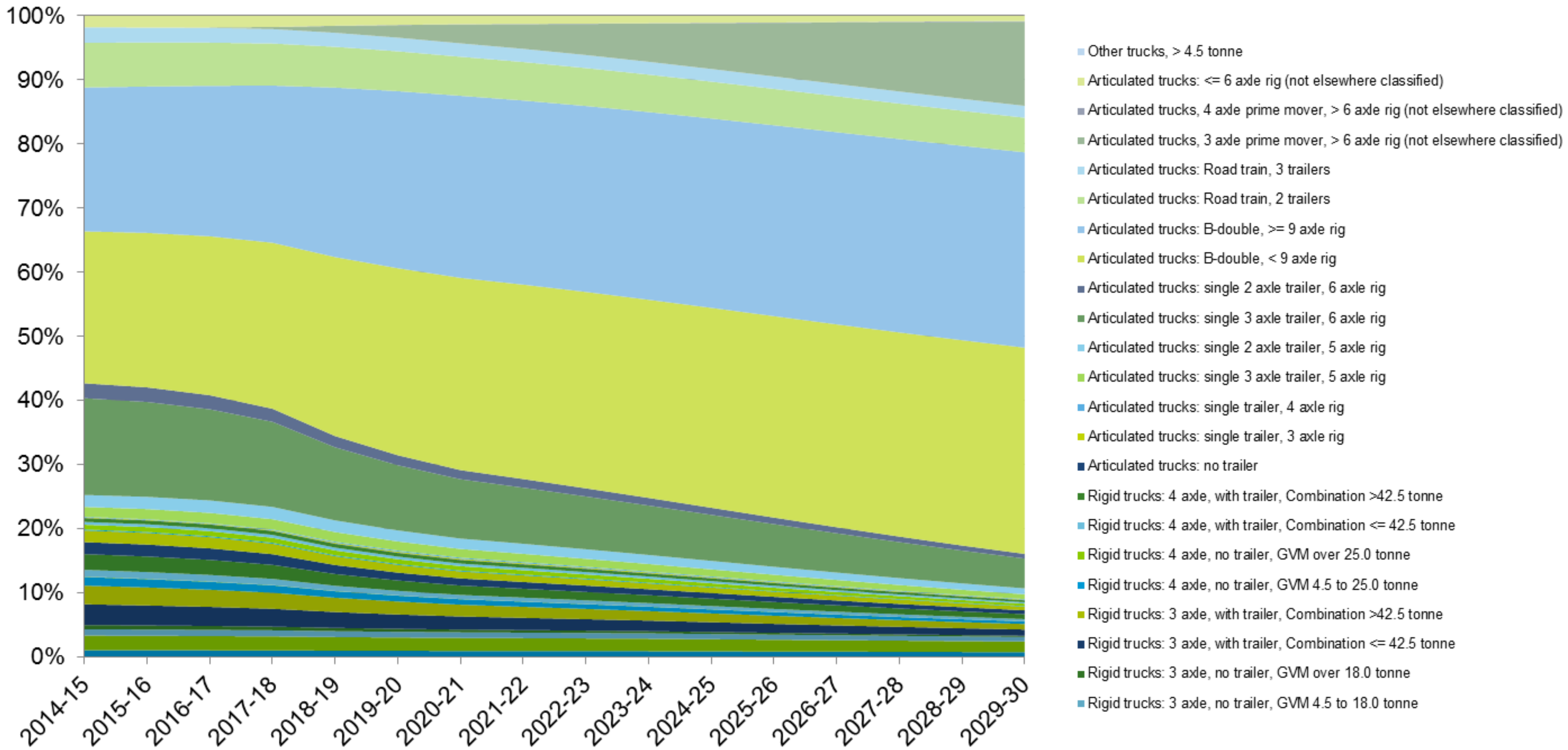


Table G.4 Vehicle shares of NTK - QLD

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	1.1	1.0	1.0	1.2	1.0	0.9	1.2	1.0	0.9	1.1	0.9	0.8
Light commercials & Other light vehicles	2.4	2.1	2.1	2.4	2.1	2.0	2.4	2.1	1.8	2.4	2.0	1.6

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	1.0	0.9	0.9	1.1	0.9	0.9	1.1	0.9	0.8	1.0	0.9	0.7
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.7	0.5	0.5	0.8	0.5	0.4	0.8	0.5	0.3	0.7	0.4	0.2
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	3.6	2.6	2.4	3.8	2.5	2.0	3.8	2.3	1.5	3.6	1.8	1.0
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	3.2	2.3	2.1	3.4	2.3	1.8	3.4	2.1	1.4	3.2	1.6	0.9
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	1.5	1.1	1.0	1.6	1.0	0.8	1.6	1.0	0.6	1.5	0.7	0.4
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	0.1	-	-	0.1	-	-	0.1	-	-	0.1	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	1.1	1.0	1.0	1.1	1.0	0.9	1.1	0.9	0.6	1.1	0.6	0.3
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	2.5	2.4	2.4	2.6	2.2	2.0	2.6	1.9	1.4	2.5	1.3	0.8
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	1.9	1.8	1.8	2.0	1.7	1.5	2.0	1.5	1.1	1.9	1.0	0.6
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	1.9	1.8	1.8	1.9	1.6	1.5	1.9	1.5	1.0	1.9	1.0	0.6
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.7	0.8	0.9	0.7	0.8	0.7	0.7	0.7	0.6	0.7	0.6	0.4
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	0.4	0.5	0.5	0.4	0.5	0.4	0.4	0.4	0.3	0.4	0.4	0.2
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.4	0.6	0.5	0.3
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	0.1	-
Articulated trucks: single trailer, 3 axle rig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Articulated trucks: single trailer, 4 axle rig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Articulated trucks: single 3 axle trailer, 5 axle rig	1.5	1.8	1.8	1.5	1.7	1.6	1.5	1.5	1.2	1.5	1.2	0.8
Articulated trucks: single 2 axle trailer, 5 axle rig	1.8	2.1	2.2	1.8	2.0	1.9	1.8	1.9	1.4	1.8	1.5	0.9
Articulated trucks: single 3 axle trailer, 6 axle rig	16.0	13.7	13.3	16.6	12.9	11.2	16.6	11.6	8.1	16.0	8.2	4.7
Articulated trucks: single 2 axle trailer, 6 axle rig	2.5	2.1	2.1	2.6	2.0	1.7	2.6	1.8	1.3	2.5	1.3	0.7
Articulated trucks: B-double, < 9 axle rig	22.5	25.6	26.0	21.6	26.4	27.8	21.6	27.6	30.1	22.5	30.6	32.2
Articulated trucks: B-double, >= 9 axle rig	21.3	24.2	24.7	20.5	25.0	26.3	20.5	26.2	28.5	21.3	29.0	30.5
Articulated trucks: Road train, 2 trailers	7.3	6.4	6.3	7.4	6.4	6.3	7.4	6.3	6.0	7.3	5.9	5.4
Articulated trucks: Road train, 3 trailers	2.5	2.2	2.2	2.5	2.2	2.2	2.5	2.2	2.1	2.5	2.0	1.8

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.6	2.5	-	1.5	6.8	-	4.9	13.1
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	-	-	-	-	0.1	-	-	0.1
Articulated trucks: <= 6 axle rig (not elsewhere classified)	1.7	2.0	2.0	1.6	1.8	1.8	1.6	1.7	1.4	1.7	1.2	0.8
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.17 Vehicle shares of NTK, ACT – Baseline

