



*A roadmap to double ENERGY PRODUCTIVITY
in Freight Transport
by 2030*

AUTHORSHIP OF THIS ROADMAP

This roadmap is published by the Australian Alliance for Energy Productivity (A2EP). It was prepared through extensive consultation with industry. The 2xEP program is led by a steering committee of business leaders, and a freight transport working group reporting to it comprises representatives of industry associations, individual firms, research organisations and energy services providers. A2EP supports the steering committee to promote this roadmap to government, encourage the implementation of measures and monitor and report on progress towards this objective. The roadmap will continue to be developed into a platform which a wide range of industry organisations and businesses will be invited to support. A2EP would like to thank the members of the 2xEP freight transport working group for their generous and considered contributions.

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Executive summary

Introduction

Transport is now the biggest user of energy in Australia, and growing. It is also a major contributing factor to many of society’s development and growth challenges including congestion, climate change, air pollution and economic productivity factors across all sectors.

Freight is a fundamental input and enabler of economic activity in all other sectors. While it currently uses only around one-third of all transport energy today, it’s energy demand is growing faster than other end uses, and within a few decades it will be the dominant segment in energy terms.

But transport faces unprecedented changes in the next fifteen years. The speed and extent of these are not yet fully understood because they could proceed down several divergent paths. The purpose of this roadmap is therefore not to define a path that will ultimately be decided by technology and the market. Instead, it explains the extent of improvements possible via known technologies; it highlights the rocky road expected from various levels of disruption that will hit the sector; and it identifies measures that could help smooth the transition to a much more energy-productive freight sector.

Urgent action is required, because the useful life of transport assets (i.e. infrastructure, trucks, ships and trains) is more than 20 years. Today’s transport and urban planning decisions will therefore lock in energy-intensive modes of transport for decades to come.

Energy productivity is the economic value created per unit of energy consumed, or per unit of primary energy spend. At a national level, GDP can capture the total economic value created, including non-energy dividends of improved energy efficiency. At a sectoral level, the value add from the sector can be substituted for GDP, and energy can be represented by total primary energy used in freight transport, or (preferably) the total duty performed per unit of energy – as per the equation below.

$$EP (freight) = \text{Sector added value (\$)} \times \frac{\text{Freight task (tonne.km)}}{\text{Sector primary energy use (PJ)}}$$

Energy and freight transport in Australia

Freight transport is not a single, homogenous activity. There are major differences in how and where freight is moved, starting with the type of vehicle and mode (road, rail, ship, or air). Further distinctions relate to freight type (bulk, containerised/intermodal, general), as well as subtypes in each of these categories (dry, liquid, parcel, palletised, and others), and the environment in which the freight is moved (urban deliveries, interstate linehaul, regional distribution, waste collection – to name a few).

Figure 1 shows modal shares (by colour) and vehicle type (wedge) of total energy used in freight transport. Clearly road freight (in blue) is the dominant mode, accounting for around 84% of freight transport energy, and suggesting it should be a focus for improvements.

The different characteristics of each sub-sector present different challenges for energy productivity. Road transport is mainly undertaken by thousands of small and micro businesses operating just one or two trucks; whereas rail transport is dominated by a handful of very large companies and a handful of smaller ones. The policy and regulatory environment for each mode is also different and complex, with perhaps the biggest obstacle to timely and significant progress being the distributed responsibility between multiple agencies at national, state and local government level. This complexity and distributed responsibility partially explains how

transport became the largest and fastest growing source of emissions and energy use, without any major programs or policy to arrest that trend.

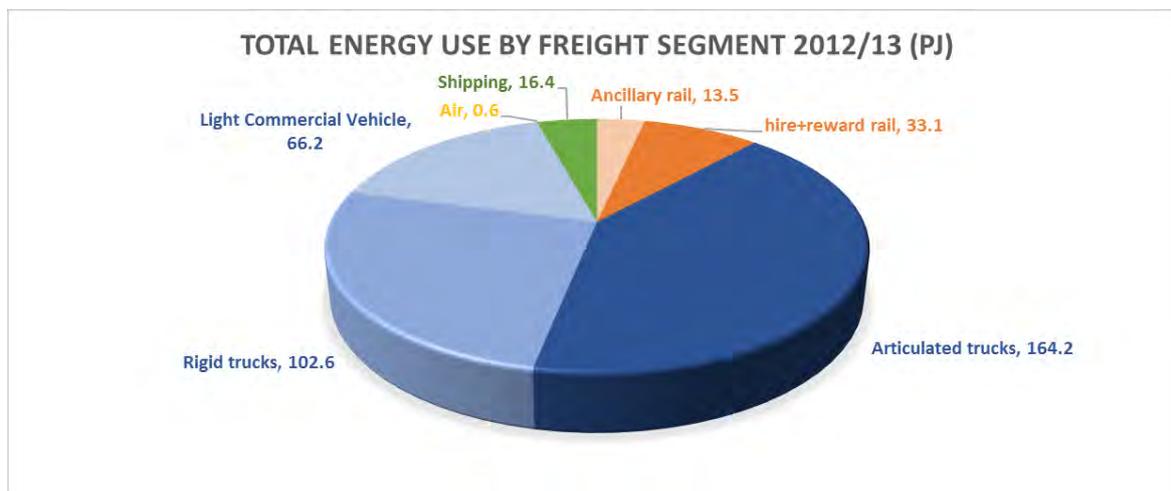


Figure 1 Share of total freight energy use by mode and vehicle type

Energy productivity can therefore benefit freight transport in several important ways beyond just the energy used, including: supporting investment and increasing returns to businesses and the community; improving business resilience; reducing carbon emissions and air pollution from transport vehicles; improving Australia’s energy security; and decoupling future freight growth from increases in energy use, emissions and congestion. This final contribution is perhaps the most important as the freight task is projected to grow by around 25% over the next decade.

Strategies and potential to improve energy productivity

Four broad strategies can be used to describe how energy productivity can be improved. Examples of technology and practices in each of these strategies are shown in Table 1 below. The only reliable way to estimate potential savings from these opportunities is to conduct a segmented fleet analysis that accounts for the differential suitability and effectiveness of the opportunities in each fleet segment.

Table 1 Energy productivity improvement strategies and specific opportunities

Traditional energy management	System optimisation	Business model transformation	Value creation
More efficient vehicles	Urban planning	Digital freight matching	Vehicle/data standards
Alternative fuels	Mode shift	Carrier collaboration	Safety/env. Standards
Improved practices	Incr. network capacity	Data services	Gov’t revenue, road pricing
Increase payload/utilisation	Incr. network utilisation		

Modelling the potential uptake and effectiveness of these measures using input from the working group and past research led to the results shown in Table 2, which compares the technical potential for improved energy intensity in 2030 (high EP scenario based on supportive policy), with the recent historical rates of improvement (BAU). Overall, it was estimated that energy intensity could be improved by 19–33% (MJ/t-km basis) assuming supportive policy; or at least 2-3 times the BAU rate.

Averaging these rates of improvement across all modes (25% by 2030) and assuming 5% mode shift is possible between road-rail and rail-shipping, and continued increased in the freight task, yields the result shown in Figure 2: that is \$5 billion in fuel savings alone by 2030 if these

best practice measures were adopted in an ambitious but realistic way. This is based purely on energy savings ignoring additional benefits from reduced congestion, health costs, road trauma and other factors.

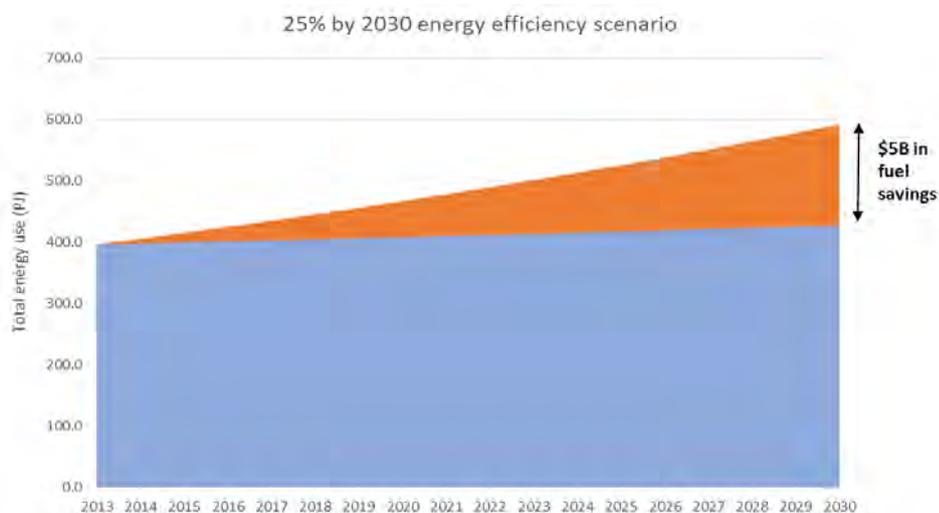


Figure 2 Potential fuel savings from EP across freight transport modes by 2030

Bridging the gap

While a 25% to 30% improvement in energy efficiency by 2030 seems a long way short of doubling energy productivity, it's important to remember that energy savings are just half the equation. The numerator of energy productivity concerns economic value added, and energy choices and other business decisions can have a big overall impact on value added as well as energy use. Yet this sector faces a perfect storm of disruption over the coming decade and a half. More than any other industry, freight transport will see fundamental changes in the way goods are moved, where they are moved, who moves them, and the energy source for that movement.

The main factors that will shape future energy productivity in the sector include:

- Increasing urbanisation
- Shift to renewable energy
- Vehicle electrification
- Connectivity and intelligent transport systems
- Automation
- Business model transformation

The individual effect of these disruptors on energy productivity is highly uncertain. For example, some proponents claim autonomous vehicles will greatly reduce energy used in transport, while others claim they will simply increase congestion and energy consumption. Similarly, a recent survey of business leaders found more than three quarters believe one connected car can generate ten times the revenue stream of a conventional “dumb” vehicle, with data fuelling new business revenue streams.

The combined effect of several such disruptors is highly speculative, particularly as some will conflict with others. However, the potential to reach a doubling of energy productivity is certainly there.

A roadmap and actions for getting to 2xEP

Best practice policy principles were used to identify the main areas government and industry action could combine to maximise opportunities for energy productivity in the freight sector. This yielded around 70 opportunities supported by the freight working group, under seven key pathways.

1. Leadership and strategic vision
2. Enabling and capacity building
3. Improving the business case
4. Linking, alignment, harmonisation
5. Support shift to renewable energy
6. Better energy data
7. Removing barriers

The full list of opportunities is detailed in Section 9 of the report.

Implementation priorities

Given the large number of measures identified, and the likelihood that not all actions will be implemented, the working group prioritised specific measures that their organisation and industry sector (road, rail, shipping) saw as high-priorities. A list of priority recommendations for all modes and stakeholders is shown in Table 2. Additional actions for each mode is shown in Table 3.

Table 2 General priority areas for government and industry

Working Group priority areas	Actions	
Setting EP targets	 Government	
	1: Strategic vision 2: Formulate supporting policy 4: Single point resp. for transport EP 5: Integrate NLFS & NPS	33: State targets 35: EP metrics in infrastructure 40: Link government actions
Promotion / information / assistance of best practice	 Joint 6: Facilitating CDP-GRI-DJSI 8: Aggregated info portal 9: Resources to fill gaps 10: Roll out support initiatives 11: Pilot energy audit standards 12: Align and link programs 15: Support ITS knowledge 16: Mode shift equalisation 21: Recognition scheme 37: Review reg framework 49: Agreed assess. classification 51: Benchmark data	 Government 30: Integrate into energy policy 39: Link land use planning 50: Investigate mandatory reporting 52: Integrate info initiatives  Industry 25: Freight customer best practice 68: GS1 EPCIS
Incentives to purchase efficient vehicles	 Joint 12: Align and link programs 22: Revitalisation local manufacture 36: Link classification scheme 48: Efficiency ratings 57: Low carb vehicle partnership	 Government 18: Feebate systems 19: Alt fuels excise 20: Old vehicle retirement 23: Cost-reflective road pricing 27: Government purchasing 28: Mode-shift schemes 34: Transport in ERF IEA reviews 47: Refuelling infrastructure 58: Reduce up-front cost

Table 3 Specific priority areas for each mode

Mode	Working Group priority areas	Responsible	Actions
Road 	Increased use of high productivity vehicles (HPV)		41: NHVR harmonisation 42: International compliance 55: Remove HPV bottleneck 56: HPV access
	Mandatory fuel efficiency standards for LCV		43: US fuel eff standards 67: LCV fuel eff standards
	Driver training programs		65: Driver training accreditation 66: Insurance discount
	Last mile access		62: CBD trial
	Allowing more night freight delivery		63: Loading dock scheduling
	Information and assistance for smaller carriers		12: Align and link programs 25: Freight customer best practice
Rail 	Heavy vehicle charging reform (road charging)		23: Cost-reflective road pricing 28: Mode-shift incentive
	Technology demonstration program		13: Technology trial
	Collaboration forums		70: Collaboration forums
Shipping 	Slow steaming		69: Slow steaming routes

The next stages of work will involve two main activities. Firstly, this draft roadmap will be distributed to relevant stakeholders for their views and comments, with key suggestions incorporated into a final version to be placed on the 2xEP website.

Secondly, actions will be reviewed to better integrate specific freight measures—especially those for road freight, mode shift and enabling industry—into the NEPP framework. Ideally this would start with a commitment to establish a single point of responsibility within each jurisdiction (national, states) to coordinate energy productivity measures in what is the single biggest energy consuming sector of all.

1 Purpose of this roadmap

Freight transport faces unprecedented changes in the next fifteen years. The speed and extent of these changes are not yet fully understood, because their emergence could proceed down several divergent paths. By definition, this means any 'roadmap' developed today is fraught with uncertainty. Nobody really knows what the future of freight transport—or indeed, all transport—will look like fifteen years from now. But it will certainly be different to what we know and see today.

The purpose of this roadmap is therefore not to define a path that will ultimately be decided by advances in technology and the market. Instead, this roadmap explains the extent of potential improvements possible (the current productivity gap) via known and emerging opportunities, and to highlight the rocky road expected from various levels of disruption that are already emerging but are currently immature – but which may, singularly or in combination, transform how we move goods around the country.

Ultimately, the roadmap is successful if it helps policymakers, the community and others outside the sector to understand how alternative fuels, organisational practices, new technologies, and good planning could potentially contribute to doubling energy productivity in freight transport by 2030— without prescribing exactly how that should happen.

The roadmap is therefore in equal parts a background brief, issues paper, and a call to action.

2 Introduction

Cheap and abundant energy has underpinned Australia's economic growth for decades. But at \$111 billion per annum, energy is a substantial and growing cost to end users – equivalent to about 8% of Australia's GDP. As energy prices rise and carbon constraints bite, our future prosperity depends on using energy more efficiently. Using less while doing more is key to Australia's economic future which is determined predominantly by productivity performance.

The Australian Alliance for Energy Productivity (A2EP) is an independent, not-for-profit coalition of business, government and environmental leaders promoting energy efficiency, energy productivity and decentralised energy. A2EP aims to inform, influence and advance the effective use of energy in Australia. It is supporting a program of business-led research, consultation, collaboration and advocacy called 2xEP (doubling energy productivity). 2xEP aims to double Australia's energy productivity by 2030 (from a 2010 baseline).

2.1 2xEP: A critical mission

2xEP is a collaborative process involving industry, governments and research partners working towards a Roadmap for doubling energy productivity by 2030. This is essential to boost general economic productivity, improve competitiveness and reduce greenhouse gas emissions.

For nearly two decades, economic productivity in many sectors of the economy has been stagnant or in decline. The underlying performance of the Australian economy has been masked by the commodity price boom, but since 2012 Australia's terms of trade have been declining with the drop in mining commodity prices. A focus only on labour and capital as the means to boost productivity is no longer sufficient. Australia has fallen behind key competitor nations in terms of our relative rate of improvement in energy productivity. This problem has been compounded by sharp increases in energy prices to result in plunging energy competitiveness.

The energy productivity opportunity is far greater than direct energy cost savings. Energy productivity aims to maximise the total value created per unit of energy (GJ) consumed or dollar spent. To achieve this, the 2xEP program is working across the national economy and into key sectors such as agriculture, manufacturing, mining, freight, passenger transport and the built environment. It is also developing cross-sectoral strategies addressing traditional barriers such as financing and innovation.

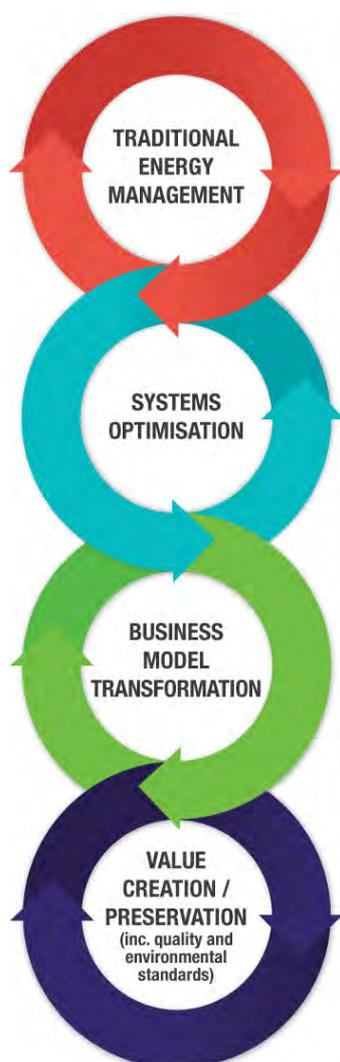
A commitment to 2xEP would lead to investment of \$100 billion over 15 years, a 2.8% increase in real GDP, a \$30 billion reduction in energy spend in 2030, and a 25% reduction in greenhouse gas emissions.

2.2 What is energy productivity?

Broadly defined, energy productivity is the economic value created per unit of energy consumed, or unit of energy spend (A2SE 2015). It aims to capture the total economic benefit to society or total value created, including the 'other dividends' of investing in improved energy efficiency, including improved health (IEA 2014). The two core measures are:

$$\frac{\text{Value of output (\$)}}{\text{Primary energy (GJ)}} \quad \text{AND} \quad \frac{\text{Value of output (\$)}}{\text{Cost of energy (\$)}}$$

Energy productivity is therefore not simply energy efficiency by a different name, although efficiency is integral to the first of four key strategies that enhance energy productivity, as illustrated below and discussed in more detail in section 5.



Unlike traditional energy efficiency which is most often defined as an engineering or thermodynamic concept, energy productivity is by definition an economic indicator using financial units. Gross Domestic Product (GDP) or company revenue can be used as the proxy for value created. But it is recognised this does not capture the qualitative aspects of economic activities, so a set of shadow metrics is proposed to track these aspects that do not translate simply to dollar values.

This definition is important because it integrates energy efficiency, the co-benefits of energy efficiency (such as reduced maintenance costs, health benefits and the value of reduced carbon emissions), energy market dynamics (that determine the price per unit of energy), as well as the relative economic value created from energy inputs.

2.3 Why a freight roadmap is needed?

The 2xEP initiative has been considering how energy productivity can increase Australia's international competitiveness, and help businesses secure their energy future by slowing or reversing increases in energy costs and increasing their resilience to shocks.

Transport is a major part of that plan. Transport is now the biggest user of energy, and growing. It is also a major contributing factor to many of society's development and growth challenges, including congestion, climate change, air pollution and economic productivity factors across all sectors. Freight transport in particular is a fundamental input and enabler of economic activity at all levels.

Meeting the growth challenges and exploiting future opportunities requires a proactive and long-term perspective. Measures are needed across the spectrum of policy, investment decision-making, technology, infrastructure and urban planning. But sectoral characteristics can make solutions complex. The sector is also not homogenous, with different modes involving very different practices and diverse equipment. One common factor across all modes is that the energy efficiency market is relatively immature.

Against this background, urgent action is required, because the useful life of transport assets (i.e. infrastructure, vehicles, ferries and trains) is more than 20 years¹ (ABS 2014). Today's transport and urban planning decisions could therefore lock in energy-intensive modes of transport for decades to come (DCCEE 2010).

The freight working group established under the 2xEP initiative has been grappling with these challenges to navigate pathways and identify actions that could enable greater and faster improvements in energy productivity. This roadmap reflects their views and the results of research into opportunities and technologies, and the barriers that currently constrain progress in this area.

¹ BITRE calculation from ABS *Motor Vehicle Census*, cat. no. 9309.0.

3 Freight transport in Australia

Transport is a significant sector of the Australian economy. Passenger and freight transport together employ around 5% of Australia’s workforce (ABS 2016b), and account for approximately 6% of 2012–13 industry gross value added (DIS 2014a, ABS 2016a).

In addition to their employment and financial contribution, transport systems are critical enablers of Australia’s economic prosperity and way of life. Freight transport is an important input factor to overall economic productivity, enabling the movement and connection of materials, equipment, products and even energy between the various stages of virtually all supply chains—from point of extraction and production to final end-use and even waste disposal. It therefore contributes to productivity in most other sectors that it serves.

It is important to understand that freight transport (and logistics, which includes the planning, organisation, control and execution of freight transport operations) are not single, homogenous activities. At the highest level, transport can be split into four ‘modes’, or by the type of vehicles used, or by the type of freight (Section 3.1). Alternatively, operations can be defined by the vehicle’s environment (e.g. urban, short-haul and long-haul freight tasks).

Another distinction is the type of transport operator. It may be a support or ancillary activity for a company’s very different core business (e.g. food manufacturing). Or the transport activity itself might be the core activity for ‘hire and reward’ operators, interfacing with third-party logistics providers (3PLs or freight forwarders) who coordinate multiple transport legs to facilitate domestic and international goods movements. These operators supply and support intermodal terminals, ports, warehousing, technology suppliers, customs agents and other ancillary services, which combine to execute freight storage, loading and delivery services.

Vehicles move goods in ‘hub and spoke’ networks within and between modes to form complex transport delivery systems based on freight characteristics or type. The term ‘supply chains’ is also often used to describe the various transport and distribution elements involved in moving particular products or freight types. Customers’ production and distribution networks overlay the transport system, using distribution centres located for their proximity to raw material and consumer demand sources. Full-load and part-load transport planning is dependent on customers’ demand planning, working capital, seasonality, inventory and procurement strategies that can produce constantly changing relationships within supply chains.

An example of road transport in a domestic supply chain is shown in Figure 3.1. Whether express single parcels or dry bulk shipping, on long-term contracts or ad hoc shipments, freight can be a source of major competitive advantage, or a necessary evil comprising a small part of a customer’s total costs.