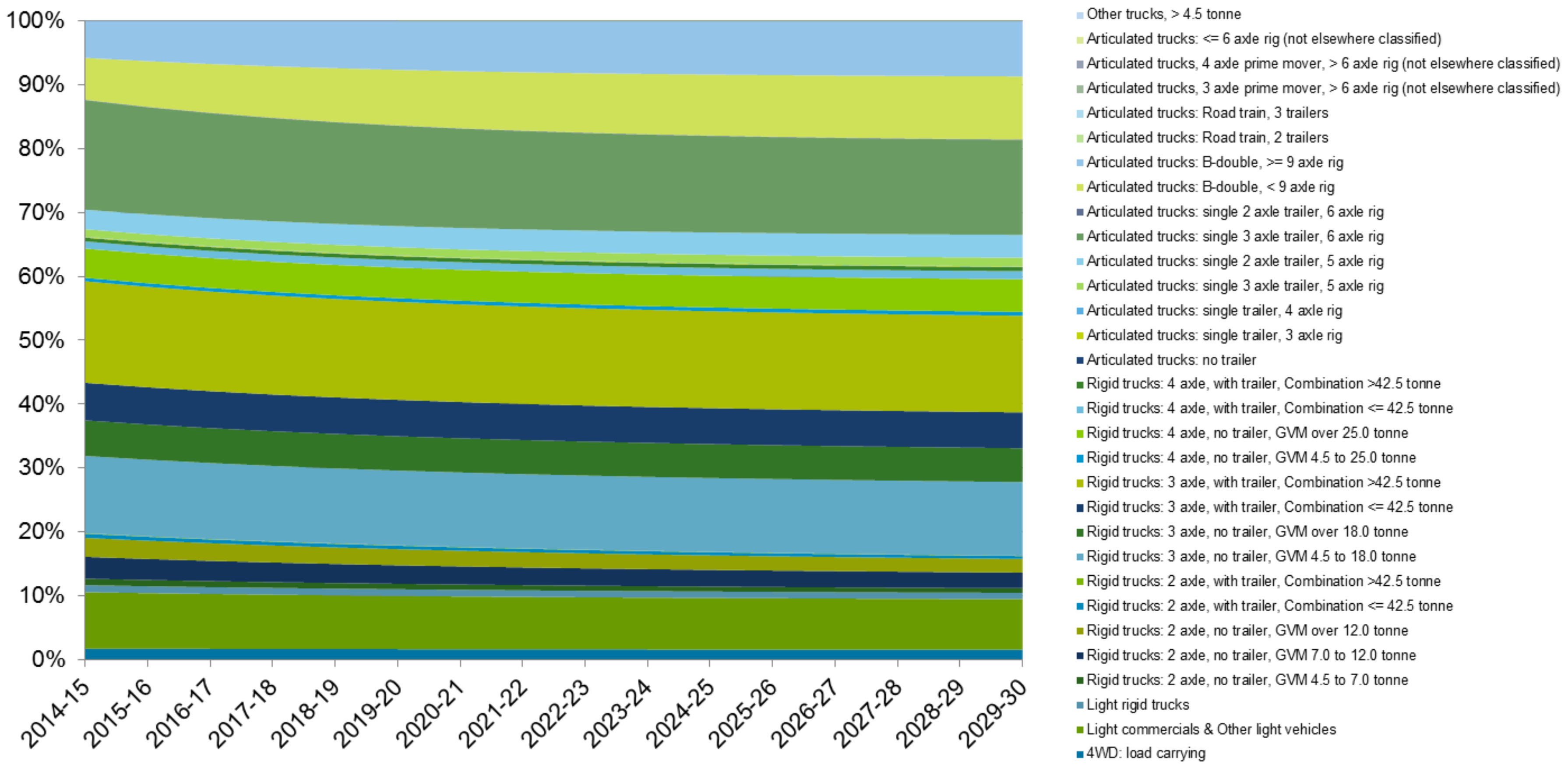


Chart G.18 Vehicle shares of NTK, ACT – Option 1

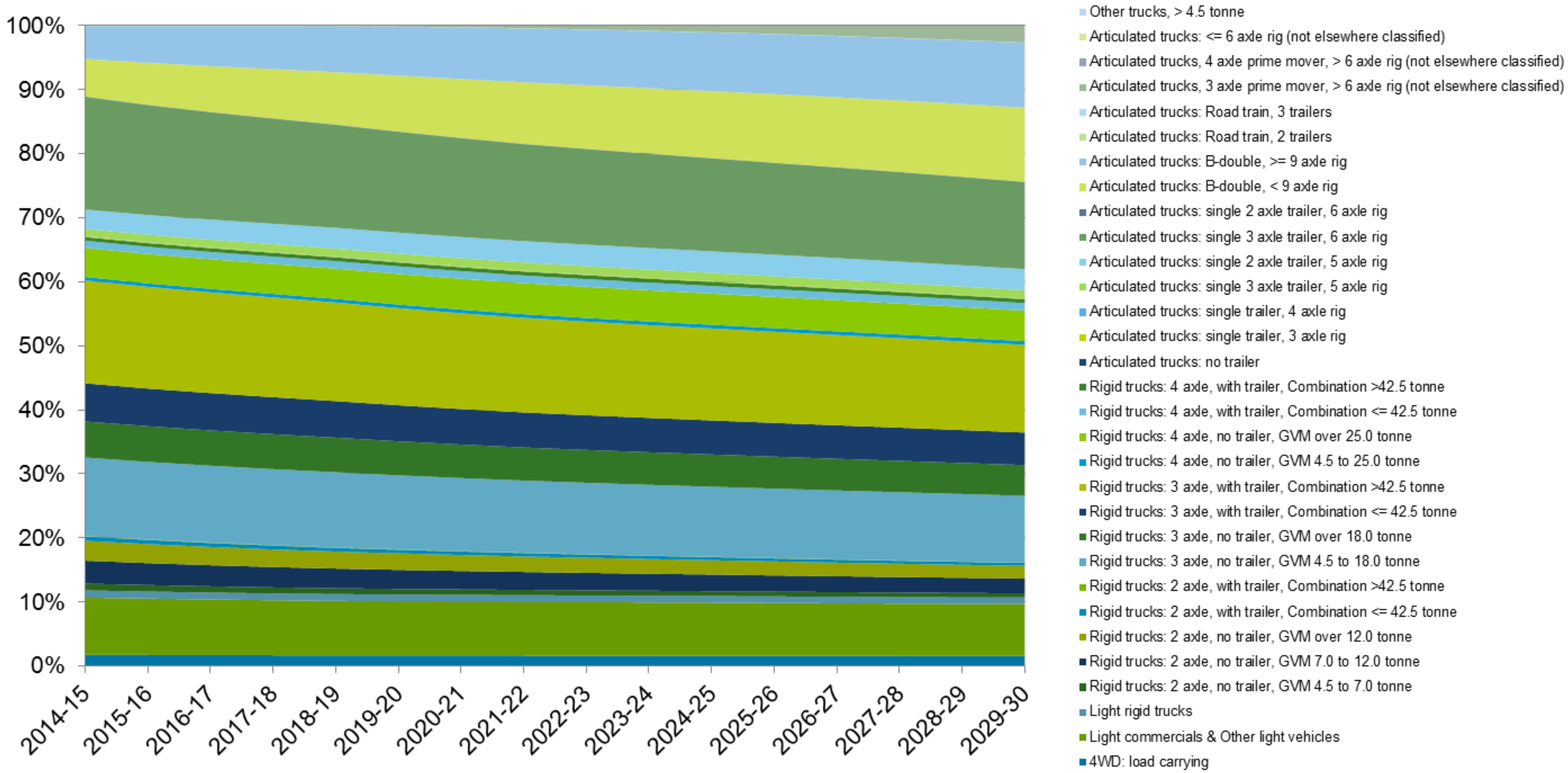


Chart G.19 Vehicle shares of NTK, ACT – Options 2, 1A and 2A

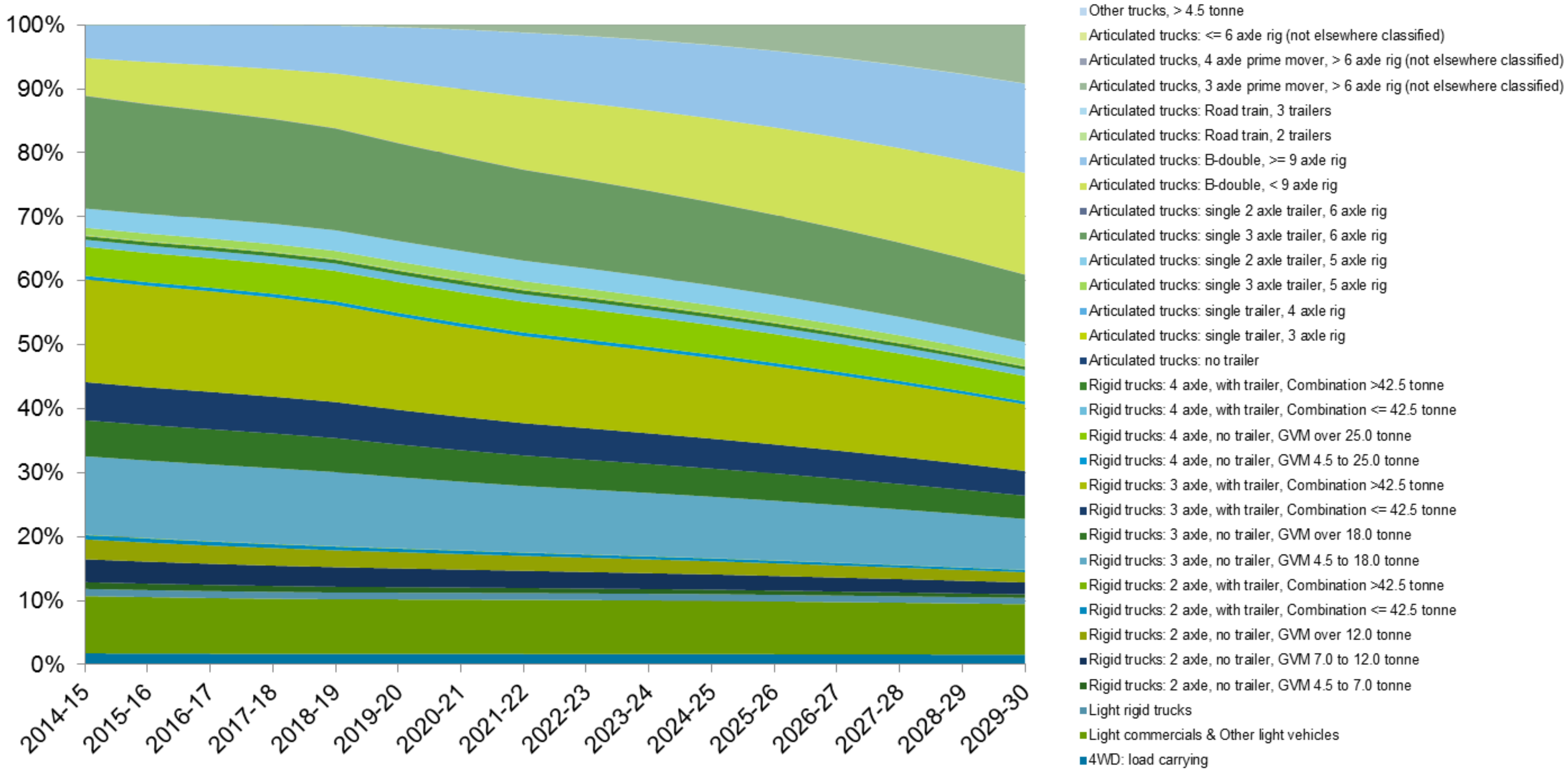


Chart G.20 Vehicle shares of NTK, ACT – Option 3

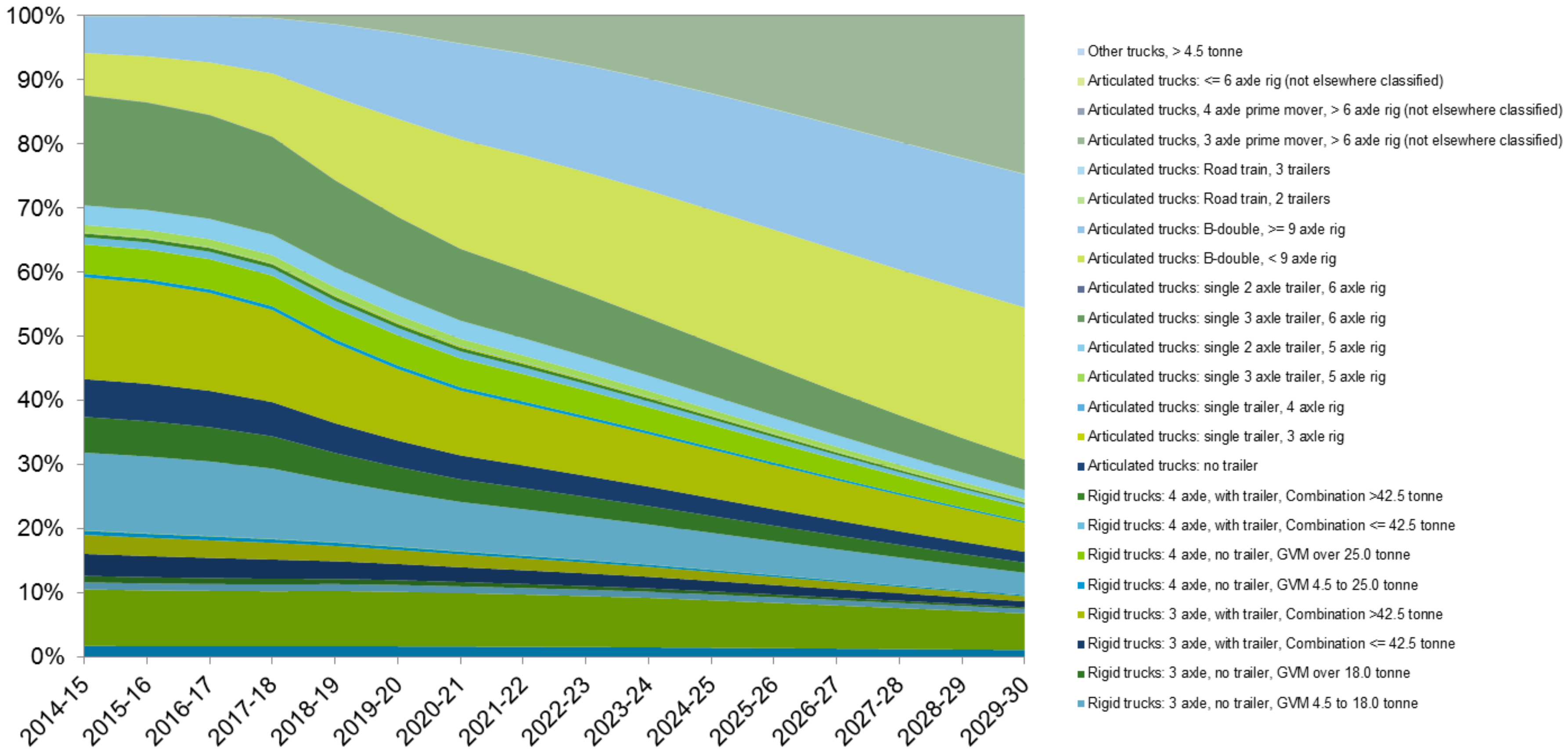


Table G.5 Vehicle shares of NTK - ACT

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	1.8	1.6	1.6	1.8	1.6	1.6	1.8	1.7	1.6	1.8	1.6	1.1
Light commercials & Other light vehicles	9.0	8.2	7.9	9.0	8.4	8.1	9.0	8.4	7.9	9.0	8.0	5.7