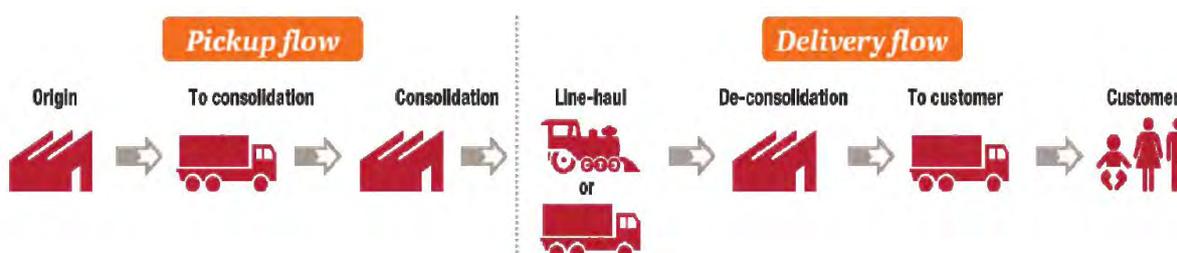


Figure 3.1

Role of road transport in the domestic freight supply chain (PWC 2013)

3.1 The overall freight task

The main distinctions in the freight task include:

- The transport mode (road, rail, marine) and type of vehicle moving the goods (articulated truck, van, bus, train, ship).
- The type of goods being moved (e.g. dry bulk, liquid, refrigerated, general palletised or containerised, hazardous goods, parcels, etc.).

Figure 3.2 shows how and where most freight is moved in Australia, with the volume of freight moved in each location and mode represented by the relative size of the arrows. It is clear that just a few concentrated rail and shipping routes (in red and green) carry the bulk of freight for these modes, while road transport (in blue) is more dispersed. The sections below describe the main characteristics of each freight transport mode.

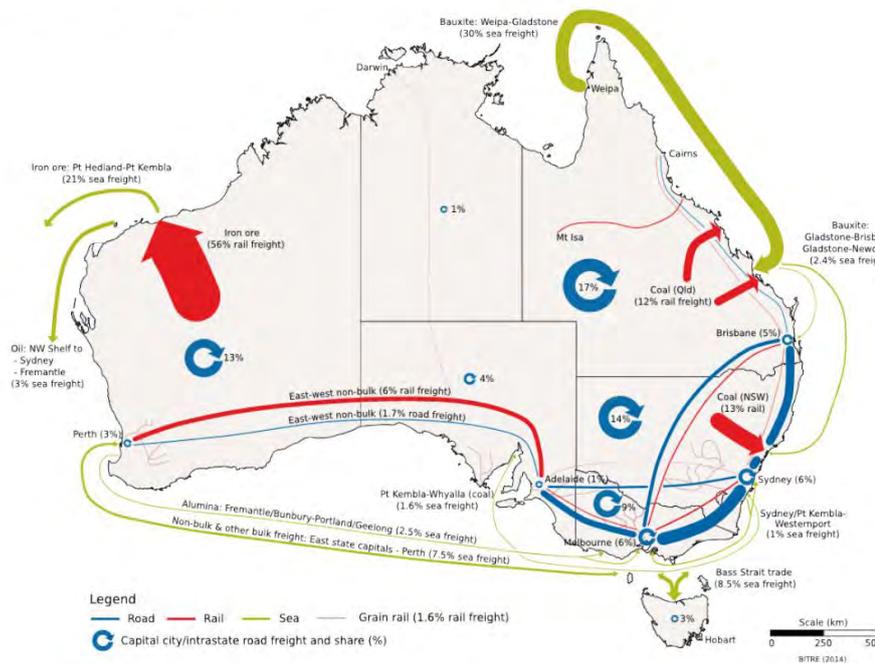


Figure 3.2
Australian freight flows by transport mode (2012)

3.2 Road freight

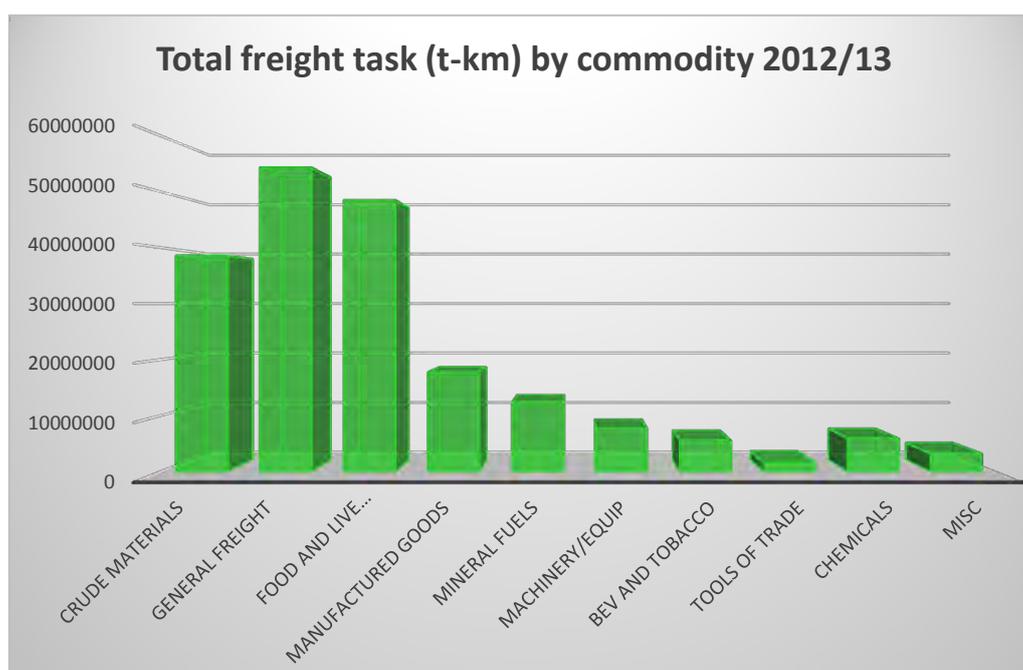
A defining characteristic of the road freight sector is the proportion of small operators. Only 1% of all fleet operators have 10 or more trucks, with around three-quarters of truck operators having a single vehicle (PWC 2013). Financially, most live 'hand-to-mouth' on short-term contracts or no contracts at all. This makes fleet improvement difficult due to access to capital, and limited capacity to invest in fuel-efficient equipment or investigate and analyse fleet improvements. Limited funds mean that they buy trucks that can do many types of tasks (to maintain scheduling flexibility) but are not particularly efficient in any one task.

Other characteristics include:

- low profitability for freight carriers
- high level of competition
- an already old and ageing fleet (one of the oldest in the OECD)

- heavy reliance on a single fuel for energy (diesel fuels 99% of trucks, and ~50% of LCVs)
- fuel costs as the largest or second largest operating cost (up to 30%).

Looking at types of freight carried by road, bulk materials are by far the largest category, accounting for almost 50% more tonnes than any other category. However, taking distance into account, general freight and food/animals become more significant, as shown in Figure 3.3.



Source: ABS (2015)

Figure 3.3

Road freight task by freight type

3.3 Rail freight

Rail is central to multi-modal freight movements. It links with road transport and shipping in supply chains throughout the country, and handles almost half of the domestic freight task on a tonne-kilometre basis (BITRE 2014).

Rail freight is particularly suited to high volume, long-distance services carrying bulk commodities, and non-bulk general freight. Iron ore and coal make up over 80%, and agriculture 8%, of total rail freight tonne-kilometres. Non-bulk freight contributes another 8% of the rail freight task, with a high market share on the east-west corridor between Perth, Adelaide and the eastern states, and 30% share of the non-bulk Melbourne–Brisbane corridor.

Over shorter routes, additional handling to facilitate intermodal services between road and rail adds cost, time and risk that makes rail uncompetitive against direct road delivery services.

The Australian rail transport fleet is dominated by diesel-powered locomotives with an average age of 21.3 years, comparing unfavourably with the USA (8.0 years) and UK (11.5 years). The cost of replacement is a significant obstacle to improving energy productivity, due to unique design requirements for Australian locomotives. Low track quality, a mix of broad, narrow and standard gauge tracks, and a unique narrow profile or envelope, all increase the cost of new

locomotives by two to three times that of 'off the shelf' models built for internationally accepted gauges and axle loads.

A legacy of pre-federation, the patchwork rail network consists of different track classifications, quality and gauges which prevent freight services across Australia using a single locomotive. This further increases costs because of smaller volumes of unique locomotives for different networks.

Significant investment in coal and iron ore hauling locomotives has been driven by competition and the profitability of these routes. The efficiency of privately owned iron ore services in Western Australia is considered world's best practice. Meanwhile, other bulk and non-bulk fleets continue to age and lag in energy efficiency terms due to unprofitability and resultant underinvestment.

3.4 Shipping

Australia's trading ships carry a small proportion of Australia's imports and exports, which are predominantly serviced by international fleets. Of the domestic freight task, coastal shipping handles a 17% share (BITRE 2014), dominated by the dry bulk sector, led by iron ore and coal along with other mineral and agricultural commodities. Figure 3.4 shows the relative shares.

Until the early 1990s coastal shipping was the leading freight transport mode across Australia (on a tonne-kilometre basis). But since the mid-1990s, when the total freight task was split evenly between the three surface modes, road and rail freight growth have accelerated while coastal shipping tonnages stalled. Road transport grew in response to the increased containerisation of goods and the use of express road transport services—an expansion facilitated by innovations in heavy vehicle design enabling more centralised distribution structures, especially in fast-moving consumer goods supply chains.

Coastal shipping is task driven and well suited to non-time sensitive and non-urgent cyclical replenishments. Regular, stable and reliable freight volumes will underpin a sustainable service, just as for the other transport modes, as does the challenge of securing a balance of flows in both directions.

Shipping still plays a significant role in Australia's domestic freight task and its revitalisation would have considerable benefits were it to become more competitive with rail, and to a lesser extent road, for containerised (intermodal) and bulk freight on major domestic freight routes. Wider benefits would include alleviating land transport bottlenecks, infrastructure constraints and environmental impacts.

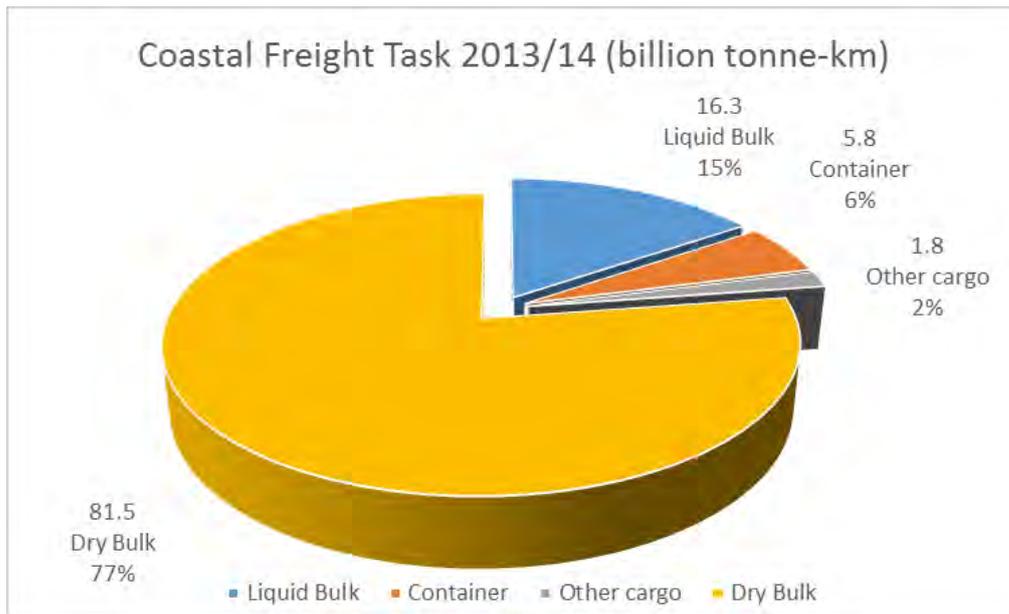


Figure 3.4
Relative share of coastal freight types (2013–14)

3.5 Policy and regulatory context

Freight transport efficiency remains one of the largest opportunities for additional initiatives under the 15-year National Energy Productivity Plan (NEPP). But of all sectors, freight transport has received perhaps the least attention from policymakers in terms of energy efficiency programs and improvement incentives. This contrasts with the situation a decade ago, when several state and federal government programs were focused on energy efficiency and emissions reductions in trucks. It also contrasts with the plethora of programs and policies directed at electricity and natural gas, both of which are less significant in energy terms.

This situation is most obvious at state level, where “energy” seems to have been narrowly and inadequately interpreted. Both New South Wales and Victoria have a suite of programs (more than nine in some cases) directed at energy efficiency, renewable energy, and sustainable business. Yet these comprehensively and irrationally fail to incorporate the biggest energy user of all (transport). In some cases, transport fuels are specifically excluded from business or household assistance programs, despite fuel being the biggest energy cost for households (ABS 2013) and one of the biggest costs for transport-related businesses.

This seems to be a significant and consistent misnomer. At the very least, this narrow interpretation of “energy” might be seen as inadequate or politicised. Under a different light, it might be seen as a policy failure or source of criticism, as others recognise that the biggest energy cost has been virtually ignored in favour of less significant energy forms.

Similarly, many transport policies and programs tend to ignore the underlying significance of energy in moving people and goods. There are some potential explanations for this. Firstly, it is a sector which, at face value, appears to provide financially viable (even attractive) opportunities that the private sector can itself pursue—at least until barriers to improvement are considered more fully.

Secondly, it is a complex sector in which to effect change, due to the industry's structural characteristics described above. Thirdly, it is already highly regulated, with strong opposition to additional regulatory burdens and government intervention. And finally, responsibility for both regulation and policy is shared between different levels of government, and multiple departments at each level, in the areas of fuels, vehicles, drivers, site/depot operations and infrastructure compatibility. For example, in the case of trucks:

- The Department of Infrastructure has responsibility for maintaining new vehicle standards covering design, safety equipment and exhaust emissions.
- The National Heavy Vehicle Regulator (NHVR) has responsibility for administering the Heavy Vehicle National Law.
- State government transport agencies ensure ongoing roadworthiness and mass/dimension compliance, supporting the NHVR.
- The Department of Environment has responsibility for ensuring fuel quality standards meet vehicle performance, community and environmental requirements.
- Until recently, the Department of Industry had responsibility for ensuring Australia's energy security in liquid transport fuels (which is now covered by the Department of Environment).
- As an independent statutory authority, the National Transport Commission develops transport policy and leads regulatory developments, including areas of technology and productivity.
- Infrastructure Australia independently assesses projects that can affect energy productivity of freight transport, particularly from network capacity and utilisation perspectives.
- The Office of the Chief Economist (under the Department of Industry) aggregates fuel and energy statistics.
- The Australian Bureau of Statistics collects statistical, operational vehicle and energy data through survey and industry and government data.

These factors combine to complicate the path to simple, coordinated and effective policy measures. However, a flurry of recent work in this area by new initiatives and key bodies such as the Ministerial Forum on Vehicle Emissions², the National Transport Commission, Austroads and CSIRO (to name a few) suggests that this sector's substantial contribution to energy and emissions policy has suddenly been rediscovered.

Nevertheless, better coordination is required across multiple government departments, jurisdictions and authorities to ensure that barriers to energy productivity can be minimised. Coordinated action by state and Commonwealth departments could recognise the interdependency of vehicles, infrastructure, technology and fuels to accelerate the required reforms. Measures to address some of the information barriers to energy productivity (for example, through pilot, demonstration or training programs) may even provide a better benefit-cost ratio in the short to medium term than infrastructure or capital investments.

² From the Department of Infrastructure: "In October 2015, the Australian Government established a Ministerial Forum to coordinate a whole-of-government approach to addressing emissions from motor vehicles. The Forum is chaired by the Minister for Urban Infrastructure, the Hon Paul Fletcher MP, and includes the Minister for the Environment and Energy, the Hon Josh Frydenberg MP." <https://infrastructure.gov.au/roads/environment/forum/>

4 Energy and freight transport

More energy is now used in transport than in any other sector of the economy. In 2013–14, oil-based fuels used in passenger and freight transport accounted for 27% of all primary energy, higher even than primary energy used in electricity production (DIS 2015a). Transport is also the fastest growing sector in terms of energy use, and is projected to increase to 32% of all primary energy in 2045–50 (BREE 2014a, 2014b).

In final energy³ terms (that is, at point of use) transport is even more significant. Around 39% of all end-use energy in Australia in 2012–13 was used in transport (DIS 2015b). Freight transport accounts for around one-third of this. Relative contributions are shown in Table 4.1.

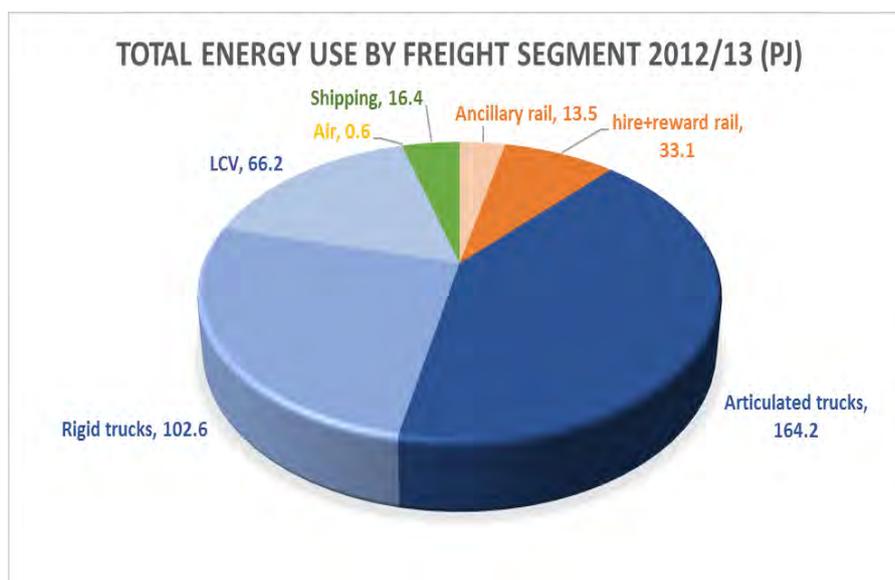
Table 4.1 Energy consumption in freight transport (excluding aviation)

Scope of final energy consumption	Energy use 2012–13 (PJ)
Total transport sector (including private passenger)	1,027,003
Total domestic freight transport	610,299
Total domestic freight (excluding air)	610,008

Source: DIS (2015b)

4.1 Energy modal split

Figure 4.1 shows the modal shares (and segment shares) of total energy use, grouped by colour—blue for road transport, orange for rail and green for shipping.



Source: DIS (2015b)

Figure 4.1 Share of total freight energy use by vehicle type

³ Excluding crude energy supply sectors.

Clearly, road transport dominates energy consumption, consuming around 84% of all energy used in freight transport, and highlighting this mode as an area for significant focus. Articulated trucks alone consume more than half of the road freight total; however, these are significantly more productive than other classes, carrying 80% of the freight task despite comprising only around 10% of the fleet. In terms of growth, energy use in freight transport rose by an average 2.5% annually from 2002 to 2012, mostly attributable to trucks and light commercial vehicles (LCVs) (DIS 2015b).

It is worth noting that LCV energy use allocated to freight in the chart above (and this roadmap in general) represents around half the total energy used by LCVs, with the remainder allocated to passenger transport. The reason for such a high allocation to passenger transport is the increasing number of dual-cab utility vehicles being purchased by private buyers, who currently represent around half of all utility sales.

4.2 Cost of energy

From a business perspective, fuel represents the largest or second largest operating cost for most road fleets, accounting for up to 30% of costs (Ferrier Hodgson 2016). In the rail sector, it is less significant (around 10%).

The main implications of fuel costs in freight transport relate to the price itself, and the volatility in prices. The price of liquid fuels is driven by global oil market dynamics and the relative value of the Australian dollar. Oil prices have been at uncharacteristic lows for 12–18 months due to oversupply and market competition between US and OPEC producers. This has eroded the business case (and therefore some market interest) in fuel efficiency and alternatives to conventional fuels. However, steady recovery in oil prices may soon reverse that, and projections from the IEA and EIA suggest continued strong demand for the next two decades at least, which is likely to keep prices higher.

Price volatility can be as strong an economic driver for a business as the price itself. Australia's currency tends to buffer local fuel prices from the worst of global price volatility, with local diesel prices mostly driven by crude prices in Singapore. However, volatility can be a major driver of behaviour change, as seen after the rapid escalation in diesel prices prior to the GFC, leading to strong interest in diesel alternatives such as natural gas and biodiesel.

For freight operators that can simply pass through their fuel costs to customers (e.g. hire and reward rail, and some road fleets with rise and fall contracts), the cost is less significant. But this is clearly not the case for all, such as ancillary fleets for producers moving their own stock or products.

At the strategic (national) level, imported crude oil and petroleum products now account for 91% of domestic demand for liquid fuels. This is particularly relevant for freight transport, because refined diesel is mostly imported. Blackburn (2014) notes that import dependency could reach 100% by 2030 under current policy settings⁴.

One interesting implication of this reduced self-sufficiency relates to trade. The value of fuel imports exceeds \$25 billion (DIIS 2016). When combined with the value of imported cars, these nearly offset completely the value of iron ore exports, thereby negating the economic benefit the nation might otherwise derive from our largest export.

⁴ Fuel security considerations associated with this reliance on imported fuel and Australian stock holdings are further discussed in Stadler et al. (2014).

Of the total import bill, freight transport's share could be roughly estimated to be around 70%, or just over \$17 billion.



Freight sector keeps Australia's overall transport rating off the bottom rung on ACEEE Scorecard

Australia continues to score poorly in global terms when it comes to transport energy efficiency. A regular assessment by the American Council for an Energy-Efficient Economy (ACEEE) ranked Australia last of 16 major OECD countries in 2014 (Young et al. 2014); and second last of 23 countries in 2016.

An important point in the context of this roadmap is that freight transport was one area that scored relatively well, based on high productivity of rail and long-haul road freight operations.

The ACEEE scorecard is a qualitative assessment against weighted criteria including policies, efficiency metrics, and economic indicators.⁵ Australia scored zero points in the categories of light vehicle fuel economy, and fuel economy standards for light vehicles and heavy trucks.

4.3 The need for energy productivity in freight transport

Energy in freight transport plays a much more significant role than merely the fuel cost it represents to individual freight businesses. Energy productivity in this sector has the potential to not only improve industry competitiveness, but also to help respond to other strategic, environmental and economic issues, and to help capture value in new technology opportunities. These areas can be summarised as follows.