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	1.1	1.0	1.0	1.1	1.0	1.0	1.1	1.0	1.0	1.1	1.0	0.7
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	1.1	0.8	0.7	1.1	0.8	0.7	1.1	0.8	0.5	1.1	0.6	0.3
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	3.7	2.7	2.5	3.9	2.7	2.3	3.9	2.6	1.9	3.7	2.0	0.9
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	3.2	2.3	2.1	3.3	2.4	2.0	3.3	2.2	1.6	3.2	1.7	0.8
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	0.7	0.5	0.5	0.7	0.5	0.4	0.7	0.5	0.4	0.7	0.4	0.2
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	0.1	0.1	0.1	0.1	0.1	-	0.1	0.1	-	0.1	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	12.3	11.6	11.5	12.3	11.1	10.4	12.3	10.1	7.9	12.3	6.7	3.5
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	5.6	5.3	5.3	5.6	5.1	4.8	5.6	4.6	3.6	5.6	3.1	1.6
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	6.0	5.6	5.6	6.0	5.4	5.1	6.0	4.9	3.9	6.0	3.3	1.7
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	16.1	15.2	15.1	16.1	14.6	13.7	16.1	13.3	10.4	16.1	8.8	4.5
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.5	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.5	0.5	0.3
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	4.4	4.9	5.1	4.3	4.9	4.8	4.3	4.8	4.0	4.4	4.0	2.1
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	1.1	1.2	1.3	1.1	1.2	1.2	1.1	1.2	1.0	1.1	1.0	0.5
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.6	0.5	0.3
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Articulated trucks: single trailer, 4 axle rig	0.1	-	-	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	-
Articulated trucks: single 3 axle trailer, 5 axle rig	1.1	1.3	1.4	1.0	1.3	1.3	1.0	1.2	1.0	1.1	1.0	0.5
Articulated trucks: single 2 axle trailer, 5 axle rig	2.9	3.4	3.6	2.8	3.3	3.3	2.8	3.2	2.7	2.9	2.5	1.3
Articulated trucks: single 3 axle trailer, 6 axle rig	17.9	15.3	14.9	18.2	14.9	13.6	18.2	13.8	10.5	17.9	9.7	4.7
Articulated trucks: single 2 axle trailer, 6 axle rig	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	0.1	-	-
Articulated trucks: B-double, < 9 axle rig	5.7	9.3	9.9	5.4	9.9	11.6	5.4	12.0	15.9	5.7	19.0	23.7
Articulated trucks: B-double, >= 9 axle rig	5.0	8.2	8.7	4.7	8.7	10.1	4.7	10.5	13.9	5.0	16.6	20.8
Articulated trucks: Road train, 2 trailers	-	-	-	-	-	-	-	-	-	-	-	0.1
Articulated trucks: Road train, 3 trailers	-	-	-	-	-	-	-	-	-	-	-	-

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.6	2.6	-	1.7	9.1	-	7.7	24.6
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: <= 6 axle rig (not elsewhere classified)	-	-	-	-	-	-	-	-	-	-	-	-
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.21 Vehicle shares of NTK, TAS – Baseline