- **Supporting investment:** Understanding the wider benefits of energy productivity beyond just efficiency makes the business case for energy investment a lot stronger, with benefits for both the company and the community. Research shows the additional benefits that flow from investment in efficiency can be up to 2.5 times greater than the energy savings alone (Young et al. 2014).
- **Business resilience:** Price volatility in such a significant input cost (up to 30% of total operating costs) can create significant hardship and business risks for small operators that make up over 90% of the industry. Energy savings can increase business resilience by reducing exposure to price shocks, and lowering the effect of volatile inputs in the business structure. Energy savings can translate to increased business profits, lower rates for freight customers and lower prices for consumers.
- **Environment:** In the case of a single fuel such as diesel, which currently dominates the freight transport sector, there is a direct correlation between volume of fuel combusted and volume of greenhouse gas emission emitted. Energy productivity reduces energy use, effectively reducing carbon emissions for the same outputs or levels of production. This will be crucial in meeting Australia's international commitments to reduce emissions. As noted during the recent COP22 climate change conference:

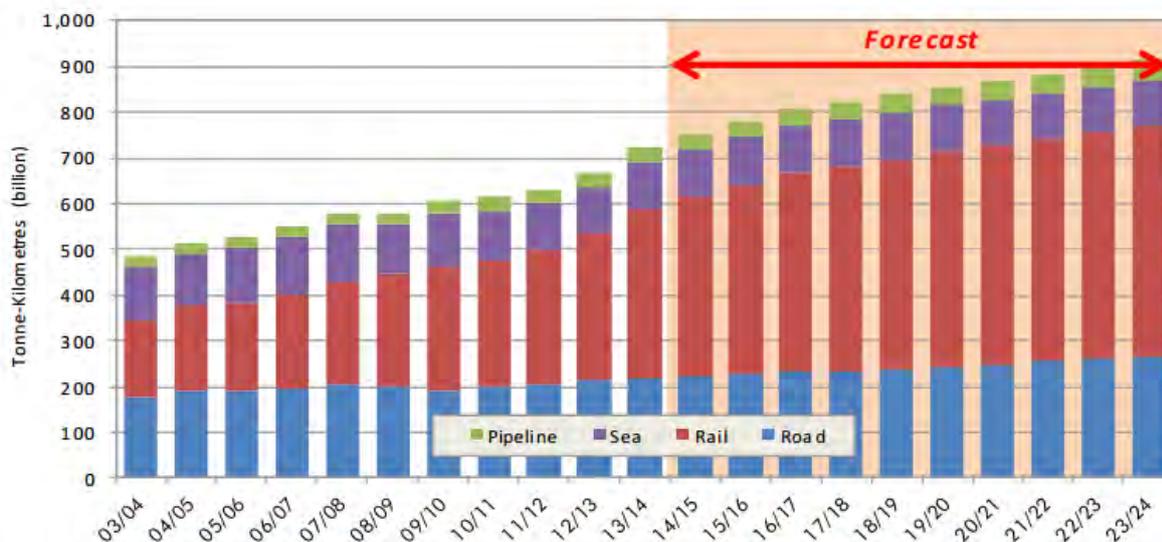
Transport is already responsible for one fourth of energy related greenhouse gas emissions. Without disruptive action, transport emissions can be expected to grow from 7.7 Gt to around

⁵ The transport metrics used in the scorecard are vehicle miles travelled per capita, fuel economy of light-duty vehicles, fuel economy standards for light-duty vehicles, fuel efficiency standards for heavy-duty tractor trucks, energy intensity of freight, freight transport per unit of economic activity transport, and use of public transit.

15Gt by 2050...This is a global problem: for 45% of countries transport is the largest source of energy related emissions, for the remainder it's the second largest source. Transport, therefore needs to be a key part of any effective solution on Climate Change. [SLoCaT 2016]

- **Energy security:** Australia is heading towards almost total reliance on imported liquid fuels for transport, despite being a significant energy exporter overall. Self-sufficiency in transport fuels has deteriorated rapidly, with import fuel requirements growing from just 60% to 90% in a little over a decade (2000–2012). In a relatively stable and mature global fuels market, this should not be a problem. After all, Australia’s supply comes from a diverse range of sources, and market mechanisms have historically proven an efficient and effective way of ensuring adequate and affordable fuel supplies. But history provides no certainty about the future. As unlikely as it may be, any disruption to the fuel supply chain could have significant implications for economic and social stability (Blackburn 2014). A high reliance on a single fuel type (diesel) in freight transport makes this susceptibility worse: as the IEA notes, “...options to reduce the dependency of the sector on oil are not yet available at scale” (IEA 2016). If Australia moves towards meeting the IEA’s 90-day stockpile target, energy efficiency can reduce the cost of providing this additional stockpile.
- **Accommodating future growth:** Global freight is growing at a rate that threatens to derail emissions reductions objectives. The IEA estimates that growth in oil consumption for road freight in their New Policies Scenario is 4.5 times that for passenger vehicles (IEA 2016). In Australia, the freight task grew by half in the decade to 2016, and could grow another 25% in the next 10 years (NTC 2016).

Even if those projections prove to be overly optimistic (e.g. rail growth), failure to improve energy productivity will see energy use for freight transport continue to increase (along with associated emissions, congestion and costs) at a similar rate as the freight task. While energy efficiency may not be the primary driver for these associated issues, in some cases the energy savings may be the lowest value of any of the benefits. The idea of energy productivity is useful precisely for this purpose, bringing together a range of disparate, non-energy benefits under a common metric.



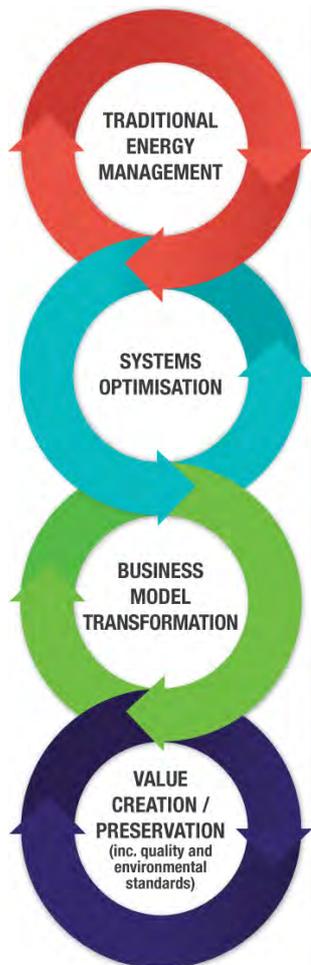
Source: NTC (2016)

Figure 4.2

Projected growth in the national freight task

5 Strategies to improve energy productivity

As defined earlier, energy productivity is real economic output produced per unit of energy used. Energy productivity can therefore be improved by adopting complementary strategies that either increase economic output or reduce the relative energy consumption per dollar of output.



The hierarchy shown at left is used by A2EP to illustrate four diverse strategies that can contribute to improvements in energy productivity.

Energy management – the approach typically associated with traditional energy efficiency activities – is shown as the first level of the hierarchy.

The inclusion of economic value (GDP) in the definition of energy productivity means that the three other non-traditional strategies in the hierarchy can also result in significant improvements in energy productivity, even if energy consumption does not fall, because they can all increase economic output. If output value increases, so too does energy productivity.

Known opportunities associated with each of the four levels of the hierarchy are discussed in the sections that follow, along with examples.

5.1 Traditional energy management

This strategy covers improvements in fuel efficiency through traditional measures such as process improvements, new vehicles and technologies, data management and benchmarking to facilitate better decision making. These are typically within the control of a fleet operator. The main mechanisms by which productivity is improved under this strategy, and the improvement potential, are discussed below.

5.1.1 More fuel-efficient vehicles/equipment

New equipment and technologies can reduce wasted energy (or recover energy) via better mechanical and thermodynamic efficiency. Advanced tyres and suspensions can reduce rolling resistance; streamlined body designs and add-on components can reduce aerodynamic drag; thermodynamic improvements can improve engine efficiency; and advanced materials can reduce friction and reduce the unloaded (tare) mass of the truck, thereby liberating more payload capacity.

Apart from improvements to the engine, some of these individual systems and equipment can achieve 5–15% reductions in fuel use (IEA 2012). Hybrid drivetrains like those used in passenger cars can be very effective in the right conditions, achieving better than 20% savings.

Truck, bus and locomotive manufacturers incorporate these into each successive generation of vehicles, and some components can be retrofitted to existing vehicles already in service.

Newer hybrid systems currently being developed—such as the Wrightspeed and Nikola micro-turbine range-extender hybrid drivetrains (Figure 5.1), and trailer electric drive axles from Adgero and others—claim to offer double those savings. Their suitability for fitment to both new and old trucks could transform the efficiency of the overall fleet.

The overall potential of vehicle efficiency can be understood from two examples, neither of which factor in the potential additional savings of autonomous vehicles.

- Fuel efficiency regulations were introduced in the US in 2014 for medium- and heavy-duty trucks. Despite mandatory regulations being necessarily conservative to act as the low tide watermark, Phase 1 of the US standards is expected to improve fuel efficiency of all new trucks between 8–25% (depending on type of truck). Phase 2 begins in 2018, and the combined benefit after full implementation of both phases by 2027 is projected to improve fuel efficiency by 30–45% for articulated trucks (compared with 2010 base), and at least 20% for all other truck classes (ICCT 2015). The bulk of the savings will be achieved with well-proven commercial technologies, with fuel savings providing a payback within 2–6 years (USEPA 2015).
- ClimateWorks (2014) and the Climate Change Authority (CCA 2014) both suggest that a 50% improvement could be achieved in new light vehicles by 2025, including LCVs used extensively in the urban freight task.

However, it is important to recognise that the size of the potential efficiency improvement from any particular opportunity varies with the type of truck, the duty cycle and the fleet’s operating practices. Few opportunities provide an equal benefit across all types of truck.

The emergence of autonomously driven vehicles (AVs) provides further scope for vehicle-based efficiency, since they move vehicle control from the driver to a vehicle system. AVs can always be operated in the most fuel-efficient mode, eliminating or reducing the 30% fuel economy variation often found between the most and least efficient drivers in a fleet.



nikolamotor.com



wrightspeed.com

Figure 5.1

New hybrid technologies: Nikola (new truck) and Wrightspeed (retrofit)

Barriers

Many of the advanced technologies and systems being adopted in overseas markets are yet to become available or to achieve significant sales in Australia. This slow uptake is partly due to the high development/adaptation costs for our relatively small market, leading to high prices. Australia is a technology taker in this area. While there is some truck manufacturing occurring

locally, this is mostly assembly, and the most significant engine, drivetrain and fuel system technologies originate overseas and are developed for bigger truck markets (US, EU, Japan, China). Many products are not sold here because the cost of adaptation for local conditions (heat, dust, weight, road condition) is prohibitive.

Another reason for limited uptake is the lack of financial incentives (rebates, grants or other tax concessions) which are available in some other markets to offset the higher costs and to establish the market for such products. As a result, the penetration of these technologies into the LCV and heavy-vehicle markets in Australia is comparatively low. For example, Figure 5.2 shows sales of alternatively fuelled, electric and hybrid trucks in Australia as a proportion of total truck sales. Note the trend shows that rather than sales increasing, low emission vehicle sales are in fact declining. Even at the peak, sales were well below 1% of all new trucks, and recent months have been trending quickly toward zero.

5.1.2 Alternative fuels

Some diesel alternatives have the potential to reduce costs and reduce emissions. Since energy productivity is based on primary energy use, renewable energy is one of the most effective paths to improving energy productivity—because renewable energy sources are considered to have a much better primary energy to final energy conversion ratio than fossil fuels (lower production losses). For the transport sector, renewable options include liquid biofuels (ethanol and biodiesel) powering conventional internal combustion engines; biogas converted to CNG and LNG (also combusted in adapted internal combustion engines); and renewable sources for electricity (powering electric trucks and trains). Hydrogen produced from renewable sources can also be used as a fuel in conventional internal combustion engines, or in a fuel cell that powers an electric drivetrain.

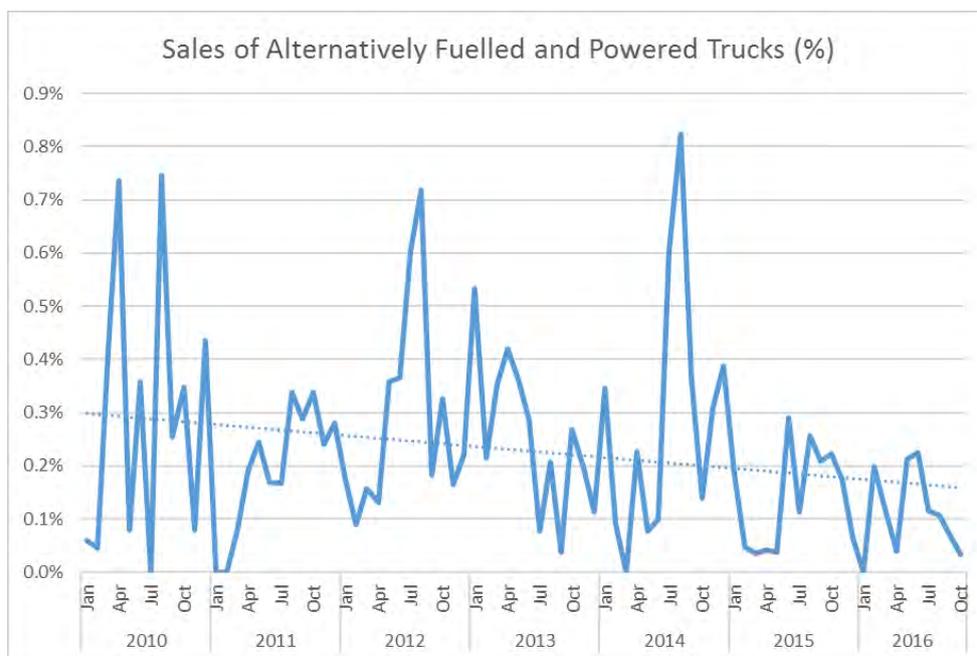


Figure 5.2

Sales of alternatively fuelled and hybrid trucks 2010–16 (TIC data)

EVs are much more efficient in their use of final energy than internal combustion engines, and can also recover some of their kinetic energy during braking. Thus, they can travel more than three times further per unit of energy supplied to the vehicle than a conventional vehicle with an internal combustion engine⁶. This must be offset against the losses in electricity generation, transmission and distribution, but these losses (up to 63%) can be reduced or eliminated by producing electricity locally (for example, via rooftop solar photovoltaic panel).

Recent developments in EVs have moved them closer to widespread use in commercial freight applications—at least in overseas markets. Deutsche Post DHL now makes its own EVs enabled by open automotive standards, bypassing auto-makers to deal directly with their suppliers to build new tailor-made delivery EVs. Tesla has announced it is developing an electric semi-trailer based on its experience with motor and battery technology used in its range of cars. Increasingly, e-bikes and e-trikes are being used for urban last mile delivery.

Despite significant interest and some government support over many years, alternative fuels have not been widely adopted for freight transport in Australia, representing just over 2% of the total fuel market: with natural gas at 1.6% and biofuels at 0.6% (DIS 2015c). Figure 5.2 includes alternatively fuelled trucks, demonstrating the poor level of uptake.

Barriers

It is not without good reason that diesel enjoys a virtual monopoly in fuelling heavy freight vehicles. Most alternative fuels involve one or more economic or operational compromises – such as lower energy density, higher price, reduced driving range (or payload penalty), lower thermal efficiency, or limited availability (of trucks, fuel, or refuelling facilities).

The innovative engineering solutions being proposed and developed by Wrightspeed, Tesla and Nikola (see above) go some way to resolving these compromises, and claim to make the vehicle even better for its intended purpose, with 2 to 3 times better fuel economy than a conventional diesel truck. A remaining barrier to increased uptake of EVs is the persistent though incorrect view that electric transport is not a lower-emissions transport option while coal continues to dominate grid-supplied electricity in Australia (Duff 2015). While this may be true for some classes of vehicles in Victoria, which has the most emissions-intensive electricity in Australia (Lal 2015), it is not the case for most average vehicles in other states (CCA 2014, RMS 2015). EV emissions intensity is also likely to reduce further as the share of renewables in the grid continues to increase, or if charged from rooftop solar panels.

Lack of refuelling infrastructure is widely recognised as a constraint on the faster expansion of both natural gas and biofuels, as well as EVs. Investors in all parts of the supply chain face the classic 'chicken and egg' situation, with limited demand for fuel constrained by few vehicle options and limited availability of refuelling locations, and the decision to expand any one supply/demand stream contingent on the other supply chain branches progressing.

The high cost of both infrastructure and vehicles is an obvious contributing factor. Trucks and locomotives designed to run effectively on different fuels can be 30–50% more costly than conventional options, and operators want to see a network to support their fleet investment. But this requires a substantial long-term commitment from fuel suppliers.

Unlike the one-directional trajectory of electricity prices, the volatility of global oil prices also undermines the business case for alternative fuels, because of uncertainty in the business case for a switch to alternatives. For example, the recent period of record low oil prices has in many

⁶ 2.4 to 3.3 times further in cars (ClimateWorks 2015); or 3.7 in a small rigid truck (RMS 2015).

cases crushed earlier interest in alternatives. This is not helped by the gradual withdrawal of favourable tax arrangements for alternative fuels before they have reached sufficient volumes.

Other barriers include a failure to account for the negative externalities of continued diesel combustion (air pollution, carbon emissions, energy security), and regulatory constraints to overcoming operational challenges.

In the case of biofuels, they are typically blended with conventional fuels, but face a maximum threshold on concentration (or blend wall) that engine manufacturers are prepared to accept before voiding the engine warranty (commonly 20%, or B20). Furthermore, because aviation has virtually no current viable alternative to liquid fuel, that sector is expected to take most of the increase in any future biofuel production to meet its growth requirements and emissions reduction targets.

Unlike the EU, which is aiming for biofuels to account for 10% of transport fuels by 2020, Australia does not currently have a coordinated national strategy or target for biofuels.

5.1.3 Improved company practices

Practices and behaviours can have a major influence on vehicle energy consumption. At the most obvious level, changes in driving technique can yield substantial energy savings. Driver training can reduce average fleet-wide fuel consumption by 10–15% (for truck fleets), and narrow the common gap of 30% between the best and worst drivers in the fleet. For rail operators, driver assistance software can help to optimise driving techniques based on detailed data about location and conditions, resulting in potential fuel savings of 5–20% (DRET 2012). Driver training can therefore be one of the most cost-effective improvement opportunities, if it is available in the company location.

Other opportunities relate to better fleet maintenance, route planning and scheduling, staff incentive schemes, anti-idling policies, tyre management and load consolidation.

The last of these involves better vehicle utilisation. ABS data indicates that around one-third of all truck trips are made either empty or partially loaded, so there appears to be significant scope to better utilise existing load capacity across the vehicle fleet, or on specific trips, by reducing empty running. Load consolidation can be undertaken internally within a single organisation, or externally with other fleets (perhaps properly called load sharing).

Finding backhaul loads to reduce empty running is a significant challenge across all modes. The emergence of new business models and ICT solutions (e.g. phone apps) could allow vehicle utilisation to improve significantly, at little incremental cost, by linking spare vehicle capacity with loads.

Better data management is another recognised method to improve energy management. Energy audits are an important element of energy management, because they enable systematic and repeatable assessment of energy performance, and they identify and quantify energy performance improvement options. In Europe, fleet fuel audits using EN16247–4 typically cost 1–5% of annual energy spend, for a 10–20% return in identified annualised savings. Similarly, the Australian experience from the former Energy Efficiency Opportunities (EEO) program is that by undertaking energy assessments large transport companies across all transport modes identified savings of 11% of energy assessed. Over 70% of these identified savings were approved for implementation by management, yielding energy savings of 8.9 PJ and annual financial benefits of over \$80 million annually. (DoI 2014)

The EEO program was effectively an energy management program with an emphasis on the energy audit component. This combination of an energy management system (e.g. ISO 50001) and rigorous energy auditing can produce immediate improvements in energy performance.

However, the greatest benefit can be obtained when vehicles and other capital-intensive investments must be made. At these points, a good understanding of fleet energy performance has strategic value, leading to better procurement decisions, and greater readiness for new technologies (hybrids, EVs) and market disruptions.

Barriers

The main barrier to behaviour change is cultural. In freight transport, the average age of drivers in Australia is over 50, with many having gained their experience on trucks that require a different driving technique than modern trucks. Resistance to change, and lack of specific knowledge are common, but not unique to this sector.

Similarly, skills and techniques such as energy analysis and energy auditing are not common in the freight sector. Lack of awareness about improvement opportunities is common, as is unavailability of suitable training in regional locations where many smaller operators are located. The absence of an energy audit standard until recently may be another factor contributing to lack of skills/knowledge, with no consistent, systematic (or accredited) process for assessing energy use in transport.

Even with a standard in place, small operators are highly unlikely (or unable) to pay consultant's rates to review their fleet and operations. Therefore, progress in this area is likely to continue to be reliant on government support through business sustainability and energy programs. This is partly a function of the industry structure (many small operators, with resourcing and budget constraints). But it is also because energy analysis is a complex activity in transport, even more so than in other sectors due to the variation in loads, routes, operator performance and duty cycles.

5.1.4 Increasing payload capacity or utilisation

Opportunities for the fleet operator to increase payload fall into one of two categories:

- better utilisation of existing payload capacity (not running underweight where possible)
- increasing maximum payload capacity.

Utilisation is an operating practice, and was discussed in the previous section. Increasing capacity can be achieved through larger vehicles, but this is only effective at improving energy productivity if existing payload capacity is fully utilised. At the upper limit, operators may seek special approval to run high-productivity vehicles (HPVs) that exceed general mass/dimension limits. Australia has a world leading system for assessing and permitting HPVs under the Performance Based Standards (PBS) scheme. Only vehicles that can demonstrate compliance with a range of safety criteria and dynamic and static performance measures can be approved under the scheme.

Various case studies have shown HPVs can result in energy savings up to 40% which are achievable on a tonne-kilometre basis (Hoelzl 2013, Transtech 2013). The perspective for this metric is important: although fuel consumption actually increases using the traditional measure of L/km, productivity increases (L/t-km) and the entire freight system is optimised because of a reduction in the number of trips required for a larger truck to move a fixed freight task.

For example, a Super B-double can carry two 40-foot containers (or four 20-foot units), which is effectively a 30% increase on the volumetric capacity of a B-double—itsself an improvement

on the single trailer semi used extensively in the past in Australia and still used overseas (Figure 5.3).



Figure 5.3

Super B-doubles (left) with 2 x 40-foot containers, compared with conventional B-double (right) carrying one 40-foot and one 20-foot container

Most PBS approvals are for rigid truck and trailer combinations that carry bulk materials. However, not all HPVs sit at the largest end of the spectrum—even a relatively minor increase in mass or dimensions can achieve double-digit percentage savings in overall energy consumption due to fewer trips required overall. As part of its productivity focus, the National Transport Commission is currently investigating options to allow trucks to be ‘cubed out’ (at full volumetric capacity, but under their maximum weight limit) to run longer or higher than standard dimensions would normally allow. NTC is seeking feedback on options in its discussion paper on this issue.

Barriers

Opportunities to increase payload typically require significant planning and are therefore constrained by the level of resources a fleet operator may have to devote to this task. This constraint applies for both load consolidation and for running HPVs. For HPV access under the PBS scheme there is a substantial administrative/technical burden involved with submitting applications, data management and ensuring ongoing compliance requirements are met.

Transport operators also cite as a barrier the slow assessment process and conservative approach of road asset owners (particularly local governments) in approving HPV road access.

Load sharing is also constrained by competition within the sector, where sharing loads might enable one competitor to grow or reduce costs at another’s expense.

5.2 System optimisation

Maximising the performance (efficiency, utilisation, load capacity) of a single vehicle is not always the most effective way to keep the freight network operating at maximum productivity. Synergies between different vehicles, fleets, transport modes or even infrastructure can generate productivity benefits regardless of the individual vehicle efficiency.

System optimisation includes integrated urban planning and design to optimise asset utilisation and reduce congestion, as well as more effective ways to consolidate loads and route vehicles.

5.2.1 Urban planning and site location

Government can influence and control the development and location of freight infrastructure through planning rules and development approvals. Intermodal terminals and distribution centres, which affect both energy use and congestion, are good examples, as is the reservation of land corridors for future road or rail development.

But planning is not only about government control. Individual organisations also decide on locations for their own warehousing and depots, which can reduce trip distances and result in less energy use.

Austrroads' (2016) investigation into policy initiatives to improve productivity, efficiency, safety and environmental impact of urban freight found a mix of solutions need to be tailored to each city. This is because efficient freight movements are affected by city size, density, extent and locations of worst traffic congestion, and relative location of the central business district as well as major freight generators (ports, industrial suburbs and freight rail terminals).

Examples of initiatives that can be progressed through planning (but not planning alone), are:

- consolidation centres enabling freight sharing/consolidation and repacking (Figure 7.4);
- integration of freight plans and routes into strategic planning;
- container train services between ports and metropolitan intermodal terminals;
- enhanced vehicle routing and scheduling systems;
- greater access for high-productivity vehicles;
- enhanced management of truck loading zones (priority parking).

Few of these areas can be progressed by one organisation alone, and building common agreement among stakeholders with varying interests and priorities is critical.

5.2.2 Mode shift

Diverting freight from roads to less energy-intensive transport modes offers substantial energy savings. It can also contribute to greater energy productivity through reduced congestion (fewer trucks on the road), fewer traffic accidents and lower greenhouse gas emissions.

Rail transport of intermodal freight (containers) is around 60–75% more efficient than road transport in energy and GHG terms, and shipping is around half better again (DIS 2015b). Yet with trucking providing convenience, reliability, flexibility, delivery time and cost advantages for its customers, practical opportunities to switch to rail or shipping are limited to perhaps 5–10% of the freight task, mainly in long-distance grain and non-bulk freight.

Mode switches may also be considered between intercontinental air to ocean freight, and short-haul air to road. However, the progressive contraction of coastal shipping in Australia means opportunities are rapidly shrinking. Long distance road freight to rail or sea has the largest potential (by volume) for lifting energy productivity. Improving the competitiveness of these modal alternatives should be the focus of policy support for mode shift.



Source: Best Practice Factory for Freight

Figure 5.4

The Green Link: last mile consolidation and delivery with electric cargo cycles and vans in Paris

While various federal and state infrastructure and freight planning documents identify actions to assist mode shift, particularly investing in and facilitating private sector development of intermodal rail hubs, policy gaps remain. The Victorian Government's Mode Shift Incentive Scheme provides \$5 million per year to shift more containerised freight from road to rail (VicED 2015), mainly on regional corridors. Queensland's Moving Freight strategy aims to expand the use of rail freight with actions to facilitate industry opportunities to make rail more competitive. NSW policies include investment in and facilitation of the private sector development of the Moorebank Intermodal Terminal, Southern Sydney Freight Line, Northern Sydney Freight Corridor, track upgrades on key grain lines, and the Port Botany rail share target. The Emissions Reduction Fund (ERF) also provides an approved methodology for mode shift projects to secure carbon abatement funding at ERF auctions.

The NSW Freight and Ports Strategy notes that the share of rail movements through Port Botany peaked at 25% in 2001 but by 2012 dropped to 14% while container throughput doubled over the period. Similarly, the ACCC's Container Stevedoring Monitoring Report recently found that, nationally:

the proportion of containers transported to and from a port by rail has been declining slightly since 2012–13, by around 1 per cent. This suggests that ambitious government targets for rail transport may not be met in the short term.

Barriers

Both the shipping and rail modes need infrastructure to better compete with road freight.

- Port wharf investment for freight movement via roll-on/roll-off vessels—where vehicles drive on and off the ship without unloading cargo—could remove extra handling steps and associated costs, time and risks during cargo transfers between road and ship.
- Dedicated terminals for both roll-on/roll-off and coastal container ships are needed to encourage the establishment of coastal shipping services that enhance the efficiency and reliability of sea freight as part of the national transport system (Figure 5.5).
- Rail needs high-speed, correctly pathed, long-haul freight trains with additional rail spurs, crossing loop extensions, dedicated freight rail lines and upgraded track capacity to handle heavier axle loads on locomotives and wagons.
- Larger height clearances on bridges and tunnels would enable double-stacking containers.

- Intermodal rail terminals linked to ports by short-haul rail shuttles reduce road congestion around urban ports, while the Brisbane–Melbourne Inland Rail project promises game-changing mode shift capability if it eventually comes to fruition.

Apart from investment in new infrastructure, better utilisation of existing rail infrastructure could be achieved through untangling freight and passenger services, and by sharing train capacity between non-competing freight customers. ITS may assist here, with open platforms that share data on freight flows opening collaboration and freight matching opportunities, and digital sensors feeding advanced analytics to improve planning and execution for single mode operators and multi-modal freight forwarders alike. Real-time information can aid mode selection decisions.

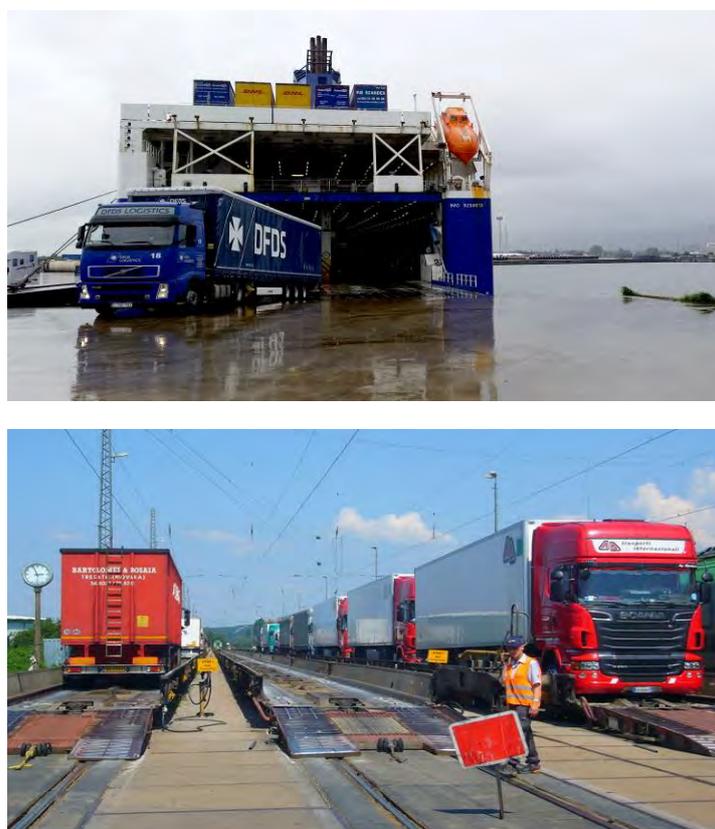


Figure 5.5

Examples of roll-on / roll-off services in shipping and rail

Removing regulatory barriers that prevent coastal shipping’s participation in contestable freight markets could not only raise freight energy productivity but also give Australian manufacturers and primary producers better economic access to domestic markets to compete with imports. Examples include:

- The cost of regulatory compliance prevents unused capacity on international container ships already travelling between capital cities from being used for domestic freight, which would be handled with virtually zero additional fuel and emissions for the ship and completely avoiding the alternative mode’s emissions.

- Contrary to international conventions, emissions from coastal shipping are not included in the National Greenhouse Gas inventory, resulting in a lost opportunity to more efficiently achieve emissions reduction targets at lower cost.
- Coastal licences to move domestic freight on international ships require applications in blocks of five, so opportunities for break-bulk cargo movements by sea are lost when there is only one cargo, and instead large oversized escorted cargos move by road, congesting highways.
- Application of the *Fair Work Act* to international shipping raises labour costs above global standards.

Because the road infrastructure supporting freight transport is co-funded by motorists, but rail freight has to pay full infrastructure access fees, the future introduction of full cost-reflective road pricing could help rail compete with road transport.

The Emissions Reduction Fund is financially unattractive for freight transport, and although the Land and Sea Transport Method is currently being revised specifically to make mode shift opportunities eligible for funding, coastal shipping and grain to rail are explicitly excluded.

5.2.3 Increasing network capacity

Fundamentally, this opportunity relates to accommodating more freight, more vehicles, and bigger vehicles/vessels. This can be achieved through either physical upgrade of infrastructure, such as by building roads with more lanes, or by removing restrictions to flow such as traffic lights and intersections. In some cases, the same result can be achieved by re-classifying existing infrastructure and vehicles. For example, the regulated mass and dimension limits of vehicles accessing the general road network can be increased to allow access by previously restricted vehicles, as has been done several times in recent decades. Alternatively, specific roads or routes can be reclassified as suitable for specific classes of higher productivity vehicles (e.g. Toowoomba to Port of Brisbane upgrade).

Another opportunity that can liberate more freight capacity is dedicating road lanes or rail lines for exclusive use of freight vehicles. Australian examples include dedicated rail lines for bulk materials (coal and iron ore) in Queensland and WA, as well as general and containerised freight on the South Sydney Freight Line. A study by Ernst and Young (EY 2014) for the Department of Infrastructure and Regional Development cites other international examples including a proposed truck-only lane in the USA, a road tunnel to Dublin port, and dedicated rail lines at various other ports in Europe and the US. However, it found that the benefits varied widely and specifically in each case, and that two hypothetical projects (a road to the Port of Melbourne and a regional rail line to Port of Brisbane) would be unlikely to be economically sustainable despite significant benefits in each case.

Perhaps the boldest expression of this concept is the Hyperloop electric transit system that uses magnets or compressed air to levitate pods inside a low-pressure tube, moving people and goods at speeds of up to 1,200 km/h (Figure 5.6). Although this form of transport has not yet been applied commercially and is still under development, Hyperloop One and leading port and terminal operator DP World are working on a Hyperloop system to move containers directly from ships at Jebel Ali port to a new inland container depot in Dubai. Other countries are also investigating commercial applications of Hyperloop style projects for either freight or

passenger transport. If proven commercially viable, there is no reason that a flagship project such as this would not be viable in Australia⁷.



Figure 5.6

Artist's impression of a Hyperloop in outback Australia [The Australian]

Barriers

Network capacity is a major issue in the rail sector, where benefits from longer and heavier trains or double stacking of containers cannot be realised due to low axle load limits based on track classification or condition.

For more ambitious, significant investment projects such as dedicated freight rail lines, double-stacking rail capacity, freight-only road lanes, or a bold Hyperloop style future transport system, visionary leadership and political will are the first and primary hurdles.

5.2.4 Increasing network utilisation

Better alignment of pickup and delivery times with origin and destination locations can reduce freight handling times. It also reduces waiting times (and resultant engine idling) which are a significant cause of fleet underutilisation (Figure 5.7). Technology is the main enabler of this alignment: ITS will evolve as the main opportunity for improving future network efficiency, enabling better communication and common/shared data for improved and flexible trip planning and less waiting.

Shifting delivery times outside peak traffic periods can also result in substantial fuel savings between 3% (LCV) and 10% (articulated truck in urban distribution) (DRET 2011).

⁷ Air routes on Australia's east coast are some of the busiest in the world, serving a population with high average incomes and an appetite for new technologies. The business case for such a venture should be just as viable along this route as anywhere in the world



Figure 5.7

A specialised urban truck and trailer, focusing on minimising noise for overnight distribution, and increasing volumes carried per vehicle

Several initiatives to trial ITS are underway within Australia, including (but not limited to):

- NSW Green Corridor trial connects trucks with traffic lights to smooth the flow of traffic, reducing the number of stops and starts;
- iMOVE CRC is a cooperative research centre working on the development of ITS in Australia through collaborative partnerships that focus on introducing rapidly evolving technologies in the areas of transport, logistics and connected mobility;
- a recently announced truck platooning trial in Western Australia (WARTA).

C-ITS innovation in Australian shipping is also underway, with the AUSMEPA Port Emissions Portal utilising satellite tracking and Big Data analysis to improve knowledge of air emissions associated with shipping activities. Addressing a current lack of data on ship emissions and efficiency, this pioneering system will ultimately connect 3,000 ports in 170 countries.

Barriers

To marry sensor technologies with existing infrastructure, governments must continuously improve road furniture such as signage and traffic lights to ensure Australian roads are well-equipped to handle innovative technologies.

It is unclear whether technology like connected vehicles and truck platooning can make a significant difference to the energy efficiency in the heavy vehicle line-haul segments of the market, where Australia’s multi-trailer combinations are already achieving better than the fuel savings expected from platooning. If the technology cannot be adapted to suit Australia’s higher productivity B-double and road trains (which are not used in Europe and the US where the technology is being developed), then it may have limited applications for this segment, but it might still be suitable for single-truck applications in urban/regional areas.

5.3 Business model transformation

Business model transformation results from changing the way products and services are delivered and paid for. It can cover any aspect of the freight and logistics supply chain, from infrastructure to fleet, labour, information or payment systems.

5.3.1 Digital freight matching

Start-ups like Uber and Airbnb have disrupted traditional sectors of the economy. With app developers looking to rethink the connection between supply and demand, many have set their sights on the freight sector, and are attracting significant venture capital investment. How much impact will they have? What will they mean for energy productivity? These questions are impossible to answer, but there are at least two certainties—freight is complex, and the size of the prize is huge.

Digital freight matching (DFM) electronically links a carrier's capacity with a shipper's demand. The principle behind DFM may seem simple, but the logistics sector isn't. The commodity-like taxi industry is a world away from the multifaceted logistics space. Freight can mean anything from a rapid parcel delivery service in central Sydney, to a road train in the Northern Territory.

The impact of DFM could be immense. The market for door-to-door pick-up, transport and delivery is estimated to be worth \$80 billion in Australia (IBISWorld 2015). Then consider Australia's retail sales, in excess of \$30 billion, with some commentators suggesting it is currently constrained by the lack of last-mile delivery solutions.

But will DFM necessarily improve energy productivity? Efficient last-mile logistics has relied on route density—small distances between drops in a fully loaded vehicle. 'On-demand' couriers in partially filled vehicles could erode this efficiency. It could even drive up congestion, with many small and new operators entering a market that has limited barriers to entry, each seeking a small slice of the prize. So, the answer is not straightforward, or even certain.

One less recognised potential synergy in a world with DFM is the potential to blur the line between passenger and freight transport. The growing urban delivery task does not require B-double payload capacity, instead it can utilise currently latent capacity in single-occupant passenger vehicles, or some future hybrid combination of a passenger-freight vehicle, probably autonomously driven. Loads can be identified and picked up along the journey and either delivered to their destination or dropped at a consolidation centre (for others to pick up en-route), all at minimal marginal cost.

Uber has just released its freight platform that matches trucks with the right load wherever they are, aiming ultimately for a self-driving freight system. Both uShip and Australia's yojee run on-line freight marketplaces, while Convoy has contracted 10,000+ regular scheduled shipments per year for Unilever, in addition to on-demand deliveries. Greater asset utilisation produces cheaper freight movement and happier, better-served customers.

Disruptors are also coming from outside the transport industry, blindsiding traditional players. Outsiders such as Google, Uber and Tesla are moving smart/shared concepts forward using technology. Amazon is building its own logistics business, buying branded truck trailers, leasing freight aircraft and building warehouses (23 globally in the third quarter of 2016 alone) to 'control its own destiny' as well as serve other retailers and consumers.

5.3.2 Carrier collaboration

Continued innovation will force transport operators to change their current operational silos and embrace load capacity sharing between competitors. While subcontracting loads to aligned partners has been traditional practice when operators can't service customer volumes

with their own capacity, and freight brokerage is nearly as old as the industry itself, new capabilities allow more than simply using ITS to protect existing business models. ITS enables exponentially expanded freight matching opportunities that cross existing competitive boundaries for transport operators and their customers alike.

Finding a clear need to better consolidate freight, the Iowa Department of Transport joined with a private partner to develop the Cedar Rapids Logistics Park with intermodal cross-dock rail–river–highway access which will return a benefit of US\$26.53 for every dollar invested. The European Union too is funding new business models that extend freight hubs into smart, connected logistics clusters.

5.3.3 Data services

Governments are facilitating data sharing to create new value for the transport industry. As mentioned earlier, Singapore is creating Big Data capability for its transport community. Similarly, the US state of Iowa's Department of Transport conducted a supply chain design model at a postcode level, for all products moving in the state, by using bill of lading data in a massive public and private sector data mining exercise.

The open-access approach required for Big Data and C-ITS to succeed opens new opportunities for information-based businesses of all kinds. Many of these cannot even be foreseen now, but will emerge as new value is placed on information.

At the lowest energy-focused level, as the market for energy services in transport matures there will be new opportunities for energy auditors and service providers to help small operators improve their operations, perhaps in an energy performance contracting model where their fees are based on energy savings. Government can accelerate this process by developing and promoting standards, and facilitating accreditation of service providers.

5.4 Value creation/preservation

This strategy involves quantitative, as well as qualitative aspects of freight transport from the perspective of individual operators, freight customers, and society in general. This includes agglomeration benefits of freight hubs in urban areas, and employment and new business opportunities as the sector grows.

At a base level, the development and adoption of standards and regulations for new vehicles can shift both the energy efficiency and pollution emissions of the entire new vehicle fleet. By ushering in electric or hydrogen vehicles more quickly, such standards can create the pathway for future generations to be transported and supplied by vehicles producing no pollution or carbon emissions (via renewable sources of electricity generation).

Similarly, the emergence of autonomous vehicles may bring a revolutionary reduction in vehicle crashes and the associated societal costs of road trauma, which costs the economy \$27 billion each year (ATC 2011), in addition to the devastating associated social cost.

Meanwhile, some emerging technologies will create new business models that don't fit simple categories, or which will leave lasting legacies for future generations. The Hyperloop One technology company is contemplating moving ports 10 miles off the coastline where ships dock 'like a giant oil platform' to off-load their cargo. An underwater Hyperloop tube could then transport cargo to shore and on to inland intermodal hubs.

Long-term value creation can also apply to support systems and charging models. Government reliance on fossil fuel-based revenues to fund transport infrastructure is in jeopardy from relentless fuel-efficiency gains even before electrified vehicles emerge, inevitably leading to a new 'user pays' road pricing model based on when, where and how people use roads.

Cost-reflective road pricing can support greater network efficiency and freight modal shift—improving productivity, reducing congestion, and funding maintenance and expansion of road network capacity linked to market demand. Pricing models can include the time of day the network is accessed, distance travelled, location (e.g. CBD/urban, rural, specified area), vehicle mass and/or model of vehicle (e.g. hybrids, safer vehicle design, fuel efficiency rating, etc.). This would allow previously externalised costs (congestion, pollution, even noise) to be internalised and signalled in access fees, to help drive behaviour change and cost recovery.

Reviews of competition and infrastructure provision reform over the past decade have consistently identified cost-reflective road pricing as a national priority, with the Turnbull government supporting its staged introduction over the long-term focusing initially on heavy-vehicle road reform. The Heavy Vehicle Charging and Investment Reform Project recommended mass-distance-location charging, with COAG considering a transition to independent heavy-vehicle price regulation by 2017–18.

A model that starts with heavy vehicles transporting freight where there is competition between road and rail freight (i.e. on national highways and arterial roads) could address the distortion of costs and pricing between modes, encouraging freight modal shift from road to rail by balancing their competitive positions.

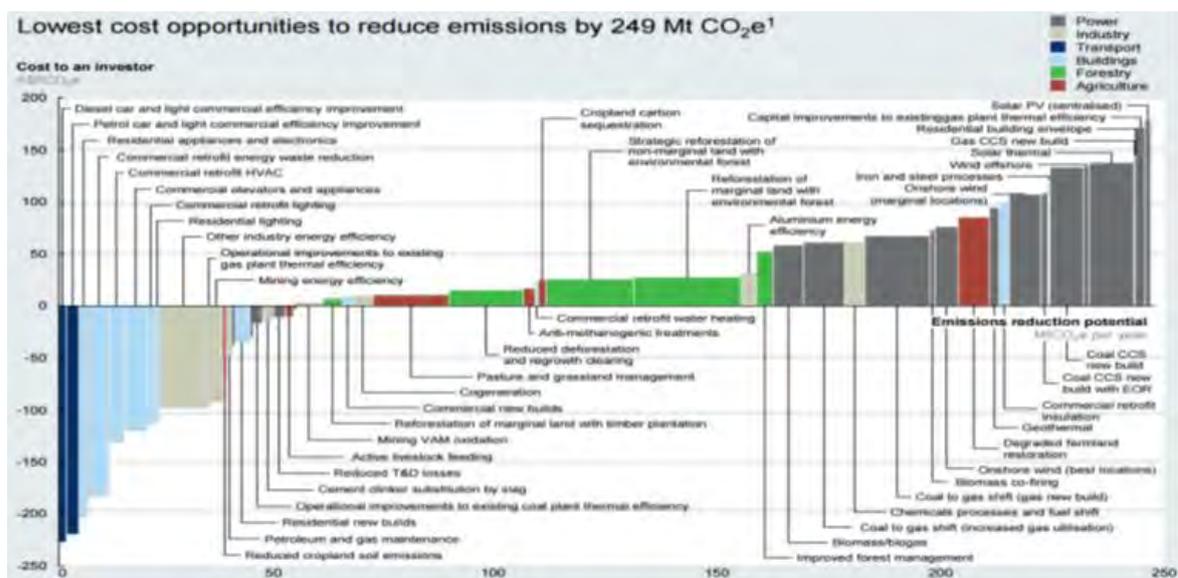
6 Estimating the potential for improvement

Many studies claim the transport sector has some of the most cost-effective opportunities for energy and emissions savings. For example, in its *Low Carbon Growth Plan for Australia*, ClimateWorks (2010) analysed opportunities for greenhouse emissions reductions across the economy and found transport offered some of the most cost-effective measures of any sector, sitting on the far left of the marginal abatement cost curve (Figure 6.1).⁸

In a subsequent study, ClimateWorks also found that opportunities in transport—particularly more efficient light vehicles, and electrification of the fleet—could contribute significantly to a near doubling of Australia’s energy productivity by 2030 (ClimateWorks 2015).