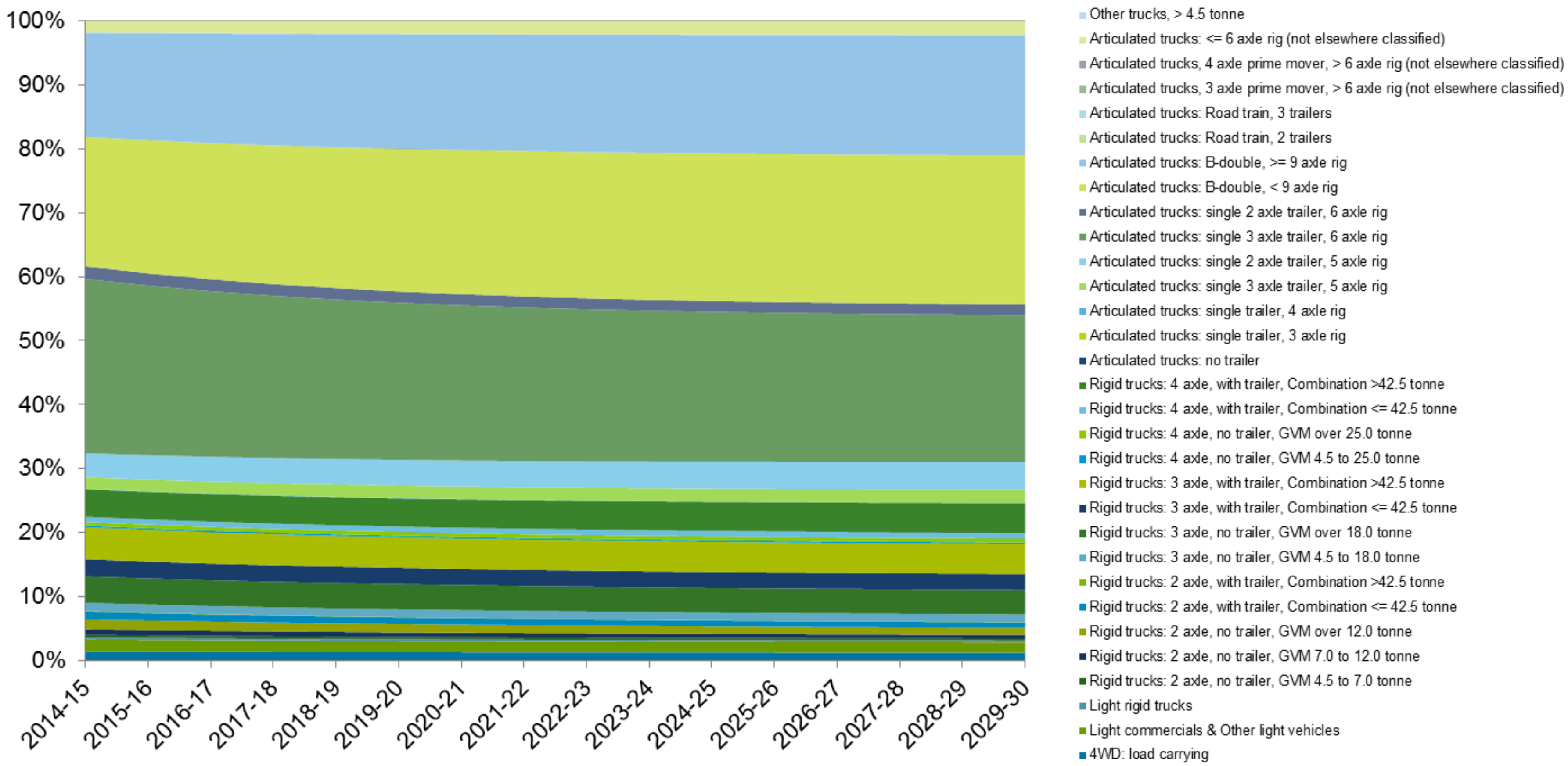


Chart G.22 Vehicle shares of NTK, TAS – Option 1

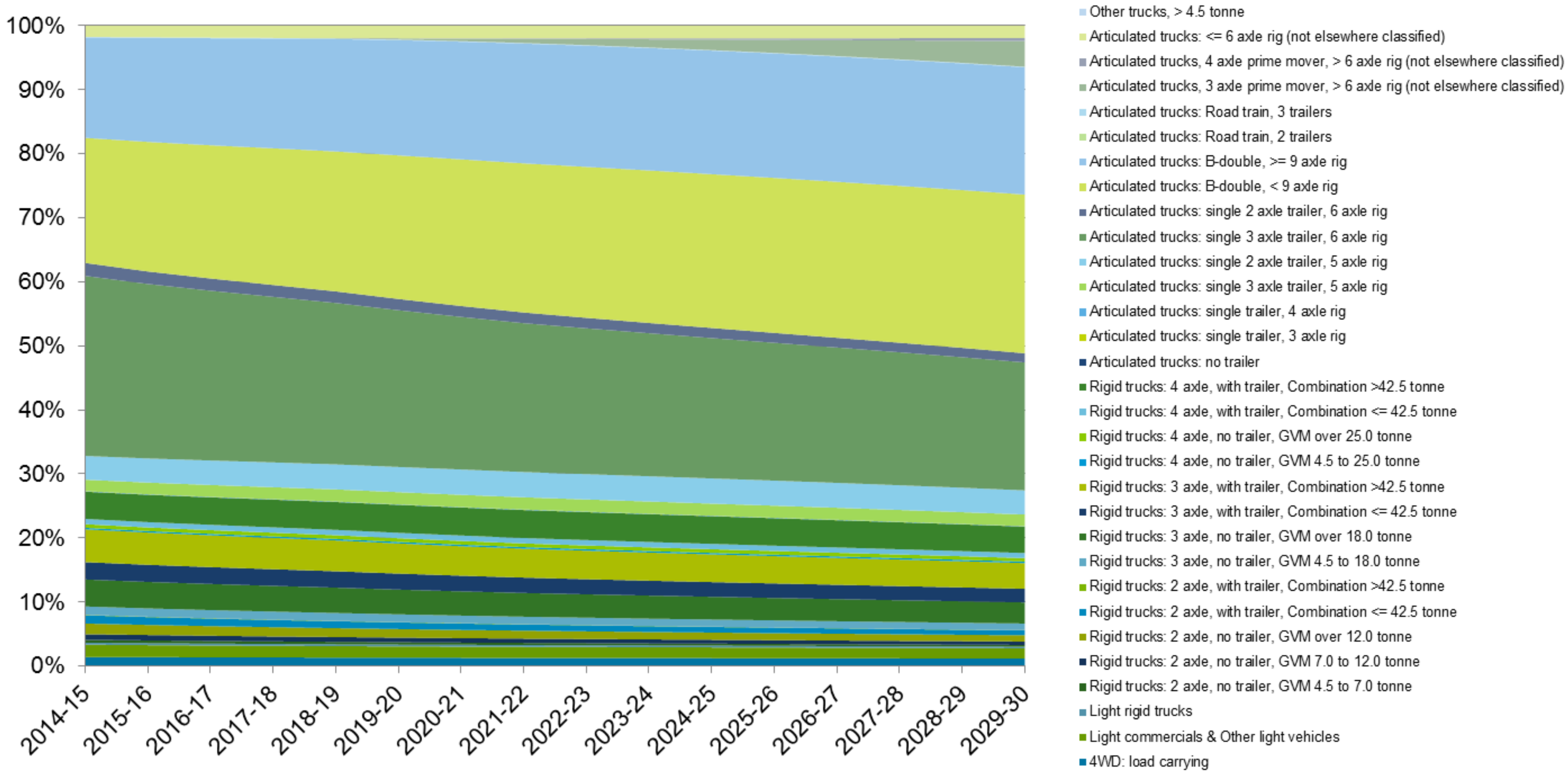


Chart G.23 Vehicle shares of NTK, TAS – Options 2, 1A and 2A

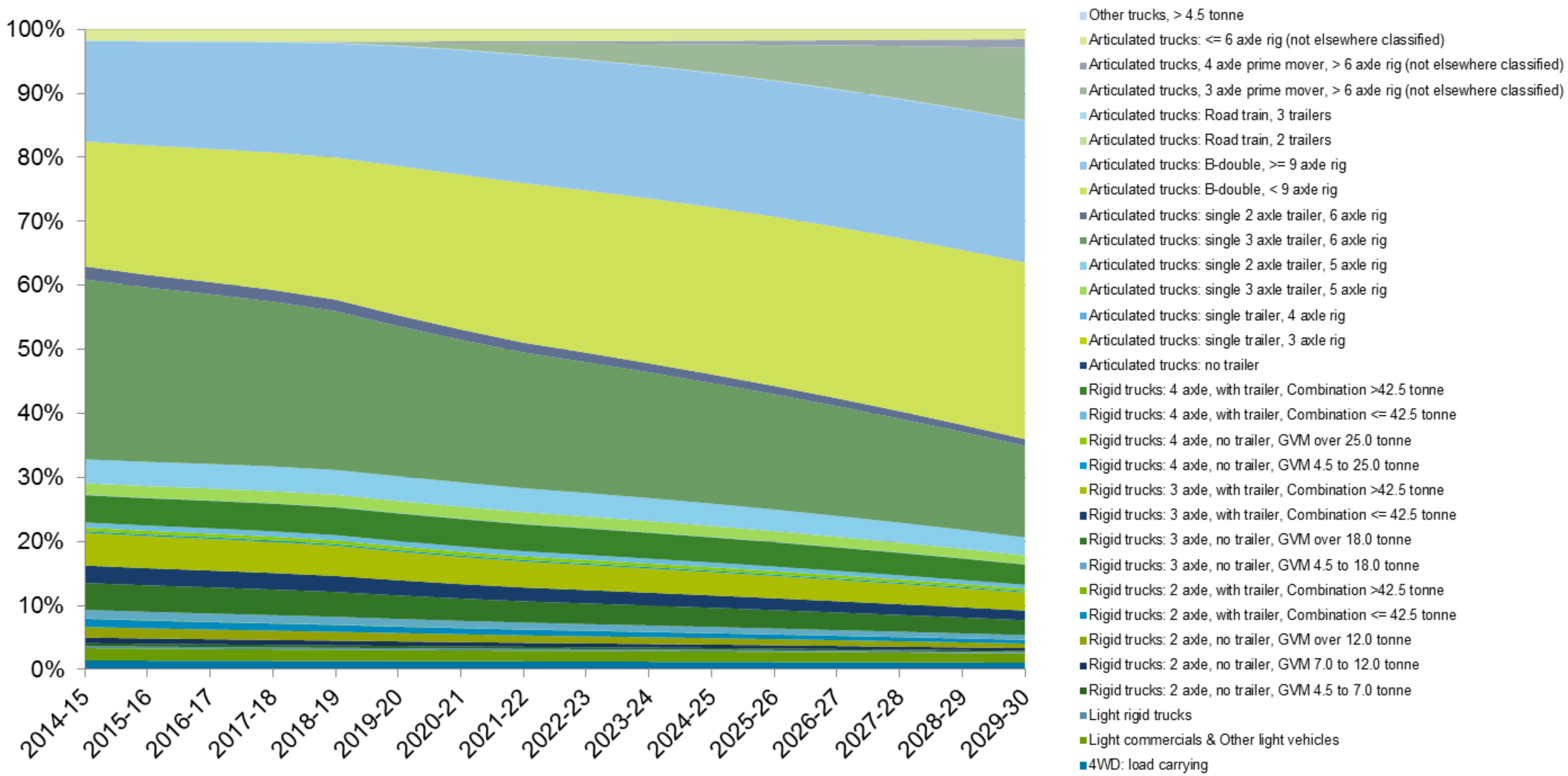


Chart G.24 Vehicle shares of NTK, TAS – Option 3

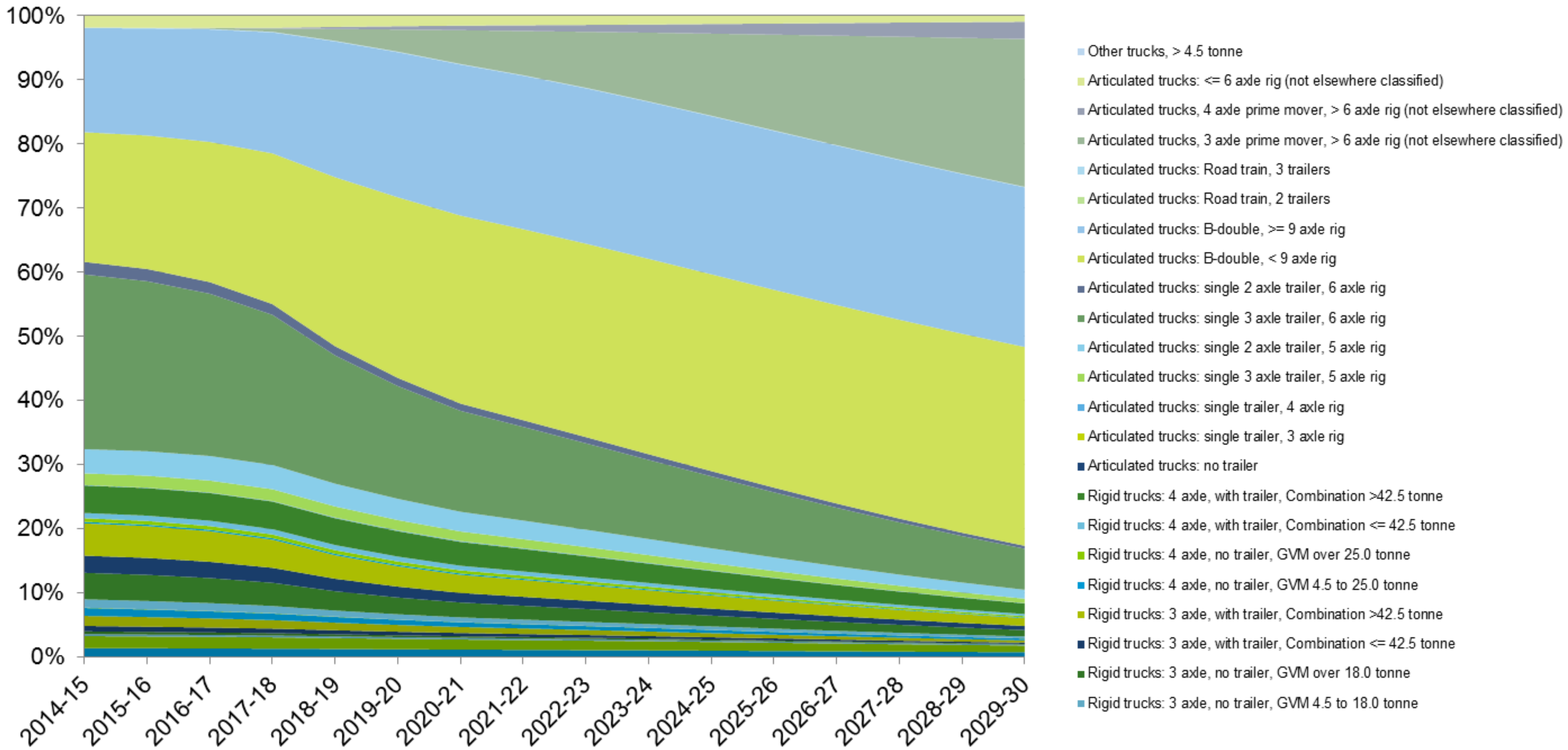


Table G.6 Vehicle shares of NTK - TAS

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	1.5	1.3	1.2	1.5	1.3	1.2	1.5	1.2	1.1	1.5	1.1	0.8
Light commercials & Other light vehicles	1.9	1.7	1.6	2.0	1.7	1.6	2.0	1.7	1.4	1.9	1.5	1.0

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.5	0.3	0.3	0.5	0.3	0.3	0.5	0.3	0.2	0.5	0.2	0.1
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	0.9	0.7	0.6	1.0	0.6	0.5	1.0	0.6	0.4	0.9	0.4	0.2
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	1.7	1.2	1.1	1.8	1.2	1.0	1.8	1.1	0.7	1.7	0.8	0.4
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	1.3	0.9	0.9	1.4	0.9	0.8	1.4	0.9	0.6	1.3	0.6	0.3
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	0.1	-	-	0.1	-	-	0.1	-	-	0.1	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	1.3	1.2	1.2	1.4	1.2	1.0	1.4	1.0	0.7	1.3	0.6	0.3
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	4.3	3.9	3.8	4.3	3.7	3.3	4.3	3.2	2.3	4.3	2.0	1.0
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	2.8	2.5	2.5	2.8	2.4	2.1	2.8	2.1	1.5	2.8	1.3	0.6
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	5.2	4.7	4.7	5.3	4.4	4.0	5.3	3.9	2.8	5.2	2.4	1.2
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.5	0.4	0.6	0.4	0.2
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	0.8	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.6	0.8	0.6	0.3
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	4.2	4.5	4.6	4.2	4.4	4.1	4.2	4.1	3.2	4.2	3.3	1.7
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 4 axle rig	0.1	-	-	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	-
Articulated trucks: single 3 axle trailer, 5 axle rig	1.7	2.0	2.1	1.7	1.9	1.8	1.7	1.8	1.4	1.7	1.3	0.7
Articulated trucks: single 2 axle trailer, 5 axle rig	3.6	4.1	4.3	3.5	4.0	3.8	3.5	3.7	2.8	3.6	2.7	1.4
Articulated trucks: single 3 axle trailer, 6 axle rig	28.9	23.8	23.0	29.9	22.8	20.0	29.9	20.4	14.3	28.9	13.5	6.4
Articulated trucks: single 2 axle trailer, 6 axle rig	2.1	1.7	1.7	2.1	1.6	1.4	2.1	1.5	1.0	2.1	1.0	0.5
Articulated trucks: B-double, < 9 axle rig	18.9	22.9	23.4	18.2	23.6	24.8	18.2	25.4	27.6	18.9	30.2	31.0
Articulated trucks: B-double, >= 9 axle rig	15.2	18.4	18.8	14.6	18.9	19.9	14.6	20.4	22.2	15.2	24.2	24.9
Articulated trucks: Road train, 2 trailers	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: Road train, 3 trailers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.9	4.0	-	2.6	11.3	-	8.7	23.1
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.1	0.5	-	0.3	1.3	-	1.1	2.7
Articulated trucks: <= 6 axle rig (not elsewhere classified)	1.7	2.1	2.2	1.7	2.0	1.9	1.7	1.8	1.5	1.7	1.4	0.9
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.25 Vehicle shares of NTK, NT – Baseline