Similarly, last year’s *National Energy Productivity Plan* highlighted opportunities for light vehicles and heavy vehicles as the largest and second largest contributors to improving overall energy productivity by 40% by 2030. These sectors are circled in Figure 6.2 (cars far left, other transport second from left).

Other studies, both domestic and international (IEA 2009, IEA 2010, ICCT/US EPA), also find transport energy efficiency to be highly cost-effective, before non-financial barriers are considered.



Source: ClimateWorks (2010)

Figure 6.1

Marginal abatement cost curve showing transport opportunities as highly cost effective

⁸ The direct link between greenhouse emissions, fuel consumption, and transport energy means that the highly attractive abatement potential can be broadly interpreted as energy-saving potential.

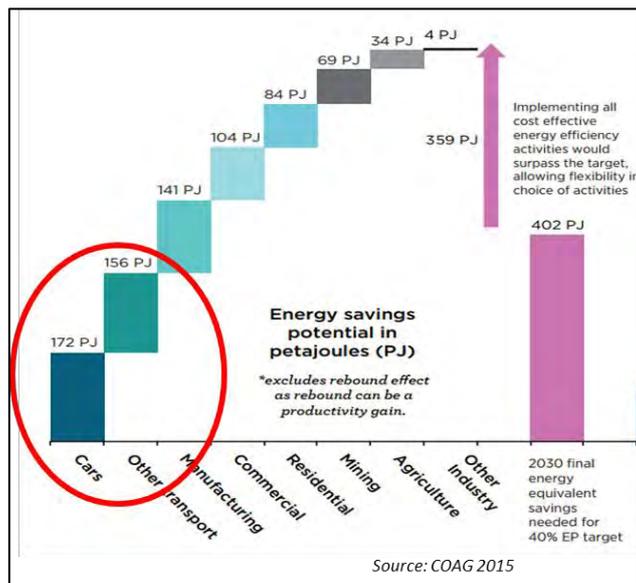


Figure 6.2

Potential energy savings from different sectors contributing to the NEPP target

6.1 Technical feasibility and best practice

Of the four levels of the energy productivity hierarchy in Section 5, industry and government have traditionally focussed their effort on improvements in the first two levels – energy management and system optimisation. Opportunities at these levels are easier to quantify, with examples of best practice or best available technology (BAT) demonstrating typical savings that can be copied by other companies, facilities or fleets

Opportunities in the other two areas (business model transformation and value creation) carry significantly more uncertainty and risk, and may depend on significant changes in behaviour and innovation. Because of this, they are harder to replicate from one company to the next: in some cases, the scale of benefit in one company may only be possible precisely because it is the first to transform its business model (e.g. Uber, Tesla). Adoption across the sector is therefore much harder to estimate. For this reason, a preliminary estimate of potential improvements is easier to focus at the first two levels, and that is the approach adopted below.

Extensive research, historical trends, and commercial experience from the freight working group were combined to estimate the likely potential improvement possible by 2030 from a range of known best practices and technologies that could be adopted more widely across the sector. These included:

- more efficient vehicles (engines, drivetrains, other components like aerodynamics, tyres)
- operator practices (driver training, maintenance, trip planning)
- payload optimisation (load consolidation, higher productivity vehicles)
- fuel switching (natural gas in CNG and LNG form, biofuels, electric)
- mode shift (road to rail, rail to ship)
- planning and development (freight hubs, urban planning, corridor reservation)
- infrastructure capacity (road/rail upgrades, HPVs, increasing mass/dimension limits)

- improved network efficiency (night deliveries, connected vehicles, reduced congestion)

To model the maximum potential benefit of these opportunities, an improvement rate was estimated based on four factors:

- the foreseeable per-vehicle improvement achievable;
- the likely suitability for different categories of the road, rail and shipping fleets;
- the likelihood that each opportunity would only be commercially viable for some businesses;
- the dependence of some technologies on the replacement of an old vehicle with a new vehicle (e.g. electric drivetrain)

The segmented analysis in step (a) is crucial to modelling future uptake of opportunities, because not all technologies or practices are suitable for all fleets (or the benefit realised will at least differ on different classes of vehicles or different duty cycles).

The results of the modelling were aggregated into a maximum 2030 improvement in energy intensity (energy use per unit of freight, or MJ/t-km), and disaggregated to an annual compounding rate of improvement (percentage). Table 6.1 shows these values, as well as a comparison with the recent annual rate of improvement over the last decade.

Table 6.1 Technical improvement potential in energy intensity (vs BAU)

Mechanism	BAU annual improvement (%)	High EP annual improvement (%)	Total 2030 reduction (%)
Road freight	1.0	2.34	33
Rail	0.4	1.32	20
Shipping	0.4	1.26	19

Overall, it was estimated that the technical potential for improved energy productivity could be between 19–33% by 2030 (on a MJ/t-km basis), depending on transport mode and assuming supportive policy. For each mode, the technical potential was at least two to three times the historical or business-as-usual rate of improvement. This result is not unreasonable for an ambitious target; however, it would rely on supportive policy that can remove some of the commercial and non-financial barriers. These barriers were discussed in the description of the opportunities in section 5.

6.2 Fuel savings from efficiency

As a rough guide to the scale of potential savings available, the 2xEP Freight Transport Working Group assumed a 5% shift from road transport to rail, another 5% shift from rail to coastal shipping and a 25% overall improvement in energy efficiency for each mode by 2030 (1.9% p.a., or roughly the weighted average of the three modes above). These were applied to the historic growth rates in freight task from the last decade, which were also assumed to continue for the next decade and half. The results were startling: a nominal \$5 billion annual saving could be achieved by 2030 if these best practice measures were adopted in an ambitious but realistic way. This is shown in Figure 6.3.

Note that this estimate considers only the energy savings. Additional benefits from reduced congestion, health costs, road trauma and other productivity factors, would all be in addition to the fuel savings (and may collectively be much larger).

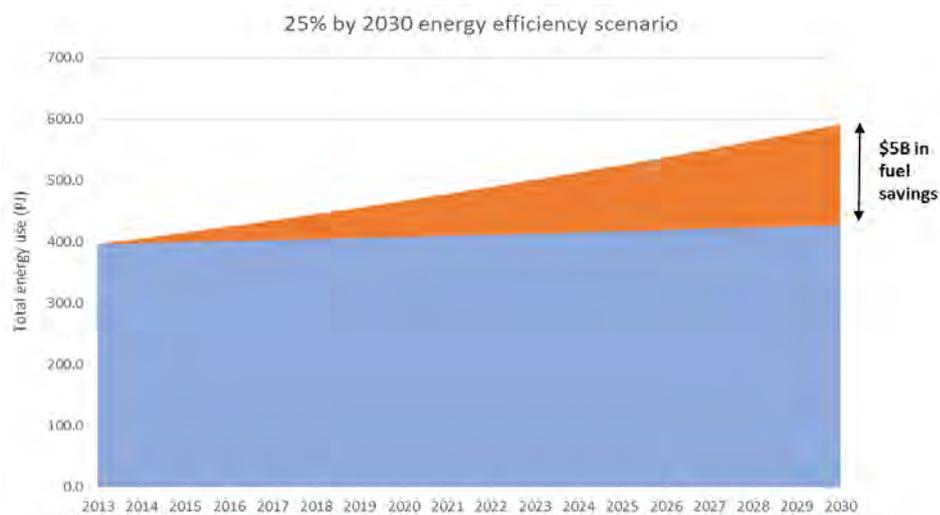


Figure 6.3

Potential savings from energy productivity across freight transport by 2030

6.3 Getting beyond energy efficiency

The \$5 billion in fuel savings described above is largely based on changes in energy efficiency. Individual companies track efficiency of their fleet by monitoring and reporting fuel efficiency (litres of fuel per kilometre, or per tonne-km delivered). The inverse of this metric – energy intensity – is also tracked for the whole sector in national energy statistics (DIRD 2015). The five-year trend in Figure 6.4 shows that the energy intensity of the fleet has fluctuated over time, but improved slightly overall (by around 5% in the five-year period).

Beyond efficiency measures alone, the primary metric used to track energy productivity at a national level is economic output (GDP) per physical unit of primary energy used, or \$/PJ. But there is no standard agreed definition for energy productivity at the sector level in freight transport. A suggested approach to provide a similar metric to the economy-wide measure would use economic output and energy input for the sector, as follows:

$$EP (freight) = \frac{\text{Sector added value } (\$)}{\text{Sector primary energy use } (PJ)}$$

Measured this way, if the energy efficiency improves by fitting fuel-saving equipment, or by shifting from road to rail, or through trip consolidation, then energy productivity improves (increases). The metric suggested above would also capture some of the non-energy benefits – for example, time saved from the trip consolidation would contribute to increased economic output, also increasing energy productivity.

The performance of the freight transport sector according to this calculation can be tracked over time, as shown in Figure 6.5. It shows that, by this definition, the sector has slightly improved its energy productivity over the same five-year period, despite an initial drop in 2009-2010.

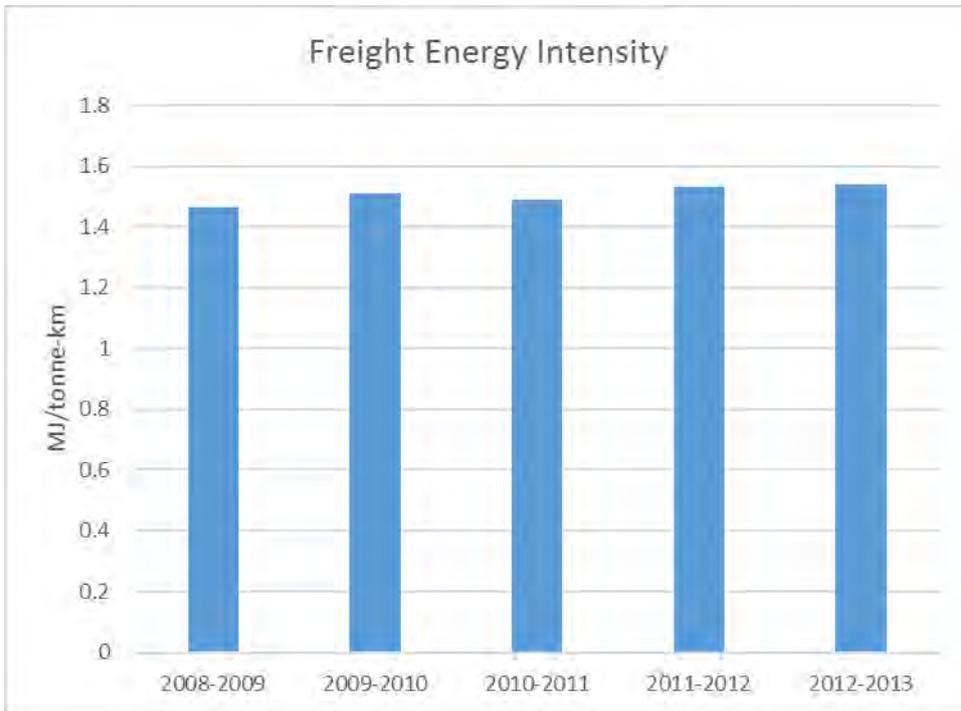


Figure 6.4
Five-year trend in freight sector energy intensity (data from DIRD 2015).



Figure 6.5
Five-year trend in freight sector energy productivity.

An alternative metric for energy productivity could combine the energy intensity of the sector with its value contribution, as per the equation below. The benefit of this approach is that it combines both economic value and physical efficiency factors.

$$EP (freight) = \text{Sector added value (\$)} \times \frac{\text{Freight task (tonne.km)}}{\text{Sector primary energy use (PJ)}}$$

Figure 6.6 shows how energy productivity improved steadily over the same five-year period, when measured using this approach.

These alternative metrics support the view that a single metric may not be sufficient to isolate or disaggregate changes in sectoral activity, energy intensity, and broader macroeconomic impacts associated with freight transport improvements (road safety, congestion, employment). Complicating the metrics issue is the availability of suitable and timely data. While sector data for freight task and energy use is readily available at a national level, disaggregation to state level (or splits between modes) reveals significant gaps in publicly available data. And the 2xEP metrics paper has already identified the issue of different sectoral boundaries between economic and energy data - for example, ABS economic data for value-add includes some non-transport activities such as warehousing and postal, which cannot be easily separated.

For these reasons, a suite of supplementary metrics is under development by the data and metrics working group, and will be tested and refined via collaboration with the freight working group and other stakeholders.

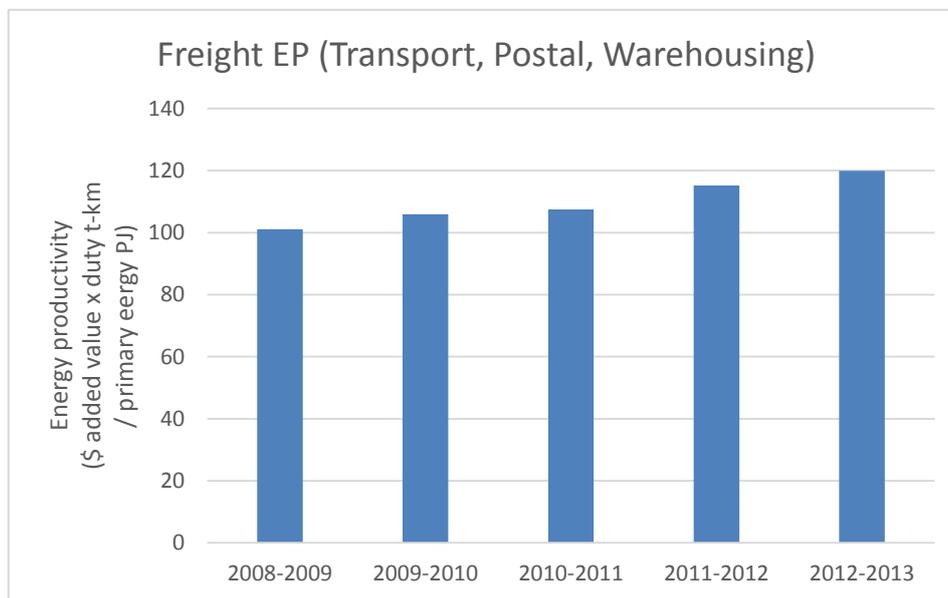


Figure 6.6

Five-year trend in freight sector energy productivity (including duty).

7 Bridging the gap

A potential 25% to 30% improvement in energy efficiency through technical measures, as described in Section 6 above, would be a significant gain, but does not appear to be close to the doubling that is the target of 2xEP. However, it is important to remember that the metric for energy productivity is not just about efficiency or energy intensity. The economic dimensions – either in GDP or sector value – also needs to be considered. And that economic dimension faces a perfect storm of disruption that could greatly influence either energy consumption or economic value of the transport sector (or both).

Perhaps more than any other industry sector, transport is facing major disruptions in the next fifteen years. These disruptions include major changes (in some cases revolutions) in the way freight is generated, how it is moved, where it is moved to, who moves it, and where the energy comes from for that movement. These changes may initially be less severe or far-reaching in freight transport than in passenger transport, but ultimately the changes will affect the freight sector to a similar or even greater extent. For some operators, old business models may soon no longer apply.

Could this disruption be a positive force for energy productivity?

Some of the foreseeable changes are discussed in the sections that follow. Even when one of these is considered in isolation, the likely impact on energy productivity is highly uncertain. For example, the ultimate effect of autonomous vehicles on energy productivity is not certain: reduced car ownership and the strong business case for high utilisation of hyper-efficient vehicles will reduce energy intensity and might reduce overall energy consumption; but it could also cause significant increases in discretionary travel that worsens congestion, reduces urban amenity, extends travel time, and constrains productivity.

A case could be made that there is similar uncertainty for each of the factors discussed in this section. Considered together, the combined effect in both energy and financial terms is therefore impossible to predict with any confidence. But to illustrate the potential effect of these factors on energy productivity, the differential effect on energy intensity and economic value are discussed separately at the end of each section. A graphical summary illustrating the high level of uncertainty is also shown in Figure 7.1.

7.1 Urbanisation: changing the nature of freight delivery

Australia is a highly urbanised society, with almost 75% of the population living in urban areas—more so than the United States and many western European countries such as Germany, France, Sweden and the United Kingdom (World Bank 2016). This level of urbanisation makes our cities significant generators of employment, economic growth, productivity and opportunities. An estimated 80% of the value of economic activity in Australia can be attributed to 0.2% of its landmass.

However, the economies of scale and network benefits, also referred to as ‘agglomeration’ benefits, are not infinite. Maximising agglomeration benefits is highly dependent on local transport systems. If not optimally managed, the negative economic cost of overcrowding and congestion increases. This has been evident in Australia for some time. A 2016 study estimated the ‘avoidable’ cost of congestion⁹ for Australian capital cities in 2015 at approximately \$16.5 billion.

⁹ ‘Avoidable’ costs being where the benefits to road users of some travel in congested conditions are less than the costs imposed on other road users and the wider community.

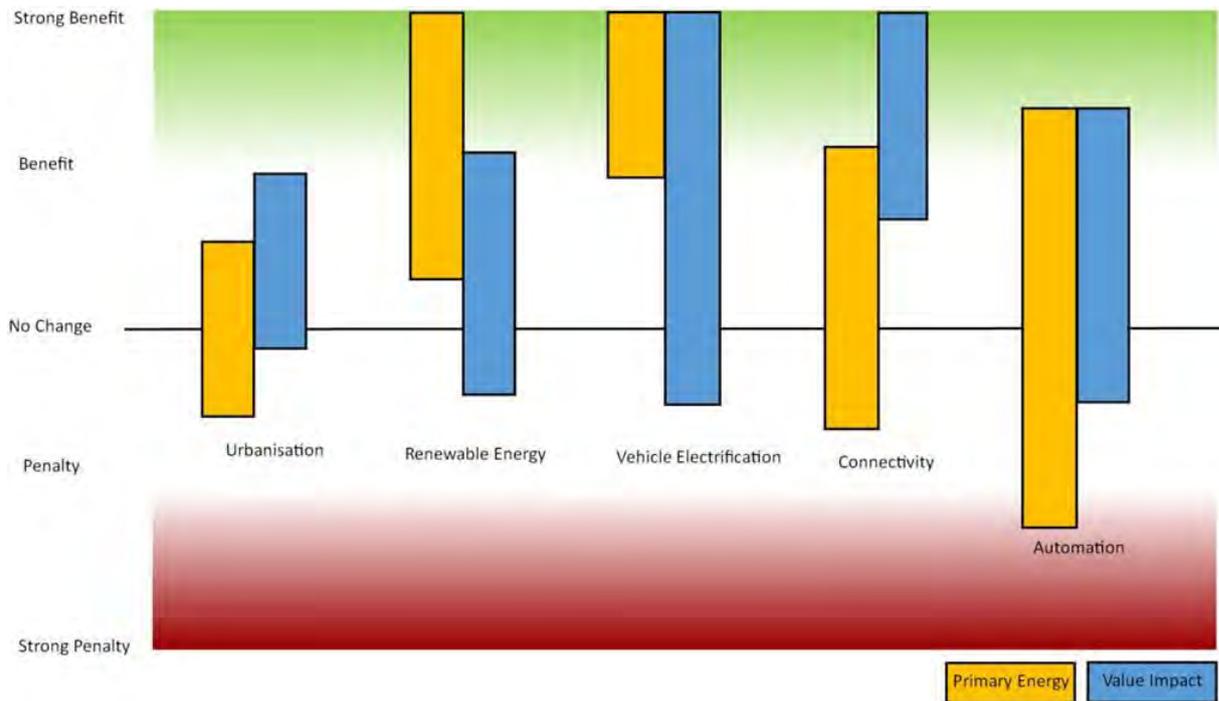


Figure 7.1 Range of possible impacts by megatrend / disruptor

And yet, the population of Australia is projected to increase strongly over the coming decades, with east coast capitals Melbourne and Sydney needing to accommodate almost twice as many people by 2050 (ACOLA 2015). This growth will also increase the level of urbanisation to 90%, and each of those households will need to be supplied their goods and services by the urban freight network. Indeed, changes in consumer behaviour and purchasing methods which see an increasing role for internet shopping and home delivery, may even result in an increase in the per-capita freight task over today’s level (coupled with the increase in population).

In the absence of measures to alleviate congestion, population growth could see congestion costs grow to \$30–\$37 billion by 2030 (BITRE 2015). The major impacts of these costs relate to productivity: business (48%) and private time lost (36%) due to delays and trip availability, as well as extra vehicle operating cost (9%) and extra air pollution cost (6%).

Urban freight transport is obviously one sector directly affected by these negative costs and the consequent drag on productivity. Any congestion-reducing measures can improve energy productivity by reducing lost time, engine idling and pollution costs. Reducing congestion can also extend the life of existing infrastructure by increasing its capacity to support transport services.

One effect of urbanisation is already being seen in vehicle sales, with a shift away from mid-size trucks to smaller, lighter vehicles for urban delivery, and larger, heavier vehicles for long-distance transport. Continuing shifts toward on-line shopping and home delivery could even have a beneficial effect on congestion and energy use, with fewer shopping and discretionary trips by consumers, and deliveries potentially coming direct from the distribution centre (eliminating trips either side of the retail store).

Improving urban freight through better use of infrastructure capacity will take serious private-public collaboration. Technology can help to meet some of the challenges:

- electric vehicles (EVs) are quiet and safe to help extend off-peak deliveries;
- vehicle routing systems provide real-time congestion and cargo updates to combine with loading zone scheduling to optimise flows;
- consolidating loads via matchmaker systems maximises equipment utilisation for fewer empty or underutilised trips;
- last-mile deliveries are already being made with e-trikes and even ground- or air-based robot drones.