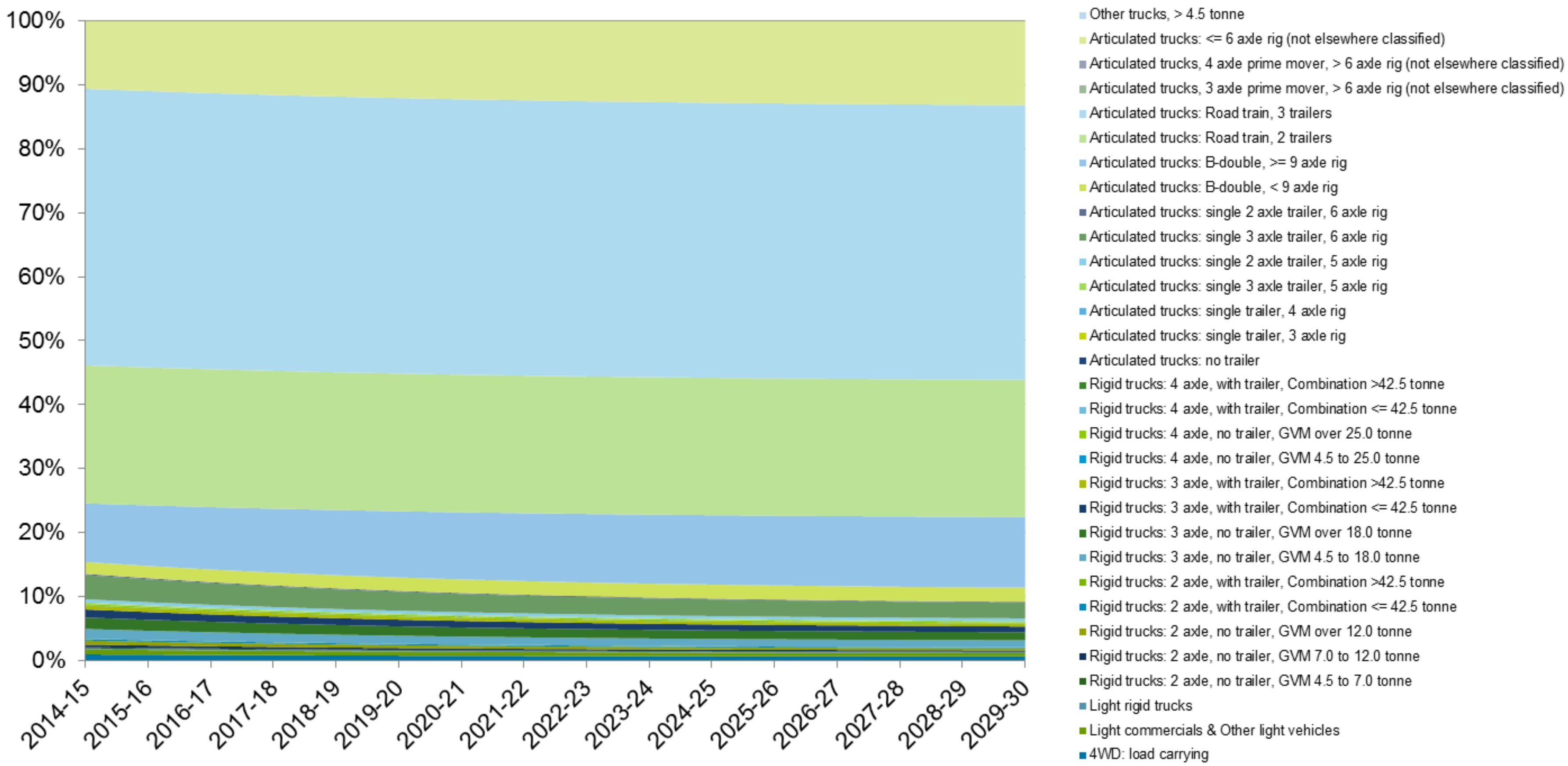


Chart G.26 Vehicle shares of NTK, NT – Option 1

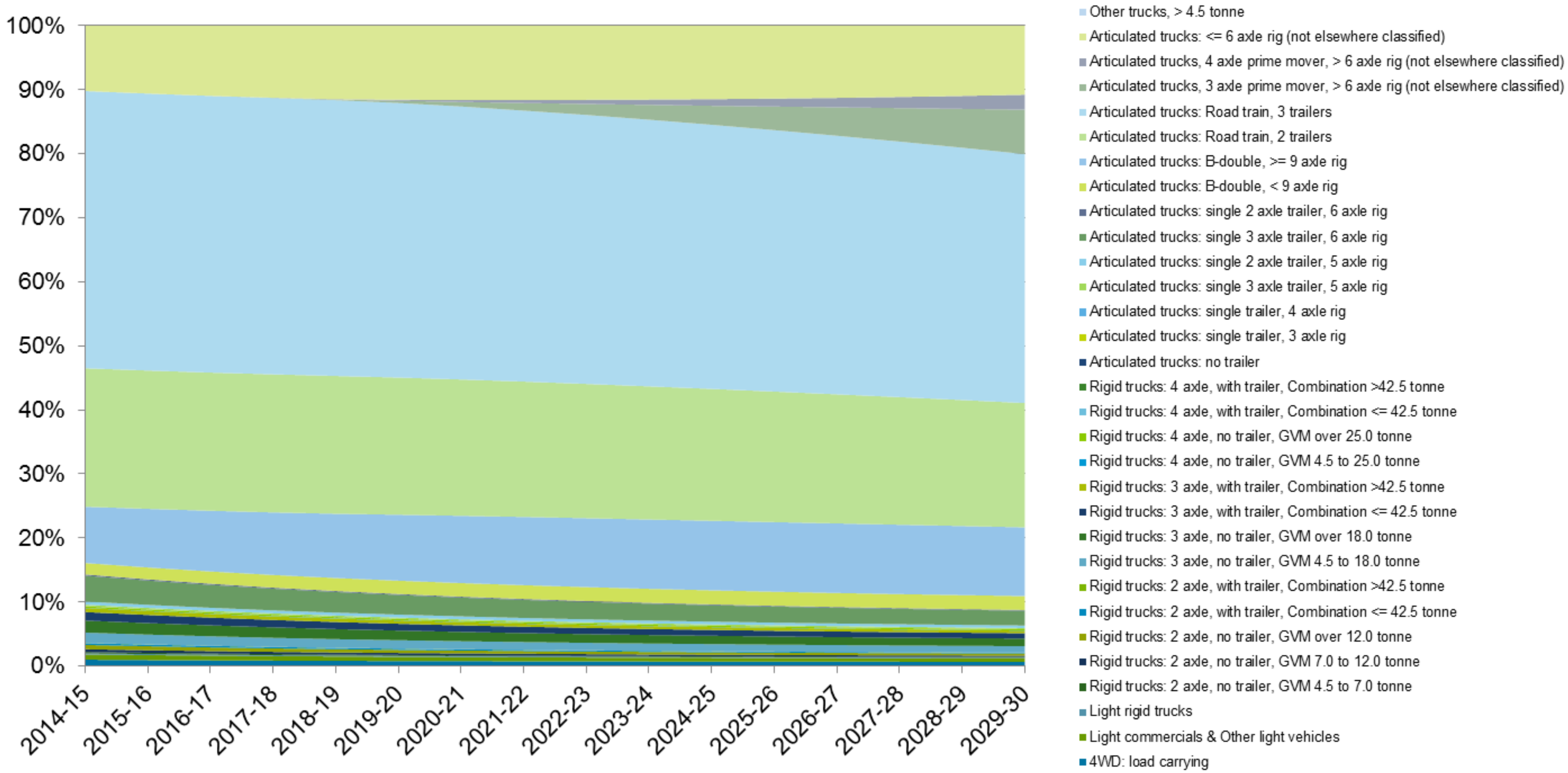


Chart G.27 Vehicle shares of NTK, NT – Options 2, 1A and 2A

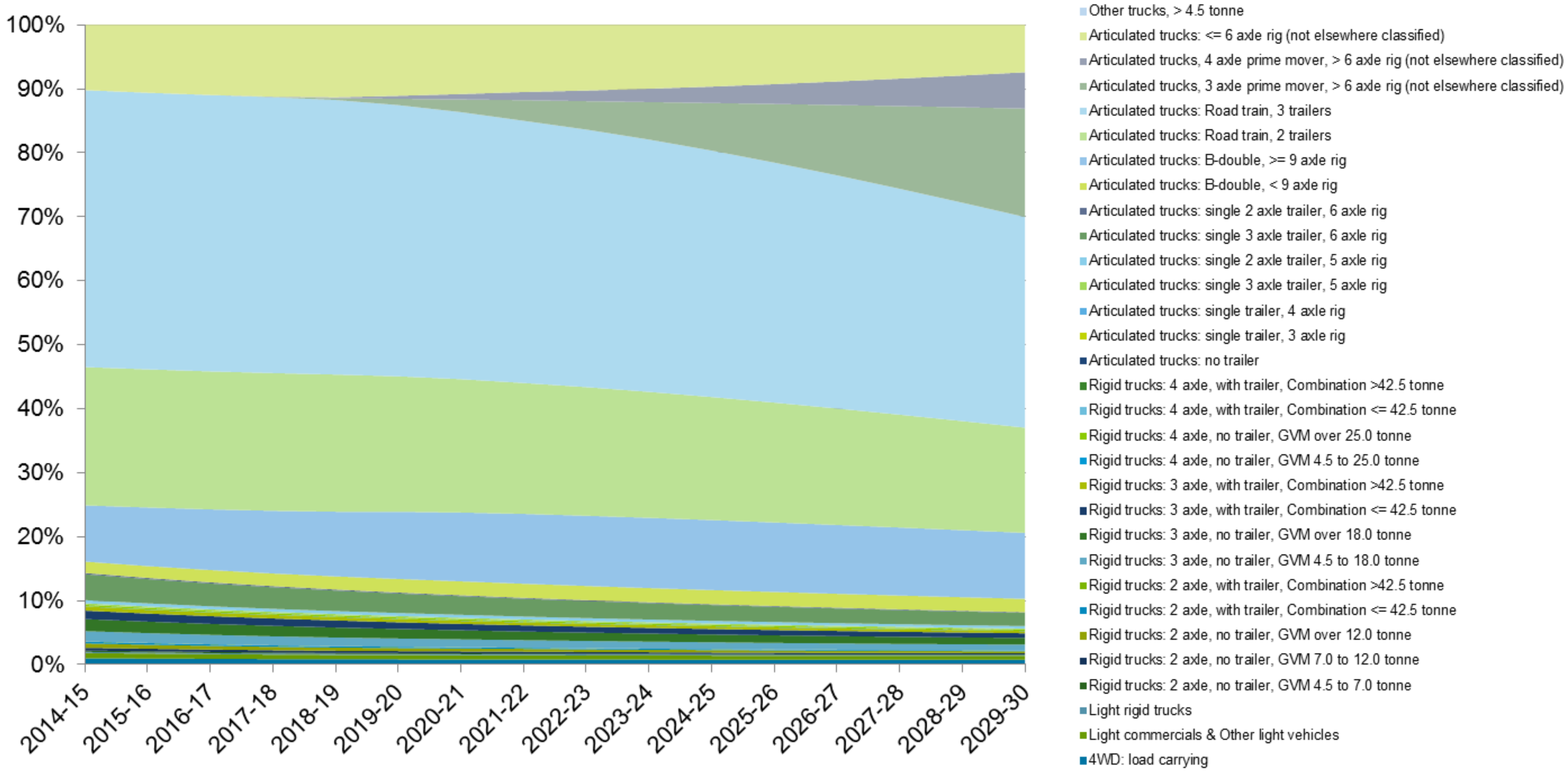


Chart G.28 Vehicle shares of NTK, NT – Option 3

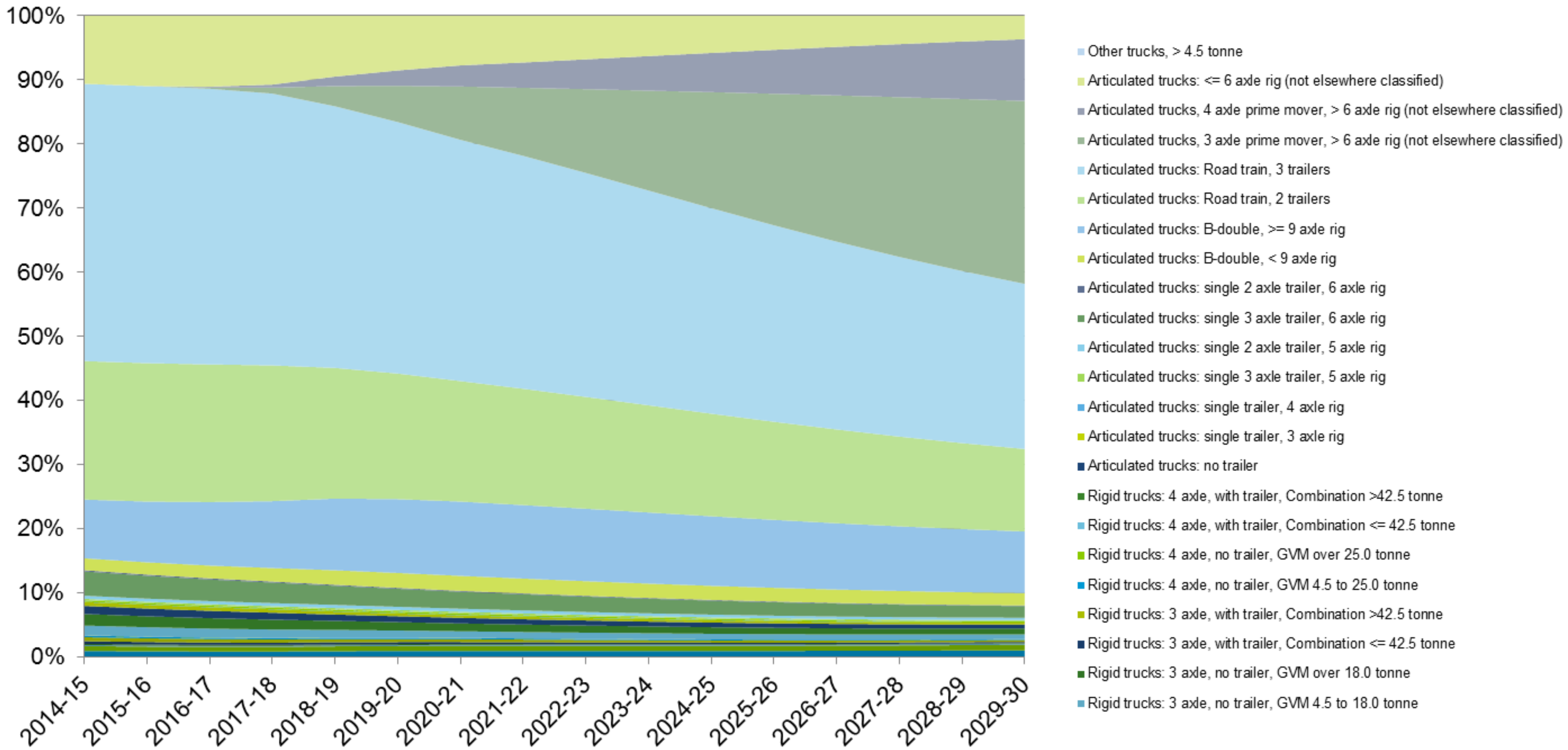


Table G.7 Vehicle shares of NTK - NT

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	1.0	0.7	0.6	1.0	0.7	0.7	1.0	0.8	0.8	1.0	1.0	1.1
Light commercials & Other light vehicles	0.8	0.6	0.5	0.8	0.6	0.5	0.8	0.6	0.6	0.8	0.8	0.9

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	0.4	0.3	0.2	0.5	0.3	0.2	0.5	0.3	0.2	0.4	0.3	0.2
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	0.7	0.4	0.3	0.7	0.4	0.3	0.7	0.4	0.3	0.7	0.4	0.3
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	1.6	1.2	1.1	1.6	1.2	1.0	1.6	1.1	0.9	1.6	1.0	0.8
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	1.8	1.4	1.3	1.8	1.4	1.2	1.8	1.3	1.0	1.8	1.1	0.9
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	1.3	1.0	0.9	1.3	1.0	0.8	1.3	0.9	0.7	1.3	0.8	0.6
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	0.6	0.5	0.4	0.6	0.5	0.4	0.6	0.4	0.4	0.6	0.4	0.3
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 4 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single 3 axle trailer, 5 axle rig	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Articulated trucks: single 2 axle trailer, 5 axle rig	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4
Articulated trucks: single 3 axle trailer, 6 axle rig	4.0	2.7	2.4	4.0	2.7	2.3	4.0	2.7	2.1	4.0	2.4	1.8
Articulated trucks: single 2 axle trailer, 6 axle rig	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1
Articulated trucks: B-double, < 9 axle rig	1.7	2.2	2.2	1.6	2.2	2.2	1.6	2.2	2.1	1.7	2.3	1.9
Articulated trucks: B-double, >= 9 axle rig	8.5	10.7	11.1	8.1	10.8	10.7	8.1	11.0	10.3	8.5	11.3	9.6
Articulated trucks: Road train, 2 trailers	21.9	21.5	21.4	22.3	21.0	19.4	22.3	20.1	16.4	21.9	17.4	12.9
Articulated trucks: Road train, 3 trailers	43.9	43.0	42.9	44.6	42.0	38.9	44.6	40.3	32.9	43.9	34.9	25.8

	Baseline			Option 1			Options 2, 1A and 2A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	1.7	7.0	-	4.4	17.0	-	13.1	28.5
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	0.6	2.3	-	1.7	5.7	-	4.7	9.6
Articulated trucks: <= 6 axle rig (not elsewhere classified)	9.9	12.5	13.2	9.5	11.6	10.8	9.5	10.3	7.4	9.9	6.8	3.6
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Chart G.29 Vehicle shares of NTK, SA – Baseline