Some potential impacts of urbanisation on energy and sector value can be summarised as follows.

	Impacts on primary energy	Impacts on sector value	Combined effect
Upside	Well executed urban development and densification could stimulate a shift from low occupancy passenger cars to active transport and more efficient freight	Agglomeration benefits and workforce specialisation could increase value in the sector	Uncertain
Downside	Poor planning could increase urban sprawl, congestion, and car reliance	Until the emergence of self-driving cars, driving time will continue to be unproductive, increase congestion by up to \$30B by 2030 (BITRE 2015)	

7.2 A shift to renewable energy

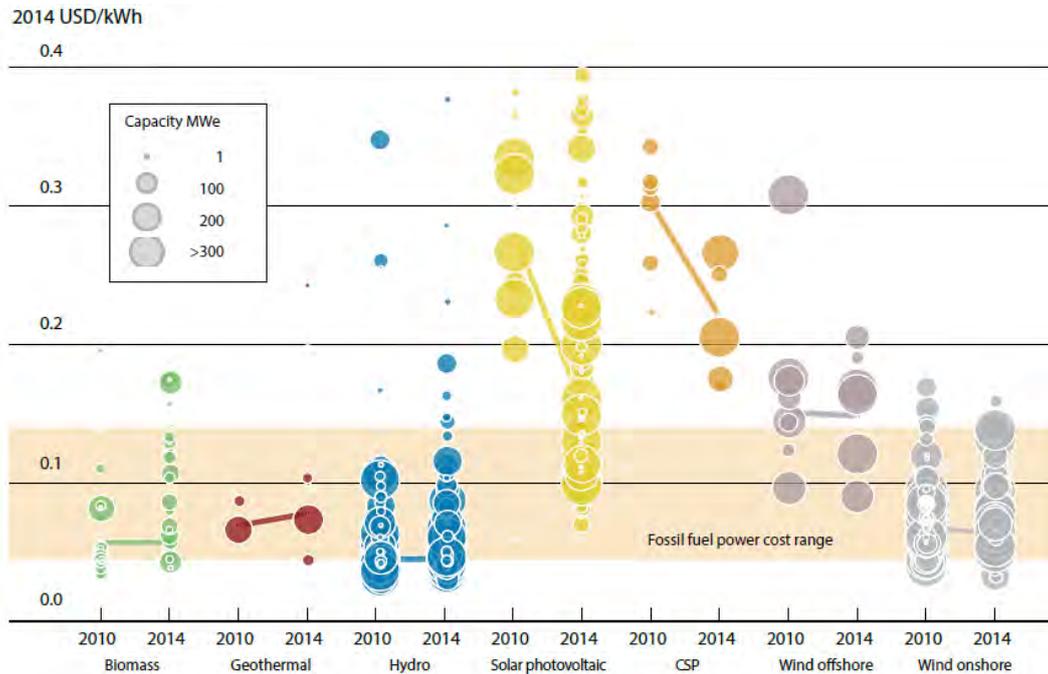
The global energy market is being shaped by two main forces: adoption of energy efficiency and a shift to renewable energy. Energy efficiency is well understood, directly relevant to transport, and is covered in the earlier sections of this roadmap.

The benefits of renewable energy are also well known: from reducing greenhouse gas emissions and pollution, to empowering consumers and communities through distributed generation, to name a few. However, while renewable energy has historically been an environmental choice, recent renewable energy projects have proceeded because they are increasingly cost competitive, and are a less risky long-term investment option under a carbon-constrained global emissions agreement.

Figure 7.2 shows the levelised cost of electricity (2014 USD/kWh) from different utility scale renewable projects (coloured bubbles) compared with conventional fossil-fuel power (in the background orange band). Clearly, many renewable projects have reached cost parity with traditional non-renewable energy projects, with some hydro and biomass beating even the low range fossil sources. Some solar is also within range, and is improving significantly each year. Solar costs have dropped 99% since the mid-1970s, and the installed cost has reduced by 65% in just the 5 years to 2014.

The net result is that global investment in renewable energy now exceeds energy projects based on fossil fuels. More than 164 countries already have green energy policies, and the sector achieved 35% employment growth over 2 years to 2015. Perhaps more importantly, countries and investors are actively seeking ways to divest their holdings in traditional fossil fuel sources such as coal, while simultaneously ramping up investment in renewables. This is a risk minimisation strategy responding to both community concern and potential reduced future demand (e.g. coal demand in China and India is predicted to peak in the next decade),

with the associated risk that such long-lived assets may become stranded in a carbon constrained future.



Source: IRENA (2015)

Figure 7.2 Levelised cost of electricity from renewables versus fossil fuels (orange band)

The implication is that as other sectors decarbonise and shift to renewables, pressure will increase on sectors such as transport to follow suit. Options to do so in transport are currently limited to biofuels (biodiesel and biogas for freight transport), and renewably sourced electricity and/or hydrogen.

Some potential impacts of renewable energy on energy and sector value can be summarised as follows.

	Impacts on primary energy	Impacts on sector value	Combined effect
Upside	Benefit is proportional to level of substitution (e.g. blended fuel, electricity mix). Maximum benefit (up to 100%) when generated on-site.	<ul style="list-style-type: none"> Mitigating cost of climate change Supporting regional industries - e.g. Qld Biofutures to create \$1B export industry by 2026 (DSD 2016) Reduced reliance on imported fuels Reduced distribution losses 	Likely High benefit
Downside	Renewably-sourced liquid fuels can still bring negative impacts to air pollution	<ul style="list-style-type: none"> Cost of new renewable generation infrastructure can be higher (project-specific). Liquid fuels production has proved unsustainable. 	

7.3 Vehicle electrification

Many in the transport industry feel that EVs are the fuel and technology solution of the future, here today. That may certainly be the case for urban passenger transport—after all, EVs are inherently more efficient than internal combustion engines using liquid transport fuels, they can also recover some of the kinetic energy traditionally lost during braking, and they are cheaper to run. They also offer the possibility of carbon neutral transport if batteries are charged by solar, wind or hydroelectricity.

The significance of this relatively easy pathway to emissions-free transport should not be underestimated. As other sectors decarbonise their energy needs, so too will the pressure ramp up on the transport sector to do so. Some countries (Netherlands, Norway) have already signalled their intent to ban sales of fossil fuel powered cars (petrol and diesel) as early as 2025. It may be easier for individual cities to quickly follow suit—cities like Beijing already limit access by vehicles on particular days, and Paris is considering a full ban on diesel vehicles older than 20 years (now) or 10 years (by 2020). EV sales in Norway already represent close to 20% of the new vehicle market, and are increasing 80% annually. Globally, EV technology is the only one of nineteen technologies being monitored by the IEA that is on track to meet its target for contributing to 2050 climate goals (IEA 2016a).

Australia lags many overseas markets in the adoption of EVs, representing only around 0.1% of all new vehicle sales. Reasons for this include the higher costs (and lower driving range) of current batteries, lack of widely available recharging infrastructure and limited availability of models.

Notwithstanding this potential for improvement, the global shift to electric drivetrains has been slower in commercial vehicles than it has been in passenger cars. This is mainly due to the performance (range) and weight of batteries, requiring a substantial battery pack that sacrifices payload capacity. But battery energy density and costs are improving constantly. Many urban freight operators also do not use their vehicles' maximum weight capacity, so battery weight is less of a problem in the city.

In the Australian commercial vehicle market, adoption rates of EVs are effectively zero. However, even conventionally powered vehicles are increasingly being electrified—from relatively low levels to power accessories and ancillary functions, to strong hybrids using a diesel engine and battery/electric motor combination. And as all vehicles become increasingly connected with each other and with infrastructure, so too will their functions and features become increasingly electrified.

Adaptations of the hybrid concept are currently being developed by various companies for use in the commercial vehicle sector, including trailers that capture braking energy and then redeploy electric drive during acceleration (e-axles), range-extender hybrids using the internal combustion engine as a generator to power an electric motor that does all the driving, and even micro-turbine charged, battery-powered axles retrofitted to older trucks.

Even if battery EVs lose favour and hydrogen takes over as the future fuel of choice (most expect a patchwork of alternatives to suit specific operations rather than a single silver bullet), the fundamental driveline of a hydrogen fuel cell powered vehicle is essentially still an EV, but with electricity supplied by the fuel cell rather than a battery.

What impact these new technologies will have on energy supply and grid demand is unclear, but electricity generators and distributors are clearly factoring EVs into their future. What is known is that government reliance on fossil fuel-based revenues to fund transport infrastructure is already in jeopardy from relentless fuel-efficiency gains even before EVs are

adopted more broadly, inevitably needing ‘user pays’ road pricing based on when, where and how people use roads.

The significance of EVs for energy productivity is that by charging with electricity generated from renewable energy, primary energy consumption can be reduced by more than 60%.

A summary of the potential impacts of renewable energy on energy use and sector value follow below.

	Impacts on primary energy	Impacts on sector value	Combined effect
Upside	<ul style="list-style-type: none"> EVs travel 3 times further per unit of primary energy EVs could represent 3% of electricity demand globally (McKinsey 2016) Electrification makes integration of renewables in transport easier 	<ul style="list-style-type: none"> Much lower vehicle operating costs (owner savings) EV support of grid infrastructure and smart grids Potential local manufacture / auto assembly 	Medium-high benefit
Downside	<ul style="list-style-type: none"> Little or no benefit on primary energy if EVs are powered by grid electricity 	<ul style="list-style-type: none"> Cost of EVs is still high (mainly due to batteries). Potential increase in urban air pollution until grid emissions intensity is reduced. 	

7.4 Connectivity and intelligent transport systems

Intelligent transport systems (ITS) offer a vision of seamless transport for people and goods by connecting all elements of multimodal transport—passengers, freight, vehicles, information, and communications technologies and infrastructures—in a digitally integrated system.

No aspect of freight transport will be untouched by this connectivity revolution. From fleet management, logistics, warehousing and supply chain optimisation to the operation of roads, railways, ships, ports, airspace and border crossings, multi-platform sensing technologies will distribute digitised real-time data via supply chain ecosystems. Optimisation of routes, schedules and inventory flows will be ITS-facilitated and continuously re-evaluated by ever-improving artificial intelligence.

Epic advances in volume and speed to generate, process and store data will fundamentally change goods movement, achieved through what is now being termed co-operative intelligent transport systems (C-ITS). This requires open access information platforms, predictive analytics and sharing of public and proprietary data. Government can facilitate progress in this area by supporting common data standards and frameworks, with work in this area currently being led by Austroads.

Even insurance will be revolutionised to reduce costs, both through significantly safer vehicle operation and telematics providing location, time and driver behaviour data to enable precise estimation of underwriting risk for lower insurance costs (already a significant input to premium calculation in the United States).

Geographic information system (GIS) mapping is a crucial foundation to these systems. It provides content and context about the environment in which things move, and where they go, measured and reported in real time. Combined with Big Data, this revolution will encourage new types of collaboration across networks of individuals and organisations sharing large volumes of critical information.

It is hard to reconcile this future vision of data utopia with the current parlous state of data management and utilisation in some freight operations. Collection, analysis and utilisation of

energy data, for example, is still not widespread in the road freight sector. Connecting this energy data with production or output data such as tonne-kilometres, as would be required to measure true productivity, is even rarer.

But there are already giant steps toward this future vision, and once the operator and network benefits are fully realised the momentum for change may be overwhelming. This momentum is likely to come, at least in significant part, from large freight customers (e.g. supermarkets, miners) who need real-time data to optimise their entire supply chain. The need for relevant data to do this will filter all the way down to the smallest sub-contracted truck operators linked into their supply chain.

Some potential impacts of connectivity and big data on energy and sector value are summarised below.

	Impacts on primary energy	Impacts on sector value	Combined effect
Upside	<ul style="list-style-type: none"> • 16% CO2 avoided when combined with automation. (GeSI 2015) • Digital Freight Matching could dramatic reduce empty miles. • Merging of freight & passenger task improving network efficiency. 	<ul style="list-style-type: none"> • \$14B (AUD) in ICT-enabled savings from better fleet utilisation, reducing car ownership. (GeSI 2015) • Connected vehicle may generate ten times the revenue stream of a conventional vehicle (KPMG 2017) • \$37M (AUD) car-sharing and route-sharing apps. (GeSI 2015) • Mitigating congestion costs due to network efficiency. 	Medium-high benefit, but high uncertainty
Downside	<ul style="list-style-type: none"> • Potential decrease in mass transit as it competes with ride-share. • Increased “on-demand” last mile delivery may reduce route density and efficiency. 		

Four examples of connectivity and data transforming freight operations follow.

- Singapore is using Big Data to optimise every mile of road on the small, densely populated island. It uses smart sensors to collect real-time transaction information at 400 million downloads per month. It aims to enable mobility-on-demand services via driverless vehicles, ride-sharing and electrification while doubling the rail network to reduce reliance on privately owned vehicles.
- Melbourne start-up Opturion’s container optimisation platform routes containers between wharf, container yards and transport yards using multi-source data sets to maximise efficiency within vehicle, cargo, site and route constraints.
- Daimler, BMW and Audi jointly own the HERE map technology business whose map data is used by four of every five cars in the world today. Daimler made HERE an open platform to encourage innovation to optimise use of infrastructure, with interesting possibilities for its truck brands.

A connected port model for the future

With no room to expand, Hamburg Port optimises its infrastructure by connecting IoT sensors to collect and share data with all port stakeholders via mobile devices.

Real-time delay updates prevent more widespread disruption within and outside the port. Smart sensors communicate truck parking availability; connect multimodal interfaces between ship, road, rail and movable bridges; and connect truck drivers to traffic lights to prioritise cargo movements.



7.5 Automation

Developing hand-in-glove with ITS connectivity, automated vehicles are being tested on public roads around the world after rapid progress in technology development on many fronts. Automated driving functions can be considered to lie on a spectrum, ranging from automation of one or two systems such as ABS anti-lock braking (level 1), up to fully-automated vehicles requiring no driver input whatsoever and not fitted with a steering wheel (Level 5). The first stages of autonomous driving technology (levels 1 and 2) are already commonplace on many cars and trucks. These include lane departure warning systems, intelligent cruise control and autonomous emergency braking, progressing up to Tesla's so-called 'Autopilot' (which is currently just an advanced driver assistance technology).

While these developments are exciting for their potential direct impact on every motorist, vehicle automation is certainly nothing new. In other industry sectors, automated machinery is already commonplace:

- Aircraft have had autopilot for many years.
- WA has a fleet of driverless mine-haul trucks moving iron ore in the Pilbara (DIRD 2014b).
- The driverless mine-haul trucks connect with trains that also operate without a driver.
- In warehouses around the world, manual stock picking by humans has been replaced by autonomous robots that can operate in the dark.

So, even though the road transport sector is playing catch-up, it is running fast. By 2018, Tesla expects to have fully-automated driver systems in its vehicles which will not require the driver for safety-critical functions. Even if one considers that to be overly ambitious, mainstream manufacturers are claiming they will have the same by 2020 (and on lower priced models). The autonomous vehicle start-up Zoox claims it will have a vehicle without a steering wheel ready for delivery and public use by 2020. And Uber Freight's self-driving truck acquisition, Otto, recently partnered with Volvo to complete its first shipment of Budweiser beer.

In other words, the technology is surprisingly close to current reality—with or without supporting infrastructure. Closer to home, Western Australia is already trialling the functionality of an autonomously driven bus in Perth (under human supervision), as shown in

Figure 7.3. In another Western Australian first, it was announced at the recent ITS World Congress in Melbourne that Western Australia plans to run a trial of truck platooning in 2017.

But other Australian states are competing to be the leader in this space. South Australia conducted the first driverless vehicle trial in Australia, and is planning other trials and industry support to position itself for future growth. Similarly, Queensland already has one connected vehicle trial underway and is looking to support that with other initiatives

The implications for the freight sector are clear. With personnel being the biggest operating cost for most freight operations, this technology holds significant potential to reduce costs. But it can also increase asset utilisation because automated control systems are not subject to fatigue and rest breaks; and if proponents of the technology can be believed, safety will increase significantly once human error is removed from the equation—another boon for productivity.

One question for governments to consider is whether they could or should incentivise the most autonomous of connected vehicles (those not dependent on infrastructure for their effectiveness) to delay or avoid significant infrastructure investment as more products come to market.



Source: www.motoring.com.au

Figure 7.3

Autonomous bus under supervised trial in Perth

Policymakers, regulators, and infrastructure planners will need to keep pace with the technology and associated social changes, and are already on the case. The National Transport Commission released several autonomous vehicle discussion papers in 2016, as well as a work plan approved by COAG transport ministers.

However, the speed of development in these systems is very fast and accelerating. The National Transport Commission believes completely driverless trucks are decades away, but high-level automation with drivers only taking control in emergencies will be here much sooner. There is a risk of mismatch between technology readiness and the typically slow pace of change in the policy and regulatory wheels of government.

If or when autonomously driven vehicles are demonstrated to significantly reduce accident rates (e.g. in overseas trials), this could escalate political pressure on regulators to mandate the adoption of the technology in new vehicles. After all, if the technology is available at little cost, an argument could be made that there are moral, economic or social obligations to require it, given the significant reduction in accident costs and trauma it could generate. The United States National Highway Traffic Safety Administration has already expressed a desire to impose mandatory vehicle-to-vehicle communications when the technology is ready (NHTSA 2014).

Other areas of freight logistics already applying automation include:

- on-rail freight shuttle systems that transport containers and truck trailers to ports
- a fleet of automated container stacking cranes at DP World Brisbane
- express freight transshipment handling systems
- autonomous robotics for last mile delivery (Figure 7.4).



Figure 7.4 Starship Autonomous freight robot (www.ttnews.com)

Some potential impacts of automation on energy use and freight sector value include:

	Impacts on primary energy	Impacts on sector value	Combined effect
Upside	<ul style="list-style-type: none"> • Automated eco driving resulting in 20% energy saving. 	<ul style="list-style-type: none"> • “seamless mobility” could add USD\$7400 per capita, boosting 2030 GDP by 3.9% (McKinsey 2016) • New business development. 	High uncertainty
Downside	<ul style="list-style-type: none"> • Potential rebound effects: mode shift from mass transit to single occupant AVs. • In a “seamless mobility” system, people would potentially travel 20%-50% more. (McKinsey 2016) 	Job loss due to disruption	

7.6 Business model transformation

Although this opportunity was first discussed in section 5, it is revisited here due to the disruptive effect on the market and energy productivity more broadly. Two areas merit special mention: vehicle manufacturing and freight allocation.

Traditional automakers have survived in a relatively protected market for a long time, with significant barriers to entry for prospective upstarts: these include massive capital investment, low profit margins, technical and manufacturing expertise, and an embedded distribution model. But vehicle electrification and automation have enabled a once-in-a-generation window of opportunity for newcomers to enter the auto industry. Innovative players are now challenging traditional automakers (and finding customers), entering a market that was, for a long time, a virtual closed shop. Tesla is the most obvious example, using smart technology, good design, and a bold vision focused on energy productivity principles. But the list is longer and growing rapidly, including Silicon Valley favourites Apple and Google, and associated players like Uber. Even Deutsche Post DHL (by purchasing start-up firm StreetScooter) now makes its own custom-designed delivery EVs that it is considering selling to other logistics providers (Figure 7.5).

Similar approaches are being employed in the fuels sector. Seattle–Tacoma International Airport is developing clean fuel infrastructure to accelerate the transition of sustainable aviation fuel from an alternative product used by a few select airlines, to a standard product that is used by all airlines at the airport, breaking the status quo of biofuel supply agreements made through individual, expensive contracts between producers and airlines.

Despite losing its remaining car manufacturing sector over the next 18 months, Australia still retains a healthy truck manufacturing industry that, unlike the car industry, is integrated into parent company global supply chains. Australian suppliers and developers also continue to play major roles in emerging business areas—for example Cohda Wireless is a world leader in connected vehicle technologies; co-founder of autonomous vehicle company Zoox is an Australian; and two heavy vehicle manufacturers (SEA Automotive in trucks, and Brighsun in buses) are looking to establish vehicle assembly in Australia as a regional centre in their operations.

While the horse may have bolted on being the Tesla of this generation, the examples above show that ongoing opportunities do exist to give established paradigms a big shake. Indeed, future manufacturing may even see global scale as a disadvantage. The company Local Motors has shown the viability of 3-D printing entire cars and mini-buses wherever the raw materials are available or can be supplied—removing the need for complex and risky supply chains, apart from a few key systems. There is no reason Australian businesses cannot play in this space.

The major disruption to freight allocation could come from a possible convergence of freight and passenger vehicles in urban delivery situations (which will only grow as urbanisation increases). The section on digital Freight Matching (DFM) describes the mechanism by which this might work. But the major challenge (and major opportunity) in new business models is leveraging significant spare capacity in passenger vehicles to carry parcels and small freight consignments previously loaded onto commercial vehicles, many of which are currently under-utilised. Ultimately, if the origins and destinations for passengers and freight coincide, and digital route planning can seamlessly combine dual-purpose trips (or even reward or compensate drivers), this could substantially reduce the volume of vehicles on the road, thereby reducing congestion and improving energy productivity.



Figure 7.5 Deutsche Post DHL StreetScooter

Business model transformations due to the convergence of connectivity, big data, automated vehicles, and artificial intelligence may impact freight energy productivity in ways that is difficult to quantify with traditional methodologies. To use one example, a recent survey of 1000 leading automotive executives found that 78% believe that one connected car can generate 10 times the revenue stream of one conventional vehicle, with data “fuelling” these future business models (KPMG 2017).

Another example is the use of “blockchain” technology, which could slash the cost of transactions and reshape the economy by facilitating and tracking financial payments, cross-border trade and freight flows. Developed to support the use of Bitcoin, it is based on a peer-to-peer digital network and operates as an open-source distributed ledger recording transactions between two parties efficiently and in a verifiable, secure and permanent way. It also enables ‘smart contracts’ that trigger transactions automatically.

Logistics companies are already using blockchain for commercial settlements of bills of lading, customs and security. Examples include:

- Bitcoin crypto-currency to pay for international cargo transaction fees
- Decentralised tracking of shipping containers
- Recording a globally accessible provenance trail for diamonds

Clearly there are enormous applications for quality assurance in retail, agriculture and pharmaceuticals supply chains.

The impact of blockchain on freight transport will go hand-in-hand with the rise of autonomous and connected vehicles and other exponential technologies. Self-driving vehicles, with routing and pricing software tuned to minimize energy use, could be guided to the quickest route by real-time traffic updates, and to the next customer by real-time requests, with blockchain eliminating the middleman that matches freight with vehicles, charges a transaction fee, and sets terms and conditions in a smart contract that sends payment to a supplier as soon as sensors confirm a shipment is delivered. No drivers, back office staff and bank or other third party commercial facilitation required.