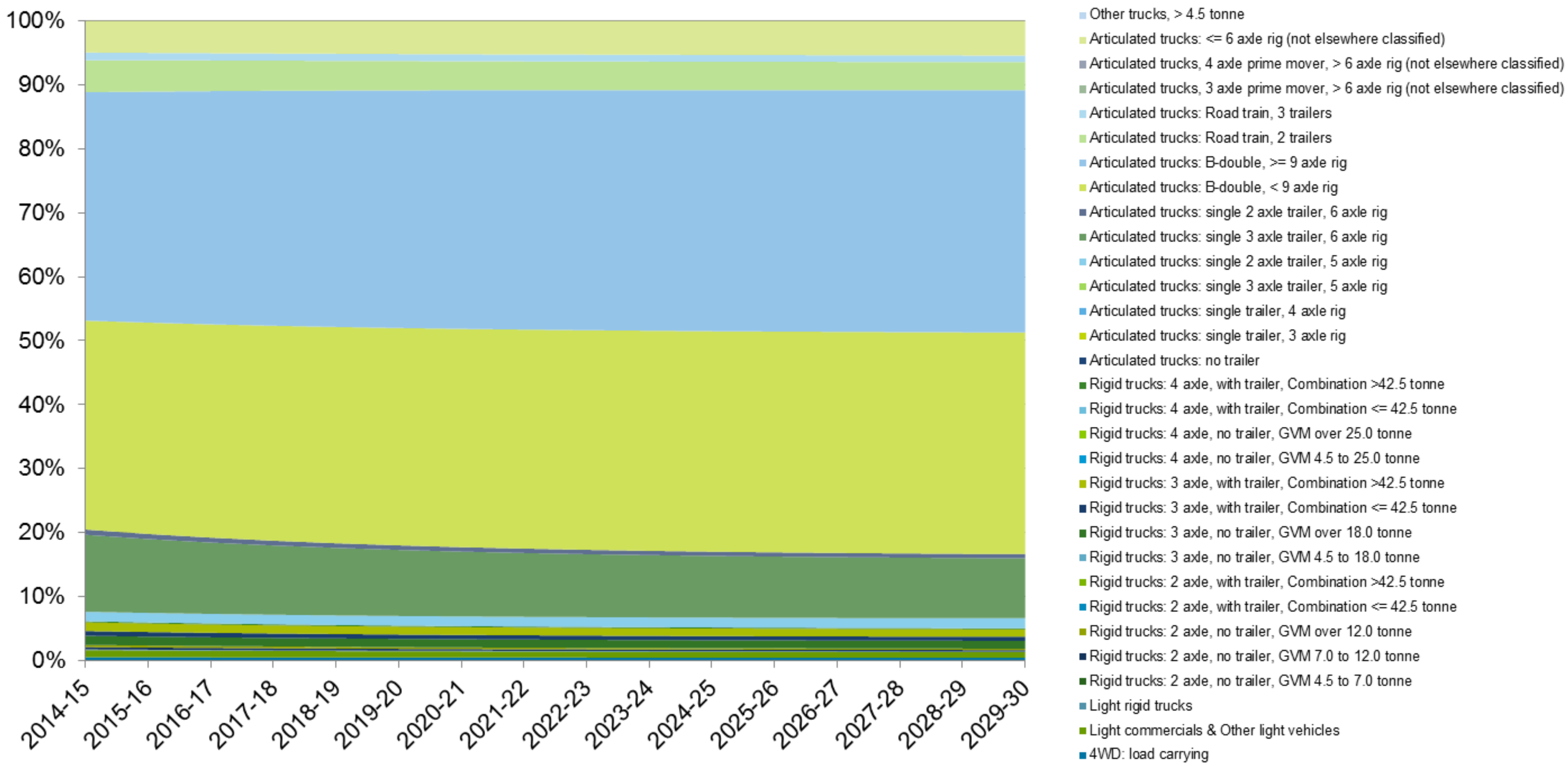


Chart G.30 Vehicle shares of NTK, SA – Option 1

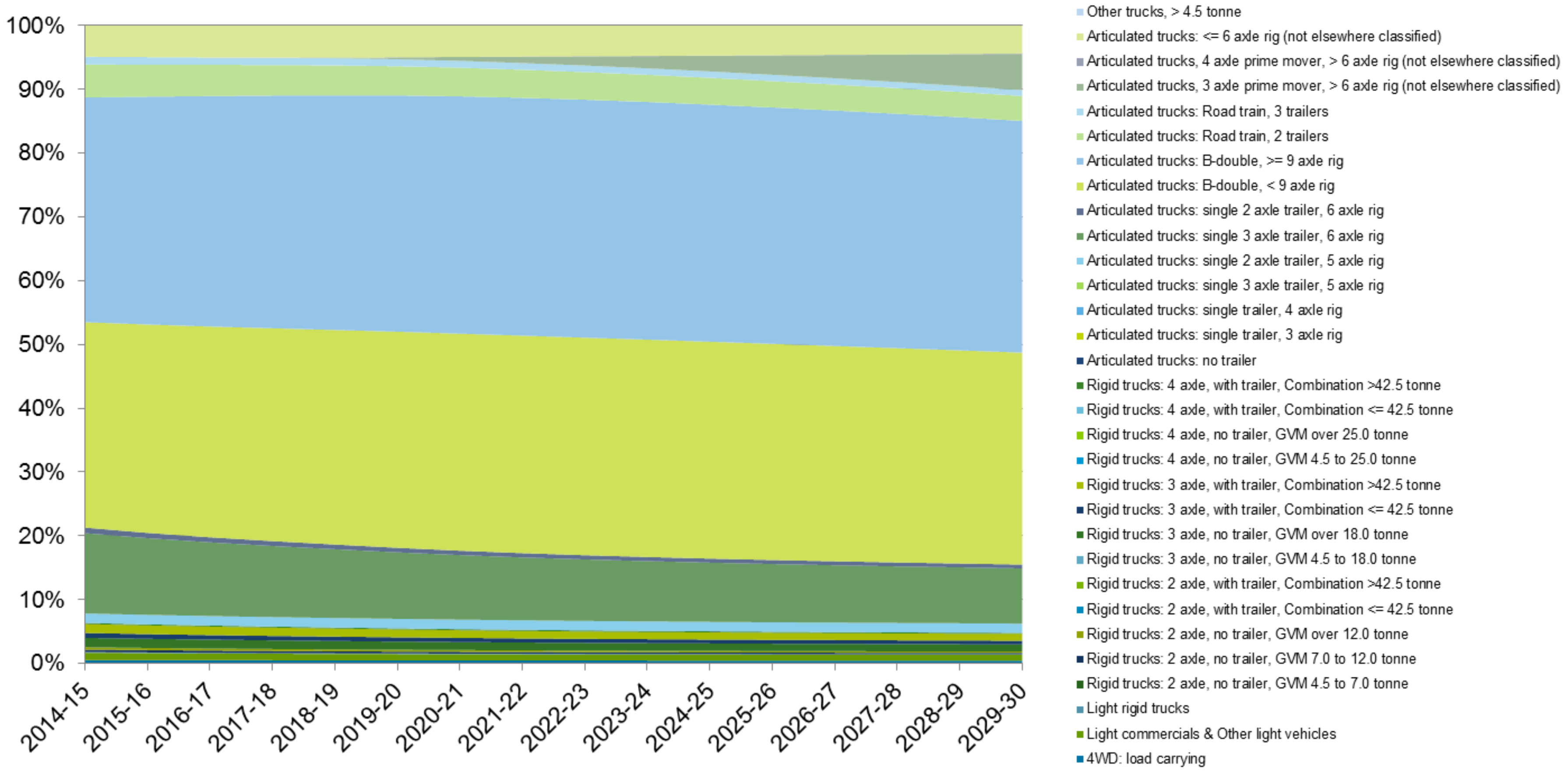


Chart G.31 Vehicle shares of NTK, SA – Options 2, 1A and 2A

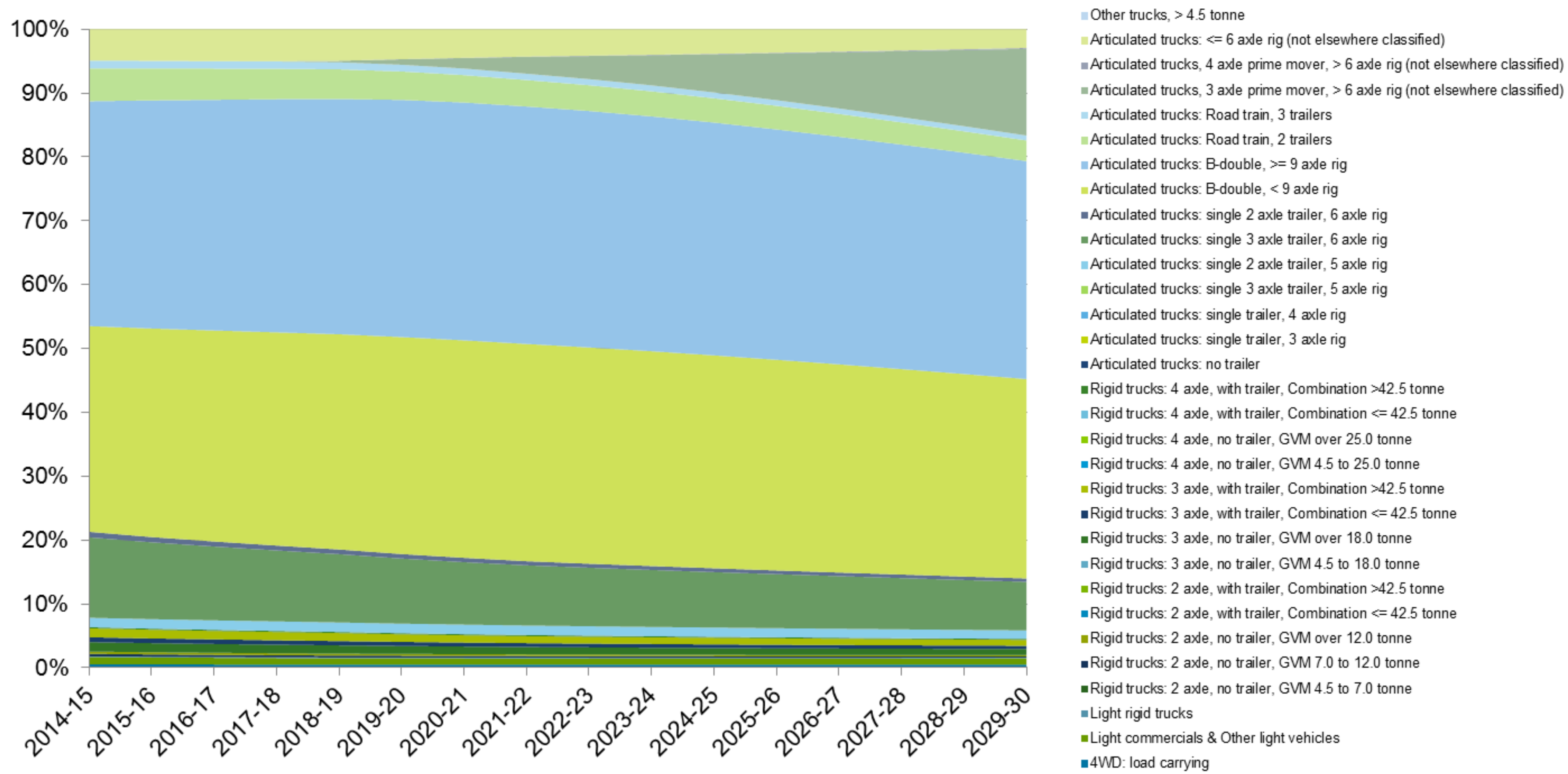


Chart G.32 Vehicle shares of NTK, SA – Option 3

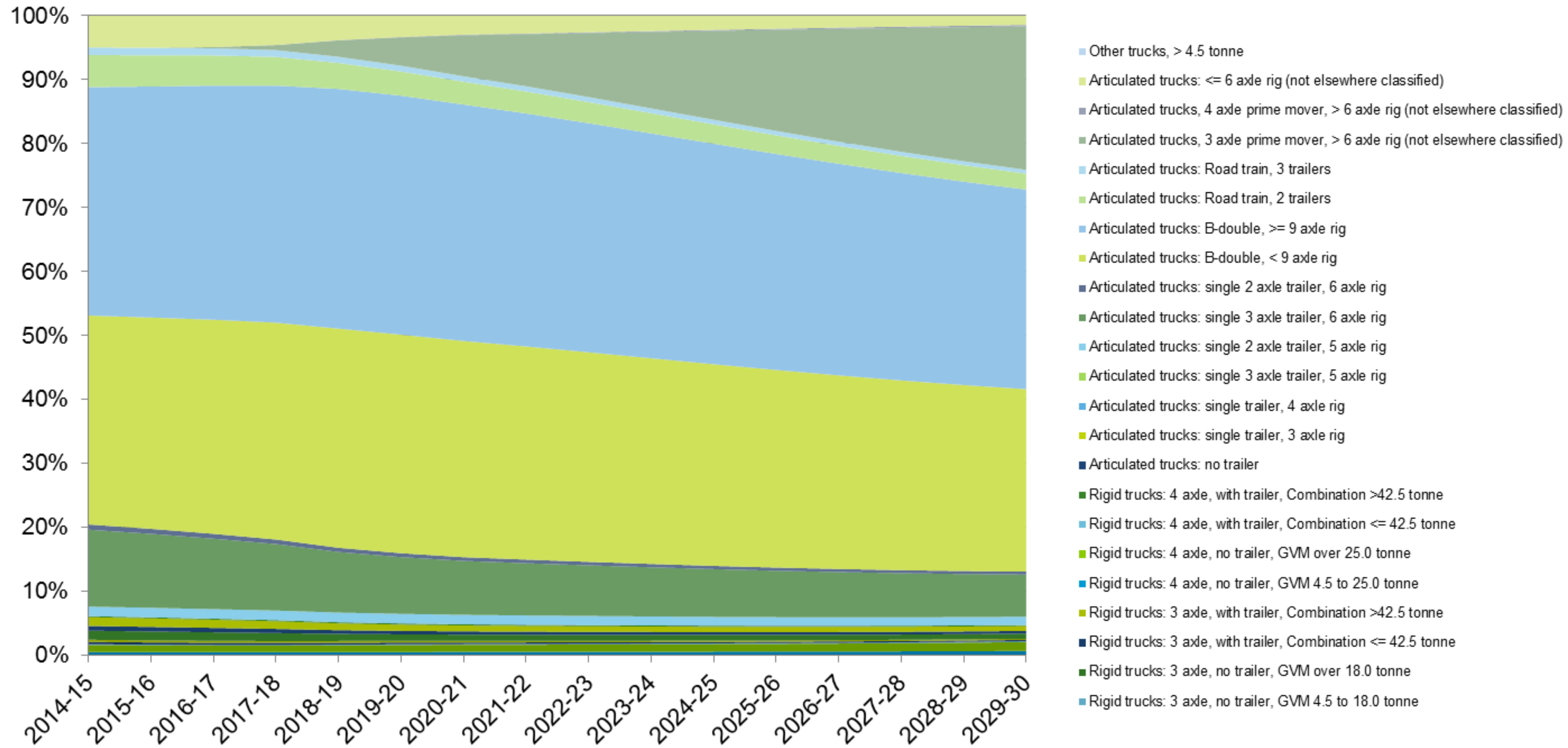


Table G.8 Vehicle shares of NTK – SA

	Baseline			Option 1			Options 2, 1A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
4WD: load carrying	0.6	0.5	0.4	0.6	0.5	0.4	0.6	0.5	0.5	0.6	0.6	0.7
Light commercials & Other light vehicles	1.2	0.9	0.9	1.3	1.0	0.9	1.3	1.0	1.0	1.2	1.1	1.4

	Baseline			Option 1			Options 2, 1A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Light rigid trucks	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	0.4	0.3	0.2	0.4	0.3	0.2	0.4	0.2	0.2	0.4	0.2	0.2
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	0.4	0.3	0.2	0.4	0.3	0.2	0.4	0.2	0.2	0.4	0.2	0.2
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	1.6	1.3	1.2	1.6	1.2	1.1	1.6	1.1	1.0	1.6	0.9	0.8
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	0.8	0.7	0.6	0.8	0.6	0.6	0.8	0.6	0.5	0.8	0.5	0.4
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	1.5	1.2	1.2	1.6	1.2	1.1	1.6	1.1	0.9	1.5	0.9	0.8
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1
Articulated trucks: no trailer	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 3 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single trailer, 4 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single 3 axle trailer, 5 axle rig	-	-	-	-	-	-	-	-	-	-	-	-
Articulated trucks: single 2 axle trailer, 5 axle rig	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5	1.3	1.5	1.4	1.3
Articulated trucks: single 3 axle trailer, 6 axle rig	13.4	9.8	9.4	14.4	9.6	8.6	14.4	9.2	7.6	13.4	7.9	6.6
Articulated trucks: single 2 axle trailer, 6 axle rig	0.9	0.7	0.6	1.0	0.7	0.6	1.0	0.6	0.5	0.9	0.5	0.5
Articulated trucks: B-double, < 9 axle rig	31.5	34.3	34.7	30.8	34.1	33.2	30.8	33.9	31.2	31.5	32.8	28.5
Articulated trucks: B-double, >= 9 axle rig	34.5	37.6	37.9	33.6	37.3	36.3	33.6	37.0	34.1	34.5	35.8	31.2
Articulated trucks: Road train, 2 trailers	5.3	4.5	4.4	5.5	4.3	3.9	5.5	4.0	3.2	5.3	3.3	2.5
Articulated trucks: Road train, 3 trailers	1.3	1.1	1.0	1.3	1.0	0.9	1.3	1.0	0.8	1.3	0.8	0.6

	Baseline			Option 1			Options 2, 1A			Option 3		
	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30	2012-13	2022-23	2029-30
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	1.4	5.7	-	3.6	13.6	-	10.0	22.4
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	-	-	-	-	-	0.1	-	-	0.1	-	0.1	0.2
Articulated trucks: <= 6 axle rig (not elsewhere classified)	4.8	5.3	5.4	4.7	4.8	4.4	4.7	4.1	2.9	4.8	2.6	1.4
Other trucks, > 4.5 tonne	-	-	-	-	-	-	-	-	-	-	-	-

Appendix H Vehicle class reconciliation tables

The various data sources used in this report often categorise vehicle classes differently. As a result, there was a need to reconcile vehicle classes between each category. The approach to reconciliation of vehicle classes is set out in the tables below.