8 A roadmap for getting to 2xEP

Specific policies and actions in isolation can generate incremental or partial improvements in energy productivity. But the extent of improvement required to double energy productivity as targeted by the 2xEP initiative requires diverse, coordinated, broad-based and long-term changes. This roadmap intends to address those challenges.

A recent report by the Carbon Trust (2016) that looked at more effective energy efficiency policy provides useful guidance for effecting changes in energy productivity. It suggests many energy efficiency programs still miss critical barriers, and recommends three key areas for action:

- strong government policy to underpin the business case
- increase awareness of opportunities and provide substantial technical assistance
- build local skills and trust to support a self-sustaining market for energy services.

Looking specifically at transport, the International Energy Agency (IEA 2016b) recommends an integrated policy package comprising six main elements:

- minimum fuel efficiency standards
- mandatory fuel efficiency labelling
- mandatory reporting of energy consumption of vehicle fleets
- targeted information to support organisational improvements
- incentives such as tax allowances
- cost-reflective road pricing.

This roadmap broadly adopts these principles, but integrates them with related actions from other studies, under some common themes or ‘pathways’. Each pathway is intended to broadly describe how government policy and industry action can be coordinated to achieve the 2xEP goal, on the basis that coordinated actions are more likely to achieve the desired result than a single ad-hoc activity or policy.

An additional characteristic of this approach is that one pathway can cover actions under multiple categories in Section 6. For example, effective road pricing can influence operator scheduling/routing (level 1), reduce congestion (level 2), change the business model for road funding (level 3), and reduce pollution (level 4). It therefore supports an integrated policy approach better than focusing on simply one problem (e.g. congestion).

The main pathways are summarised below, and recommended supporting actions for these are provided in Section 8. They are based on a few underlying principles, including that:

- industry is likely to adopt opportunities when they are financially beneficial and not constrained by non-financial barriers to adoption;
- a clear role for government is in removing barriers and market failures;
- externalities should be priced to encourage behaviour shifts toward preferred/prioritised community benefits;
- regulatory and compliance burdens should be directed upstream of the freight operator;
- government has a central role in providing the right policy settings and information to drive energy efficiency (IEA).

8.1 Leadership and strategic vision

As the biggest and fastest growing energy consuming sector, with factors driving energy consumption predicted to grow strongly in coming decades, and few direct policies to change that outlook, the transport sector badly needs an integrated strategic policy vision. This vision could address one specific objective (cleaner vehicles, freight productivity, greenhouse emissions reductions, energy security or whatever is politically palatable), or multiple objectives in the same way as energy productivity does.

Whatever the vision relates to, some firm statement of intent is required to define a future position, create policy certainty, and galvanise investment around a common objective. Alignment of more than one policy objective (e.g. exhaust emissions, greenhouse gas emissions, energy or innovation) under such a vision would multiply the policy justifications and rationale.

Outside the transport sector, a good example of such an approach is the Australian Government's renewable energy target. It establishes an objective (use of renewable energy), sets a target and timeframe for achievement, creates a market, motivates investment and tracks progress. Transport needs something similar. Industry has consistently provided this feedback to government forums and studies investigating alternative fuels, energy productivity, and emissions reductions – seemingly without any subsequent policy action.

Two other transport-related examples included in Figure 8.1 show a successful national vision for electric vehicles in New Zealand, and a state-based vision for biofuels in Queensland. In both cases, the vision was established to support multiple policy objectives. A similar approach could be taken focusing on transport emissions, fuel/energy diversification or freight productivity. This can be established at state or national level, but ideally needs a national vision or target, supported by state-based initiatives.

The private sector can also demonstrate leadership and commitment to any one of these aligned objectives. Large, institutional freight customers such as supermarkets and international food and resources corporations have a large influence on freight practices. Growth in public environment and sustainability reporting in corporate supply chains, including energy and emissions of tier 1 and 2 suppliers, is slowly reaching Australian divisions of global businesses. Sustainability frameworks such as CDP (formerly Carbon Disclosure Project), the Global Reporting Initiative (GRI) and Dow Jones Sustainability Index (DJSI) provide a mix of useful tools, third party validation, and market recognition that is increasingly important to institutional investors, and corporate boards are listening.

8.2 Enabling and capacity building

Businesses of all kinds exist to make a profit by servicing a market need, and the freight sector is no different. Reducing the cost of inputs and increasing revenue for outputs is fundamental to good business practice. If options for improving productivity are known, financially viable (and reliable) and available, it is highly likely that operators will adopt them—provided they have the capacity to assess them. This pathway aims to establish those market conditions by removing barriers and increasing the sector's knowledge and implementation capacity.

Information about the technology and process improvement opportunities in freight transport is widely recognised as a barrier. The structure of the road freight industry (which comprises many small operators responsible for the bulk of the freight task) constrains the availability, accessibility and relevance of information for many operators, which becomes a major barrier to improvement.

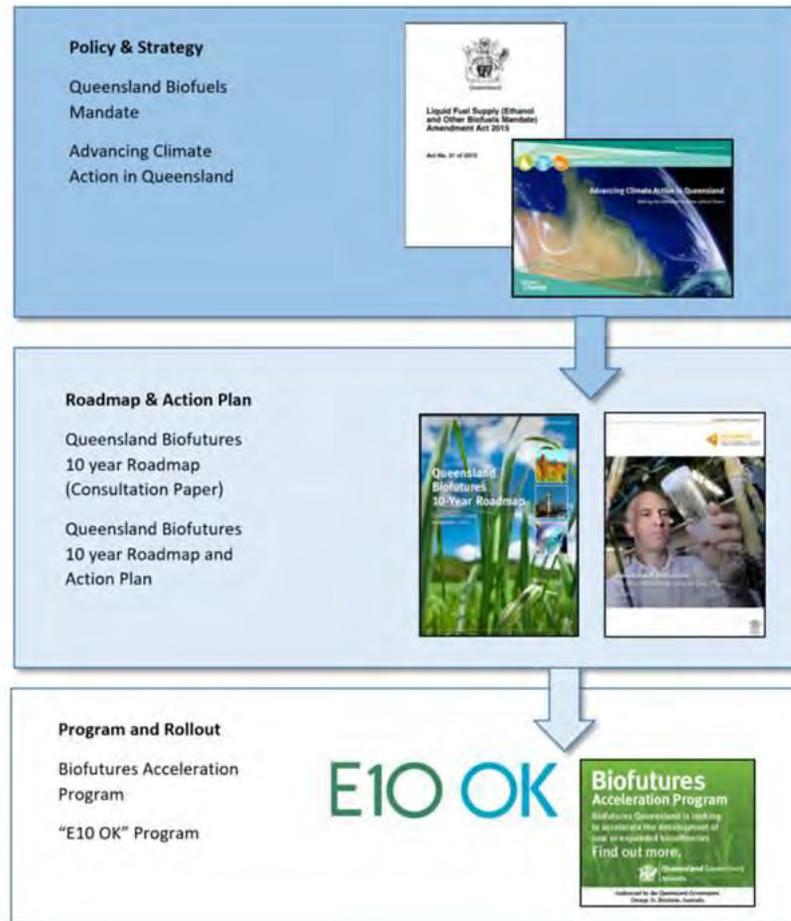


Figure 8.1

Examples of strategic policy leadership in transport/vehicles, integrated with supporting measures

The EEO report *Fuel for Thought* identified a lack of adequate data on the real-world benefits of new technologies in the transport sector—particularly for heavy vehicles (DRET 2012). Some past government programs attempted to compile energy/emissions information, but there are still information gaps and few of these early programs remain active¹⁰.

Given the limited capacity of most of the sector to research and analyse energy information and to run trials and improvement programs, there is a potential role for support programs that do more than simply publish case studies. Previous attempts by the NSW Government to support regional clusters of freight and bus operators (under the Sustainability Advantage program) demonstrate both the need for direct company support, and the potential success of such programs. Perhaps the most significant barrier to such initiatives is the lack of integration, which is discussed in Section 8.4.

In some countries, the emergence of Green Freight programs attempt to connect some or all of these information and support activities. SmartWay in the United States is one example; Green Freight Europe and Green Freight China are two others. Yet in Australia, despite a commitment to such a program under the G20 Energy Efficiency Action Plan in 2014, such an integrating initiative does not appear to be any closer.

Such programs need not be expensive, and often have a high benefit-cost ratio. SmartWay has been running since 2004, saving an estimated US\$6.1 billion (EPA 2012). Such a program could potentially be delivered by a non-government organisation, like the proposed 2xEP Challenge program, by an industry association, or by a state government authority on behalf of COAG. Funding could be provided by government or by allocating a proportion of road user charges for this purpose.

And far from being a mere handout from government, green freight programs help build the skills and capacity industry need to find their own improvements. As an example, SmartWay assists the road freight industry to measure, benchmark and improve logistics operations while providing verification of fuel-saving technologies and operational practices. Importantly, it is designed to improve supply chain logistics, involving freight customers as well as providers.

Apart from supporting fleet operators, one additional area such programs can support is in maturing the energy services market, by including accreditation or performance requirements against professional standards—for example, the standard for energy auditing of transport operations (AS/NZS 3598.3). This could provide greater certainty for companies seeking the service or advice of providers, and more confidence in the results.

Embedding transport energy auditing and management skills into education delivery can also support the industry broadly and effectively. Introduction of training packages for all transport modes and roles (drivers, operators, managers, etc.) via the Transport & Logistics Industry Skills Council provides a structure for delivery of professional energy management skills by accredited organisations such as the Chartered Institute of Logistics and Transport Australia, TAFEs, and other registered training organisations.

¹⁰ The Green Truck Partnership conducts technology trials and publishes case studies. The EEX website provides case studies of energy savings from the EEO program and other sources. And the SCLAA energy efficiency portal provides basic information about technologies and improvement plans.

Another area requiring unblocking is the provision of comparative information on vehicle efficiency. Currently, fleet managers do not have objective, comparable information on heavy vehicles to support purchasing decisions based on fuel efficiency. Unlike light vehicles, which can be compared via a single number score (grams CO₂/km), heavy vehicles cannot be compared on a simple basis. Their energy use depends on load, body style, configuration or trailer type, accessories and how the vehicle is used (duty cycle). Industry association and vehicle manufacturers could work with the government or other proponents to establish a rating scheme to effectively compare similar vehicles and help operators select more efficient models at the time they renew their fleet.

For large freight companies, a formal energy management system (EMS) can be used to coordinate their energy productivity activities. In the European Union, the 2012 Energy Efficiency Directive requires large companies to undertake energy audits, but this requirement is waived in some countries if a formal EMS under ISO 50001 is implemented instead (EC 2013). A similar approach could be adopted in Australia, whereby companies are given the option of implementing an energy management system, joining a SmartWay-like program, or undertaking energy audits on their operations.

Large organisations can also help or incentivise their subcontractors and suppliers, sharing their vision and helping partners to develop systems to support energy reporting.

8.3 Improving the business case

Businesses can be expected to invest in efficiency and productivity improvements when there is sufficient financial justification or incentive to do so. However, financial barriers are a major obstacle to investment in new vehicles and technology. High cost of equipment (due to a small market size), uncertainty in the business case (due to oil price volatility), limited access to finance and long payback periods, all inhibit investment in productivity opportunities.

To counter these barriers, a combination of both direct and indirect financial measures is needed to make the business case for fuel-efficient technologies more appealing, or to reduce investment uncertainty. An explicit, direct price on carbon emissions has been shown to be effective at driving behavioural change to more efficient practices and equipment, and is one of the preferred policies of many business groups in transport and other sectors. Examples of incentives used successfully overseas include direct grants to purchasers of eligible vehicles, registration or stamp duty discounts, different rates of fuel tax on alternative fuels, investment allowances and tax deductions.

In the United States, grants and co-investment have been employed in conjunction with regulations—effectively incentivising operators to replace older rail locomotives with newer, less polluting fleet that meet emissions standards (despite compliance being mandatory). Similarly, the Californian Air Resources Board (CARB) recently announced funding to support the purchase of 15 all-electric buses and rechargers (CleanTechnica 2016). In the UK, the Office of Low Emission Vehicles (OLEV) recently announced a £4 million expansion of a program providing grants of £20,000 for the purchase of electric vans. The expansion increased eligibility from light vans (<3.5 tonnes) to larger vehicles above that limit. (Gov.UK 2016)

Yet, unlike their overseas counterparts, Australian governments at all levels seem loath to offer direct incentives to stimulate the uptake of technology or to reduce emissions. This may be due to a reluctance of governments from both sides to interfere in existing (though imperfect) markets, and a recognition that past interventions have sometimes produced unintended consequences.

In contrast, overseas experience shows that time-limited, well-designed financial support can cost-effectively increase the uptake of lower carbon fuels and more efficient vehicles. Australian schemes that do offer financial support for buying more efficient fleet and equipment include the Emissions Reduction Fund (ERF), and discounted financing from the Clean Energy Finance Corporation (CEFC). However, these schemes face fundamental challenges in attracting and securing transport deals. Transport projects under the ERF are uncommon because:

- projects in other sectors can achieve reductions at far lower abatement cost;
- abatement certainty is often low, due to the suitability or reliability of technologies;
- the administrative requirement for verification and compliance is high (in an industry with limited spare human resources).

The limited success of transport projects in the ERF may be due to the low abatement price seen at auctions to date (\$10-\$14/tonne CO₂). Figure 8.2 shows that at diesel prices around \$1.30/litre and a carbon price of \$10/tonne (April 2016 auction), the abatement certificates or carbon credits as industry calls them are equivalent to just over 2% of the fuel savings (and a much lower percentage of total project costs). In other words, not enough to simultaneously provide a sufficient return AND offset compliance costs and liability risks for most projects.

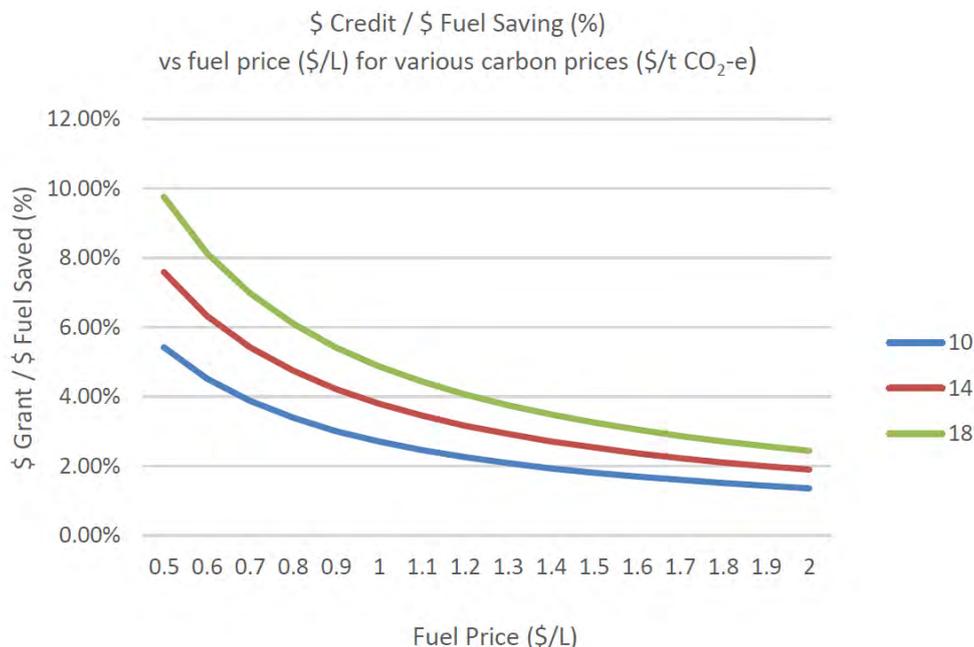


Figure 8.2

ERF incentive proportion of fuel saving for various carbon and fuel prices

The CEFC has an existing scheme offering discounted financing for the most efficient vehicles. However, apart from the few hybrid and electric trucks available, it is unclear what other trucks or buses might be eligible for this funding, or how their eligibility can be demonstrated.

Looking beyond a single vehicle purchase, CEFC and state government programs could also investigate discounted financing for establishing the business case for fleet investment—for example, by aggregating demand for fleet energy audits (resulting in lower fees), or even buying groups to secure better prices/higher volumes for hybrid and alternative-fuel vehicles.

An alternative or supplementary scheme proposed by the Truck Industry Council (representing truck manufacturers, distributors and engine suppliers) aims to incentivise the replacement of the oldest, most polluting trucks in the fleet through differential returns in the diesel fuel rebate scheme. Under this plan, newer less polluting trucks attract the highest level of rebate while old trucks not complying with any emissions regulations receive less or no rebate. The scheme could effectively be made carbon neutral. The Australian Railways Association has a similar plan to replace or repower the oldest, most polluting (and least efficient) locomotives. But both require government support.

The global response to climate change has created a green finance sector that offers funding specifically for investments with positive environmental impacts. From climate finance instruments created at United Nations level, to government incentives and private sector green finance products, demand keeps growing for green investments. A green bond from Canada's Export Development agency supported Queensland's Gold Coast light rail system, and the Victorian Government issued green bonds that finance public transport rail projects.

Extending this thinking to investment in intermodal rail hubs, dedicated freight rail lines for port shuttles and port roll-on/roll-off wharf infrastructure could underwrite freight modal shift away from roads where other modes are competitive, with substantial energy productivity benefits.

Finally, in lieu of a globally-agreed explicit carbon price, many regional, national and sub-national jurisdictions have explicit carbon prices in place. Leading corporations also use internal carbon prices to factor future regulatory risk into current investments and create self-replenishing funds for carbon reduction activities. With internal carbon prices ranging from US\$6 to \$80 per tonne, most expect the cost of emitting greenhouse gases to rise, so are integrating currently externalised carbon costs into traditional financial metrics to decide which projects proceed.

8.4 Linking, alignment and harmonisation

The linking pathway has several related dimensions. Chief among them is the need to include transport in energy policy, and to include energy considerations in traditional transport policy. Neither of these are currently being achieved successfully. Transport is not part of 'energy' focused programs at state level or federal level, with a common focus being on stationary energy (residential and commercial electricity and gas customers). For example, the Energy Efficiency Action Plan (NSW) does not cover liquid fuels for transport, and Victoria's Energy Assessment Grants program specifically excludes transport energy from its scope.

This situation might be understandable if transport energy was the focus of some specific, separate programs, such as those for electricity users. But that is not currently the case for transport, leaving the awkward situation of the biggest energy using sector in the economy being ignored by energy policy and programs.

The second element requiring virtual or physical links is the split responsibility for transport systems between federal, state and local governments, and different departments within each of these levels. This can result in siloed decision making that does not allow for government agencies to collaborate on integrated planning and decision making (Simpson 2014). The Ministerial Forum on Vehicle Emissions, convened in late 2015, is a good example of success in inter-departmental collaboration, albeit limited to the areas of vehicle and fuel regulation.

The third element involves linking the various energy/emissions/fuels policy and programs so that their objectives align with a productivity objective. This was discussed in Section 8.2. States could better coordinate their support programs by linking them to an overarching national or state policy (Section 8.1), connecting with incentive and funding initiatives (Section 8.3), and with reward and recognition programs. These disparate elements have traditionally been considered independently. In short, there is no one-stop shop or integration of initiatives in the 'customer's' eyes.

Australia's energy policies are due to be reviewed by the IEA in early 2017. Also, next year the federal government will review the operation and design of the Emissions Reduction Fund. Both reviews provide an opportunity to assess how transport is (or isn't) affected by current energy/emissions policy.

Fourthly, many freight transport businesses operate nationally, and are therefore affected by policy, regulations and compliance requirements across all their operating jurisdictions—from local, state and federal government. To the greatest extent possible, these should not be duplicated (or worse, conflict) between different regulatory and operating requirements across different jurisdictions.

Fuel-efficient vehicles offer the greatest potential for productivity improvements across the vehicle fleet. However, a major barrier to efficiency improvements in road and rail transport is the fact that Australia is largely a taker (rather than developer) of new engine and driveline technologies. So, the need for overseas manufacturers to develop vehicles or systems specifically for the Australian market, due to demanding environmental conditions and unique regulations, leads to high development and adaptation costs. Yet low sales mean that the business case for offering new technology vehicles or components in Australia often doesn't stack up (as seen in the sales graphs in Section 6).

This issue could be partially addressed via closer collaboration and harmonisation with products and regulation in overseas markets. Aligning regulations with those from overseas (where feasible) could potentially unlock significant untapped potential. An example provided by industry is the difference in vehicle width limits in Australia compared with the United States: our narrower width limit prevents many technologies, particularly aerodynamics, being simply transferred from there to here to reduce fuel consumption; yet the market here is not sufficiently large to justify an entire industry to develop and support these products.

Finally, a single voice advocating the benefits of low emission (or more productive) vehicles, and the needs of industry to bring them here, could make a significant difference in the market. The Low Carbon Vehicle Partnership (LowCVP) in the UK works as an advocacy body representing the interests of industry and the government in producing information and reducing barriers to the uptake of LEVs. It is supported by the UK government's Office for Low Emission Vehicles (OLEV), with £600 million to position the UK at the global forefront of ULEV development, manufacture and use.

8.5 Support for renewable transport energy

Like every other sector, transport will ultimately need to transition to a renewable energy future if the world's emissions targets are to be achieved. Pathways to achieve this shift need to be identified now, and suitable projects supported to demonstrate viability where the technology or project is scalable and can guarantee emissions reductions.

Initiatives under this pathway could differ from past industry calls to support alternative fuels by requiring that any such support be contingent on the renewable aspect of fuel source (or a quantum reduction in emissions). This principle would contribute greatly to improving energy because of the primary energy to final energy conversion advantage the renewable energy sources incur.

In principle, this could make biofuels (including biogas), hydrogen and electricity eligible for support measures—provided they are renewably sourced and produced—as well as any other energy sources that can demonstrate compliance with the required emissions/energy source criteria. Or other criteria could be used that align with some overarching policy vision described in Section 8.1, such as domestically produced fuels.

With eligibility established, support measures could include co-investment in refuelling and recharging infrastructure, additional support for research and early stage production, and other direct/indirect support measures proposed in Section 8.3.

8.6 Better energy data

Road transport operators have high-quality data available to them direct from their vehicles—perhaps more so than equipment in any other sector. This includes data about vehicle efficiency and performance, driver technique, vehicle condition, utilisation and (sometimes) trip data. However, the challenge for most of the industry, which comprises many small operators, is finding time to collect, analyse and interpret that data in a way that informs good decision making. The cost of collecting data is not often seen as recoverable, and there are types of data (such as benchmarking) that no single operator can compile.

The opposite is true in much of the rail freight sector: old locomotives with outdated technology make data capture difficult, even though the organisations comprising the rail sector are better resourced and could make good use of it.

A crucial foundation missing from the current road vehicle productivity landscape is an agreed classification framework that could be used to compare similar vehicles based on energy efficiency. Currently, different classifications are used for driver licensing, sales reporting, statistical data (ABS), and vehicle design standards. Agreement on an efficiency-focused framework could underpin a range of other measures proposed by this roadmap, such as benchmarking, efficiency ratings and even future fuel-efficiency standards such as those already implemented in the US, Japan, China and soon the EU.

Along the same lines, the existing Australian Standard for transport fleet energy audits (AS/NZS3598.3:2014) offers a golden opportunity to advance energy management practices in the freight transport industry, yet it languishes unused by industry and not promoted by government. Developed in 2014 by a working group involving large transport businesses and led by the Department of Industry, this voluntary standard helps transport fleet operators evaluate their data in a systematic audit to understand energy consumption and identify energy savings projects. Industry adoption of this standard, or incorporation into state government energy/business support programs, would lead to improved productivity and business value.

From a broader perspective, energy use data could be better incorporated into infrastructure investment decision making. Despite development principles that include systems, social, economic, environmental and governance criteria (IA 2013), traditional transport infrastructure policy has not explicitly considered energy productivity. One result is that past planning and infrastructure investment policies directed funding to road infrastructure—essentially the ‘point of greatest pain’. However, this simply reinforces the dominance of road transport against all other modes.

The National Transport Commission recently published a paper on the development of a national land transport productivity framework. The paper acknowledges that there are no nationally agreed productivity indicators for transport, and the data that is available on freight movements is not entirely reliable. The paper went out for public consultation and will drive future work in the establishment of suitable productivity metrics. It is important that energy metrics become part of the reporting suite.

8.7 Removing barriers

There are few regulations and constraints on what can be moved and where it can go, but transport operations that move freight (including the site, fleet, drivers and fuels) are highly regulated. In most cases regulations and policies have been developed in response to legitimate concerns (e.g. safety or infrastructure protection). But in some cases, the regulatory hurdles are simply because that is how things have evolved over time or have always been done, and they constrain improvements in productivity.

The emergence of new technologies such as connected vehicles and autonomous control systems, or new practices such as night freight deliveries, can sometimes highlight or accelerate the effect of these barriers. Both the National Transport Commission and Austroads (respectively) have active work program to identify and respond to identified barriers in these areas, but other opportunities are identified in Section 9.

Cost-reflective road pricing could include congestion fees to capture congestion costs, or mass-distance time charging to better connect road use and its associated costs. These have been under discussion and consideration in Australia for a long time. Reform is likely, but has been slow.

Industry is actively addressing information barriers that inhibit visibility across end-to-end supply chains. The Australian Logistics Council (ALC) assembled the Supply Chain Standards Working Group, which includes GS1 Australia. They trialed a multimodal, east–west coast corridor, to demonstrate how adopting the GS1 EPCIS standard could deliver greater supply chain visibility. This harmonised information protocol may also assist in tracking energy use in supply chains, enabling energy productivity visibility.

Green Freight programs allow shippers to select carriers with the lowest emissions intensity. It then simultaneously allows shippers to reliably measure and report the environmental footprint of their supply chain. The establishment of such a program in Australia could help the local industry link with data and initiatives in other countries, as well as drive change in local procurement and reporting, leading to lower emissions and energy costs.

9 Action recommendations

For each of the policy themes in Section 8, supporting actions were identified along with the responsible actor (government, industry, government/industry together), and likely timeframe for realisation. Nominal timeframe categories were defined as:

- short-term: within 2 years
- medium term: 2–5 years
- long term: more than 5 years.

Although the list of actions is extensive, their delivery need should not be daunting. Some of the actions are relatively minor or simple, many of the measures are related to others in the list, and some are already underway or their planning well advanced (e.g. road pricing, better HPV access and fuel efficiency standards for LCVs, to name a few).

It is important to note that not many of the actions are capital intensive, and most focus on reducing the effect of market barriers and enabling industry to make better decisions in a properly operating market.

9.1 Leadership and strategic vision

Actions/activities to support the theme	Responsibility	Timeframe
1. Establish strategic vision/policy objective for transport energy/fuels/vehicles	Government (federal)	Short
2. Formulate policies/programs supporting the goal	Government (federal)	Short
3. Consider once-in-generation lighthouse project (e.g. dedicated high-speed freight rail or Hyperloop on east coast, dedicated coastal shipping terminals for intermodal and roll-on/roll-off cargos)	Government	Long
4. Establish single-point responsibility for transport energy productivity (to align and link programs in Section 9.4)	Government (all)	Short-medium
5. Use next reviews of National Land Freight Strategy (2012) and National Ports Strategy (2011) to integrate federal and state energy, transport and infrastructure plans into coherent vision	Government (federal)	Medium
6. Help freight customers lead improvement via facilitating widespread use of CDP-GRI-DJSI reporting methodologies	Government/industry	Short

9.2 Enabling and capacity building

Actions/activities to support the theme	Responsibility	Timeframe
7. Audit info resources from existing/past programs, identify gaps (e.g. EEO, EEX, Green Truck P/ship, SCLAA, SAFC, etc.)	Government	Short
8. Aggregate transport energy efficiency information in a single location (e.g. US Trucking Efficiency website)	Government/ industry	Short
9. Develop resources to fill gaps, including assessing the need for an integrating Green Freight program (G20 commitment)	Government/ industry	Short
10. Roll out support initiatives (e.g. benchmarking, data tools, direct support service, etc.)	Government/ industry	Short-medium
11. Pilot, promotion and accreditation of energy audit standard (esp. non-EEO fleets)	Industry/ government	Short
12. Align and link programs at various levels (Section 9.4)	See Section 9.4	Short-medium
13. Establish a technology trial program for the rail sector	Industry/ government	Short-medium
14. Support energy management skills training for operators and managers in all modes, via T&L Industry Skills Council	Government/ industry	Medium
15. Support ITS knowledge development to assist innovation and take-up in freight sector	Government/ industry	Short

9.3 Improving the business case

Actions/activities to support the theme	Responsibility	Timeframe
16. Infrastructure to support mode shift equalisation (<i>e.g. coastal ro-ro and containerised wharf and rail facilities, port shuttles, rail payload capacity increases</i>)	Government/ industry	Short-long
17. Establish an effective carbon pricing mechanism	Government	Medium
18. Establish differential rego/transfer fees based on efficiency of trucks, differentiated port fees for efficient ships	Government (states)	Medium-long
19. Re-establish a fixed excise advantage for alternative fuels	Government (federal)	Medium
20. Revenue-neutral incentives for accelerated retirement of older vehicles (<i>e.g. TIC truck plan, ARA fleet plan</i>)	Government (federal)	Short-medium
21. Recognition or accreditation scheme for fleet operations (<i>link to Green Freight program and state government programs, or voluntary component of existing industry programs, i.e. TruckSafe, RightShip</i>)	Industry/ government	Short-medium
22. Revitalisation scheme for new-gen local auto manufacturing (including incentives for purchase of clean technology vehicles)	Government (state & federal)	Short-medium
23. Full cost-reflective road pricing (including congestion charging) to encourage mode shift (aligned with other justifications)	Government	Medium-Long
24. Investigate options for internal carbon pricing	Industry	Short
25. Freight customers lead change with incentives for best practice smaller operators (<i>not penalise with lower rates</i>)	Industry (government support?)	Short
26. Assistance for renewable fuels: refuelling networks for electric recharging, hydrogen, biofuels, including at intermodal hubs/ports/DCs, shore power for ships at berth	Industry/ government	Medium
27. Government purchasing/contracting policy for clean energy buses, waste vehicles	Governments	Short
28. Specific mode shift incentive schemes	Governments	Short
29. Introduce Port Connectivity Index to guide investment in connecting infrastructure, promote port competition	Governments	Short

9.4 Linking, alignment and harmonisation

Actions/activities to support the theme	Responsibility	Timeframe
30. Integrate transport into energy policy (and vice-versa)	All government	Short-medium
31. Continue and extend interdepartmental coordination of vehicle policy through Ministerial Forum on vehicle emissions (potentially expand to cover access/utilisation)	Government (federal)	Short
32. Extend or create new business energy schemes to include transport (e.g. NSW Energy Saver, Vic Energy Assessment Grants)	Government (states)	Short
33. Support national vision/target with state policies for low emission vehicles and alternative transport fuels (Section 9.1)	Government (states)	Medium
34. Ensure 2017 ERF and IEA reviews of energy policies assess how transport can be better included	Government (federal)	Short
35. Include metrics and hurdles for energy productivity into infrastructure investment criteria	Governments	Short
36. Link classification scheme with benchmarks, ratings, green freight program, recognition and incentives	Governments/industry	Short-medium
37. Review regulatory frameworks to ensure regulations, standards and accreditation systems support/enable the take-up of new technologies	Governments/industry	Short-medium
38. Establish a voluntary Green Freight program similar to SmartWay (measure, benchmark, improve, verify). Link with action 22 and/or 2xEP Challenge.	Governments/industry	Short-medium
39. Link land use planning priorities of national and state infrastructure plans with strategies for freight hub and corridor development	Governments	Short
40. Link government actions supporting 2xEP pathways to existing industry initiatives, i.e. Australian Centre for Rail Innovation, Green Truck Partnership, Shipping Australia/Maritime Industry Australia	Governments	Short
41. Continue harmonisation of national regulations via NHVR	Government	Short-medium
42. Investigate possibility of permitting overseas length/width compliant trucks/trains, even if only specific route based	Government	Medium
43. Assess extent of compatibility of Australian fleet with US fuel efficiency standards	Government	Short-medium
44. Harmonise rail track designs for network integration and locomotive/equipment standardisation	Government	Medium-long

9.5 Shifting to renewable energy

Actions/activities to support the theme	Responsibility	Timeframe
45. Acknowledge value and pathways of renewable energy in transport (possibly part of strategic vision in Section 9.1)	Government	Short-medium
46. Prioritise renewable energy in funding/investment criteria for government support in transport fuels	Government	Short-medium
47. Support or co-invest in refuelling infrastructure (electric, biofuels, biogas)	Government	Short-medium

9.6 Better energy data

Actions/activities to support the theme	Responsibility	Timeframe
48. Develop comparative efficiency ratings for new heavy vehicles, including pilot scheme	Government/ industry	Short
49. Establish an agreed classification scheme for energy assessment and comparison purposes	Government/ industry	Short
50. Investigate re-introduction of mandatory energy reporting	Governments	Short-medium
51. Establish benchmark data supporting industry improvement	Industry/ government	Short
52. Integrate data under the information initiatives/Green Freight Program in Section 9.2	Government	Short
11. Pilot, promotion and accreditation of energy audit standard (especially non-EEO fleets)	Industry/ government	Short
35. Include metrics and hurdles for energy productivity into infrastructure investment criteria	Governments	Short
53. Industry to work with government to incorporate energy into the National Land Transport Productivity Framework	Government/ industry	Short

9.7 Removing barriers

Actions/activities to support the theme	Responsibility	Timeframe
4. Establish single-point responsibility for transport energy productivity (to align and link programs in Section 9.4)	Government (all)	Short-medium
48. Develop comparative efficiency ratings for new heavy vehicles, including pilot scheme	Government/ industry	Short
23. Full cost-reflective road pricing (including congestion charging) to encourage mode shift	Government	Medium-Long
49. Establish an agreed classification scheme for energy assessment and comparison purposes	Government/ industry	Short

Actions/activities to support the theme	Responsibility	Timeframe
54. Investigate options for introduction of fuel-efficiency standards on heavy vehicles	Government (federal)	Short
55. Remove bottlenecks in HPV route assessments	Governments	Ongoing
56. Expand access for HPVs in congested areas or on specific routes (e.g. NSW SPECTS, larger HPVs on Hume Highway)	Governments	Ongoing
57. Establish a low carbon vehicle partnership modelled on UK scheme to advocate for LEV availability and support	Industry/ government	Short
58. Introduce financial incentives to reduce up-front cost of new vehicles/conversions to clean fuel technology	Governments	Short
59. Extend fuel tax credit to biodiesel blends above B20	Government	Short
60. Flexible mass/dimension limits when using alternative fuels / fuel saving devices (e.g. tyres, aero kits)	Government (federal)	Medium
61. Remove restrictions and compliance costs for international ships to carry domestic freight	Government (federal)	Medium
62. Pilot CBD freight collaboration project trialling ITS for load consolidation, load/delivery zone scheduling, vehicle routing, off-peak hour extensions and last-mile EV delivery	Government/ industry	Short
63. Incorporate requirement for loading dock scheduling into all new commercial developments.	Industry / government	Short
64. Pilot SmartPort collaboration trial of ITS for operations and planning based on Hamburg SmartPort model	Government/ industry	Short
65. Establish driver training accreditation scheme to recognise driver training and link to licensing/insurance	Industry	Short-medium
66. Insurance industry to develop risk-based discount scheme for companies using driver training	Industry	Medium
67. Fuel-efficiency standards for LCVs (part of car standards)	Government	Medium
68. Adopt GS1 EPCIS standard into operations to improve supply chain visibility	Industry	Medium
69. Carriers to work with customers to find routes/consignments suitable for slow steaming	Industry	Short-medium
70. Rail industry collaboration forums to test technologies and reduce empty running	Industry	Short-medium

10 Implementation

The actions proposed in this roadmap combine short, medium and long-term measures, with responsibilities shared between industry, government and industry associations. The timing and allocation of actions is summarised in Figure 10.1.

The detailed actions in Section 9, and the implementation summary below, do not dictate how specific measures should be implemented. It is assumed that responsible parties are best placed to judge how their organisation or sector can effect the changes intended by the nominated actions, within the context of their own personnel, resources and leadership.

What is clear is that the distributed responsibility for transport and the nature of the sector itself will require better collaboration and coordination: between industry and government, between state and federal levels of government, and between departments and agencies at each level of government.

10.1 Priority recommendations

It is well understood that not all measures from Section 9 will be implemented, or that some will be favoured by different stakeholders. After all, there is likely to be significant change in political will and ideology within the period covered by this roadmap, involving at least five elections in each state and at federal level.

Given the large number of measures identified, and the likelihood that not all actions will be implemented, the working group was asked to prioritise specific measures that their organisation and industry sector (road, rail, shipping) saw as high-priority initiatives. Criteria for identifying these high priority measures included the extent of likely energy savings, the likely contribution to energy productivity through non-energy benefits and the likely difficulty of implementation.

The resulting priority areas are summarised in Table 10.1 for general priorities (all modes), and in Table 10.2 by transport mode. In addition, specific actions from Section 9 that support these priority areas are listed in the tables with their corresponding number.

	Actions			
				
 Strategic vision for transport	1		4	
 Enabling industry to improve	8		1	
 Improving the business case	3		9	2
 Linking, alignment & harmonisation	3		12	
 Fuel shift to renewable energy			3	
 Better energy data	4		3	
 Removing barriers	6		9	5

Figure 10.1

Implementation summary with relative allocation of actions to responsible parties, and broad timing expectations for the pathways

Table 10.1 Priority areas covering all modes

Working Group priority areas	Actions	
Setting EP targets	<div style="text-align: center; border: 1px solid black; padding: 5px; margin-bottom: 10px;">  Government </div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>1: Strategic vision</p> <p>2: Formulate supporting policy</p> <p>4: Single point resp. for transport EP</p> <p>5: Integrate NLFS & NPS</p> </div> <div style="width: 45%;"> <p>33: State targets</p> <p>35: EP metrics in infrastructure</p> <p>40: Link government actions</p> </div> </div>	
Promotion / information / assistance of best practice	<div style="text-align: center; border: 1px solid black; padding: 5px; margin-bottom: 10px;">  Joint </div> <p>6: Facilitating CDP-GRI-DJSI</p> <p>8: Aggregated info portal</p> <p>9: Resources to fill gaps</p> <p>10: Roll out support initiatives</p> <p>11: Pilot energy audit standards</p> <p>12: Align and link programs</p> <p>15: Support ITS knowledge</p> <p>16: Mode shift equalisation</p> <p>21: Recognition scheme</p> <p>37: Review reg framework</p> <p>49: Agreed assess. classification</p> <p>51: Benchmark data</p>	<div style="text-align: center; border: 1px solid black; padding: 5px; margin-bottom: 10px;">  Government </div> <p>30: Integrate into energy policy</p> <p>39: Link land use planning</p> <p>50: Investigate mandatory reporting</p> <p>52: Integrate info initiatives</p> <div style="text-align: center; border: 1px solid black; padding: 5px; margin: 10px 0;">  Industry </div> <p>25: Freight customer best practice</p> <p>68: GS1 EPCIS</p>
Incentives to purchase efficient vehicles	<div style="text-align: center; border: 1px solid black; padding: 5px; margin-bottom: 10px;">  Joint </div> <p>12: Align and link programs</p> <p>22: Revitalisation local manufacture</p> <p>36: Link classification scheme</p> <p>48: Efficiency ratings</p> <p>57: Low carb vehicle partnership</p>	<div style="text-align: center; border: 1px solid black; padding: 5px; margin-bottom: 10px;">  Government </div> <p>18: Feebate systems</p> <p>19: Alt fuels excise</p> <p>20: Old vehicle retirement</p> <p>23: Cost-reflective road pricing</p> <p>27: Government purchasing</p> <p>28: Mode-shift schemes</p> <p>34: Transport in ERF IEA reviews</p> <p>47: Refuelling infrastructure</p> <p>58: Reduce up-front cost</p>

Table 10.2 Specific priority areas for each mode

Mode	Working Group priority areas	Responsible	Actions
Road 	Increased use of high productivity vehicles (HPV)		41: NHVR harmonisation 42: International compliance 55: Remove HPV bottleneck 56: HPV access
	Mandatory fuel efficiency standards for LCV		43: US fuel eff standards 67: LCV fuel eff standards
	Driver training programs		65: Driver training accreditation 66: Insurance discount
	Last mile access		62: CBD trial
	Allowing more night freight delivery		63: Loading dock scheduling
	Information and assistance for smaller carriers		12: Align and link programs 25: Freight customer best practice
Rail 	Heavy vehicle charging reform (road charging)		23: Cost-reflective road pricing 28: Mode-shift incentive
	Technology demonstration program		13: Technology trial
	Collaboration forums		70: Collaboration forums
Shipping 	Slow steaming		69: Slow steaming routes

10.2 Next steps

The 2xEP freight working group will continue work to progress the industry-based actions with members of the group and the wider freight industry, including industry associations. Meanwhile, A2EP will support this with continued engagement, collaboration and advocacy at state and Commonwealth Government levels, to at least establish single point responsibility for all transport energy productivity.

The next stages of work will involve two main activities. Firstly, this draft roadmap will be distributed to relevant stakeholders for their views and comments, with key suggestions incorporated into a final version to be placed on the 2xEP website.

Secondly, actions will be reviewed to better integrate specific freight measures—especially those for road freight, mode shift and enabling industry—into the NEPP framework. This is the main mechanism by which government can commit to supporting and implementing the changes required to improve freight energy productivity.

Appendix A

2xEP Steering committee and working group members

2xEP Steering Committee

The 2xEP Steering Committee was inaugurated in July of 2015 and is tasked with guiding the program through development and completion. The Committee meets quarterly to review progress, refine strategy, and provide leadership. Most Steering Group members are involved in one or more of the sector working groups.

Kenneth Baldwin, Director, Energy Change Institute, Australian National University
Matthew Brown, Environmental Manager, Pacific National
Graham Bryant, Deputy Chair, Energy Users Association of Australia
Tony Cooper, Chief Executive Officer, Energetics
Bo Christensen, Manager Sustainability, Linfox
David Eyre, General Manager, Research & Development, NSW Farmers
Chris Greig, Fellow, Australian Academy of Technology, Sciences and Engineering
Tim Hicks, Senior Manager, Economic Policy, Australian Chamber of Commerce and Industry
Travis Hughes, Head of Energy Services, AGL Energy
Jonathan Jutsen, Deputy Chairman, Australian Alliance for Energy Productivity
Andrew Lamble, Co-Founder and Chief Operating Officer, Envizi
Adam Lovell, Executive Director, Water Supply Association of Australia
Luke Menzel, Chief Executive Officer, Energy Efficiency Council
Sid Marris, Director – Industry Policy, Minerals Council of Australia
Brian Morris, Vice President, Energy & Sustainability Services, Schneider Electric
Matt Mullins, Chairman, Advisory Board, Resource Governance International
Gordon Noble, Managing Director, Inflection Point Capital
Andrew Peterson, Chief Executive Officer, Sustainable Business Australia
Glenn Platt, Group Leader, Energy Technology, CSIRO
Tennant Reed, Principal National Adviser – Public Policy, AiGroup
Duncan Sheppard, Director Communications and Policy, Australian Logistics Council
Anna Skarbek, Executive Director, ClimateWorks Australia
Scott Taylor, Head of Living Utilities, Lend Lease
Kane Thornton, Chief Executive Officer, Clean Energy Council
Suzanne Toumbourou, Executive Officer, Australian Sustainable Built Environment Council
Laura Van Wie McGrory, Vice President, International Policy, US Alliance to Save Energy
Stephen White, Energy for Buildings Manager, CSIRO
Stuart White, Director, Institute for Sustainable Futures
Bruce Wilson, Syndicate Chair, CEO Institute, Transport specialist
Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation

2xEP is supported by 10 working groups; for each key end use sector of the economy plus finance, innovation, metrics and communications.

Freight Transport Working Group

Matthew Brown, Environmental Business Partner, Pacific National

Bo Christensen, Manager Sustainability, Linfox Logistics

David Coleman, Clean Transport Action

Albert Dessi, Department of Environment

Angus Draheim, ADC Consulting

Scott Ferraro, Head of Implementation, ClimateWorks Australia

Mark Gjerek (Group Coordinator) Principal, MOV3MENT

Jordan Groeneveld, Manager Sustainability, Aurizon

John Harvison, Group Manager, Environment and Sustainability, Asciano

Jonathan Jutsen, A2EP

Ro Mueller & Chris Loose, Technical Manager, Australian Trucking Association

Nick Prescott, Group GM, Environment and Energy, Toll Group

Ximena Ramirez-Moya, Department of Environment

Duncan Sheppard, Director Communications and Policy, Australian Logistics Council

Appendix B

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