Table H.1 NTC vehicle classes listed in SMVU to BITRE classes

NTC	BITRE
4WD: load carrying	LCVs
Light commercials & Other light vehicles	LCVs
Light rigid trucks	LCVs
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	2-axle rigid trucks
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	2-axle rigid trucks
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	2-axle rigid trucks
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	2-axle rigid trucks
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	2-axle rigid trucks
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	3-axle rigid trucks
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	3-axle rigid trucks
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	3-axle rigid trucks
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	3-axle rigid trucks
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	gt 3 axle rigid trucks
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	gt 3 axle rigid trucks
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	gt 3 axle rigid trucks
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	gt 3 axle rigid trucks
Articulated trucks: no trailer	lt 5 axle articulated trucks
Articulated trucks: single trailer, 3 axle rig	lt 5 axle articulated trucks
Articulated trucks: single trailer, 4 axle rig	lt 5 axle articulated trucks
Articulated trucks: single 3 axle trailer, 5 axle rig	5-axle articulated trucks
Articulated trucks: single 2 axle trailer, 5 axle rig	5-axle articulated trucks
Articulated trucks: single 3 axle trailer, 6 axle rig	6-axle articulated trucks
Articulated trucks: single 2 axle trailer, 6 axle rig	6-axle articulated trucks
Articulated trucks: B-double, < 9 axle rig	B-doubles
Articulated trucks: B-double, >= 9 axle rig	B-doubles
Articulated trucks: Road train, 2 trailers	Road trains
Articulated trucks: Road train, 3 trailers	Road trains
Articulated trucks, 3 axle prime mover, > 6 axle rig (not elsewhere classified)	B-triples
Articulated trucks, 4 axle prime mover, > 6 axle rig (not elsewhere classified)	AB-triples
Articulated trucks: <= 6 axle rig (not elsewhere classified)	Other articulated trucks
Other trucks, > 4.5 tonne	Other articulated trucks

Table H.2 NTC vehicle classes listed in SMVU to CBA model classes

NTC	CBA
4WD: load carrying	4WDs: light commercial
Light commercials & Other light vehicles	Light commercial (non 4WD)
Light rigid trucks	Light rigid trucks less than or equal to 4.5 tonnes
Rigid trucks: 2 axle, no trailer, GVM 4.5 to 7.0 tonne	Rigid trucks: 2 axle: no trailer: GVM 4.5 to 7.0 tonne
Rigid trucks: 2 axle, no trailer, GVM 7.0 to 12.0 tonne	Rigid trucks: 2 axle: no trailer: GVM 7.0 to 12.0 tonne
Rigid trucks: 2 axle, no trailer, GVM over 12.0 tonne	Rigid trucks: 2 axle: no trailer: GVM over 12.0 tonne
Rigid trucks: 2 axle, with trailer, Combination <= 42.5 tonne	Rigid trucks: 2 axle: with trailer: GCM to 42.5 tonne
Rigid trucks: 2 axle, with trailer, Combination >42.5 tonne	Heavy Truck Trailers GCM over 42.5 tonne
Rigid trucks: 3 axle, no trailer, GVM 4.5 to 18.0 tonne	Rigid trucks: 3 axle: no trailer: GVM 4.5 to 18.0 tonne
Rigid trucks: 3 axle, no trailer, GVM over 18.0 tonne	Rigid trucks: 3 axle: no trailer: GVM over 18.0 tonne
Rigid trucks: 3 axle, with trailer, Combination <= 42.5 tonne	Rigid trucks: 3 axle: with trailer: GCM to 42.5 tonne
Rigid trucks: 3 axle, with trailer, Combination >42.5 tonne	Heavy Truck Trailers GCM over 42.5 tonne
Rigid trucks: 4 axle, no trailer, GVM 4.5 to 25.0 tonne	Rigid trucks: 4 axle: no trailer: GVM 4.5 to 25.0 tonne
Rigid trucks: 4 axle, no trailer, GVM over 25.0 tonne	Rigid trucks: 4 axle: no trailer: GVM over 25.0 tonne
Rigid trucks: 4 axle, with trailer, Combination <= 42.5 tonne	Rigid trucks: 4 axle: with trailer: GCM to 42.5 tonne
Rigid trucks: 4 axle, with trailer, Combination >42.5 tonne	Heavy Truck Trailers GCM over 42.5 tonne
Articulated trucks: no trailer	Articulated trucks: > 6 axle rig (not elsewhere classified)
Articulated trucks: single trailer, 3 axle rig	Articulated trucks: single trailer: 3 axle rig: 2 axle pm
Articulated trucks: single trailer, 4 axle rig	Articulated trucks: single trailer: 4 axle rig: 2 axle pm
Articulated trucks: single 3 axle trailer, 5 axle rig	Articulated trucks: single 3 axle trailer: 5 axle rig: 2 axle pm
Articulated trucks: single 2 axle trailer, 5 axle rig	Articulated trucks: single 2 axle trailer: 5 axle rig
Articulated trucks: single 3 axle trailer, 6 axle rig	Articulated trucks: 6 axle rig
Articulated trucks: single 2 axle trailer, 6 axle rig	Articulated trucks: 6 axle rig
Articulated trucks: B-double, < 9 axle rig	Articulated trucks: B-double: to 8 axle rig
Articulated trucks: B-double, >= 9 axle rig	Articulated trucks: B-double: over 8 axle rig
Articulated trucks: Road train, 2 trailers	Articulated trucks: Road train: 2 trailers
Articulated trucks: Road train, 3 trailers	Articulated trucks: Road train: 3 trailers & B triples
Articulated trucks, 3 axle prime mover, > 6 axle rig (NEC)	Articulated trucks: Road train: 3 trailers & B triples
Articulated trucks, 4 axle prime mover, > 6 axle rig (NEC)	Articulated trucks: Road train: 3 trailers & B triples
Articulated trucks: <= 6 axle rig (NEC)	Articulated trucks: > 6 axle rig (not elsewhere classified)
Other trucks, > 4.5 tonne	Other trucks (special vehicles)

Appendix I Literature review on lifecycle approaches to pavement management

This Appendix sets out a review of literature on lifecycle approaches to pavement management conducted for the 2013 CBA. Although not exhaustive, the papers listed below are some of the more prospective sources for establishing potential benefits of lifecycle approaches to pavement management in an Australian context. The overall result of the review was inconclusive. This led to the use of a broader literature on pavement management systems to establish a range for estimating the benefits in the CBA.

Note that literature reviewed for this model update are summarised in Appendix B.

I.1. Literature reviewed in the 2013 CBA

Labi, S. and Sinha, K., (2005)

This paper investigates the cost effectiveness of various levels of life-cycle preventive maintenance in three road classes. All up, there were 15 pavement management strategies analysed with the effectiveness of each strategy estimated as the increase in service life relative to a base-case strategy. The cost was estimated in terms of agency and user costs associated with the treatments comprising that strategy. The conclusion of the paper is that increasing preventative maintenance expenditure is generally associated with increasing cost effectiveness but only up to a certain turning point beyond which cost effectiveness decreases. The results do not provide a quantitative estimate of the overall savings that are possible from lifecycle approaches to maintenance.

Hunt, PD and Bunker JM., (2004)

This paper is referenced elsewhere in our report as providing an indication of the expected deterioration in road quality without maintenance intervention but it also has some applications for lifecycle approaches to maintenance.

The purpose of this paper was to examine the variables which affect pavement performance over time. They develop a new method of calculating the rate of deterioration which may can then be used to identify optimal timing for intervention. Unfortunately, No reliable trend could actually be found when determining the optimal approach to pavement maintenance. Instead, the authors were able to identify what constituted poor maintenance.

Tsunokawa, K and Ul-Islam, R., (2003),

This paper investigates the relationship between optimal pavement design and maintenance strategy and the level of economic development (LED), using HDM-4. HDM-4 simulates the deterioration scenarios of the pavements of given designs under given maintenance options and has the ability to identify optimal pavement design and maintenance strategies. Unfortunately this paper focusses on the trade-off between initial pavement strength and maintenance interventions and how this relationship changes during across countries with different levels of development rather than looking at how this trade-off affects whole of life costs.

Ouyang, Y and Madanat, S.M., (2002),

This paper presents a mathematical programming model for optimal highway pavement rehabilitation planning which minimizes the lifecycle cost for a finite horizon. This paper focusses on theoretical approaches to solving the problem of optimal pavement management rather than providing an estimate of its benefits.

Roberts, J and Roper, R., (1998)

This paper is a description of an integrated model used by ARRB, to assess lifecycle approaches to pavement management. The paper covers the contents of the model, what parameters are used and the model's short-comings in detail. The paper is, for the most part, a description of the model without providing usable results. The appendix contains a demonstration of the model which does generate some numbers but these are not designed to be reflected of potential real world savings and it does not compare the lifecycle approach to alternative approaches.

Martin, T and Roper, R., (1997)

The purpose of this paper was to identify how maintenance and rehabilitation strategies influence network pavement life-cycle costs (PLCC). The PLCC analysis included road user costs and road agencies costs of maintenance and rehabilitation in a present value discounted cash flow analysis over a given life-cycle.

The parameters that were varied in the study to test the sensitivity of network PLCC were:

- Pavement deterioration rates – Measured as a rate of deterioration in terms of NRM e.g. 11NRM per year (high). This was varied to examine the effect on average maintenance expenditure
- Road agency unit cost rates for rehabilitation. These were varied from the current average value to low and high unit of costs to examine how they affected the total life-cycle costs.
- Road user cost rates for travel time and VOC. These were varied from the current average value to low and high unit rates to examine how they affected the total life-cycle costs.

Within each of the above elements they had imposed budget constraints which varied between $150 million to $300 million to examine how this affected the roughness of the network.

The main findings were:

- Pavement deterioration had the greatest influence on the annual agency costs of maintenance and rehabilitation and their distribution across roads. The impact was larger than road user costs and unit agency costs.
- There are potential savings of 39% or $780 million across Australia if current rates of pavement deterioration are reduced to the lowest observed deterioration rate.
- Conversely, there are potential increases of 53% or $1060 million across Australia if current rates of pavement deterioration increase to the highest observed deterioration rate.

As with many of the above paper, this paper is both simulation based (and so is not grounded in real world experience) and does not provide a comparison between current cost levels and costs under a lifecycle approach to maintenance.

Limitation of our work

General use restriction

This report is prepared solely for the internal use of the Department of Infrastructure and Regional Development. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of providing an economic analysis of the potential end-states for heavy vehicle road reform. You should not refer to or use our name or the advice for any other purpose

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