

Future directions 2030

*A roadmap for the Australian
LPG vehicle industry*



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1 Introduction

The Australian transport energy sector is facing an unprecedented period of market dynamism, which is characterised by changing market and public policy responses to two national strategic imperatives.

The first imperative relates to growing uncertainty surrounding the outlook for the supply of affordable transport energy that is sufficient to meet Australia's needs to 2030 and beyond.

The second imperative is associated with Australia's aspirations (and international obligations) to reduce its GHG emissions in an effort to reduce the adverse impacts of climate change on human settlement.

Within the context of these two imperatives, the Australian LPG industry has recognised that there is a need to reconsider its future directions and the new market opportunities being created by the commercialisation and market entry of advanced LPG vehicle technologies.

Essentially, the Australian LPG vehicle industry has reached a watershed in its 30-year evolution. The industry must now decide whether to continue an almost sole focus on the conversion of older in-service vehicles, or expand its focus to accelerate the market entry of advanced LPG technologies and new purpose-built LPG vehicles.

In considering this decision, the industry must take due account of both the transitional risks associated with any change, and the market perception issues that have been created by the past operation of the LPG vehicles market.

Any new direction will therefore require maintenance of the industry capacity that has already been developed, and the reinvigoration of consumer perceptions beyond LPG being merely a 'cheap alternative fuel for older vehicles and taxis'.

This paper is intended to provide the reader with an:

- understanding of the wider strategic context in which the LPG vehicle industry is operating;
- indication of the potential community dividends associated with increased use of LPG in Australia's light vehicle fleet;
- appreciation of the strategic directions that will be pursued by the Australian LPG vehicle industry over the next 20 years in order to realise the potential industry and community benefits.

Papers of this nature can always be criticised for self-promotion and protection of industry self-interest. Mindful of this, LPG Australia has erred on the side of conservatism in estimating likely community benefits and has sought to complement this discussion with a full and frank assessment of the current challenges facing the industry in delivering these benefits.

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2 Strategic context

2.1 The energy security imperative

A recent report by the Department of Resources, Energy and Tourism describes energy security in an Australian context as ‘the adequate, reliable and affordable supply of energy to support the functioning of the economy and social development’ (DRET 2009).

Australia’s oil self-sufficiency has been declining rapidly over the past decade due to the combined effect of dwindling domestic production and rising demand. Even with supplementation of resources from known domestic alternatives, 70% of Australia’s transport energy demand is expected to come from imports by 2030 (Figure 1). The projected cost is expected to climb from \$20 billion to \$100 billion per year, leading to a

significant imbalance of trade. This looming fall in self-sufficiency is likely to be triggered by the fact that:

- Australia’s demand for oil is predicted to increase by 50% between 2000 and 2030 (ACIL Tasman et al. 2009);
- national oil production is simultaneously forecast to decline sharply;
- within the Australian transport sector, annual demand for transport energy could rise by as much as 35% by 2030 – from around 345 million barrels of oil equivalent in 2007, to more than 470 million barrels of oil equivalent by 2030 (ACIL Tasman et al. 2009).

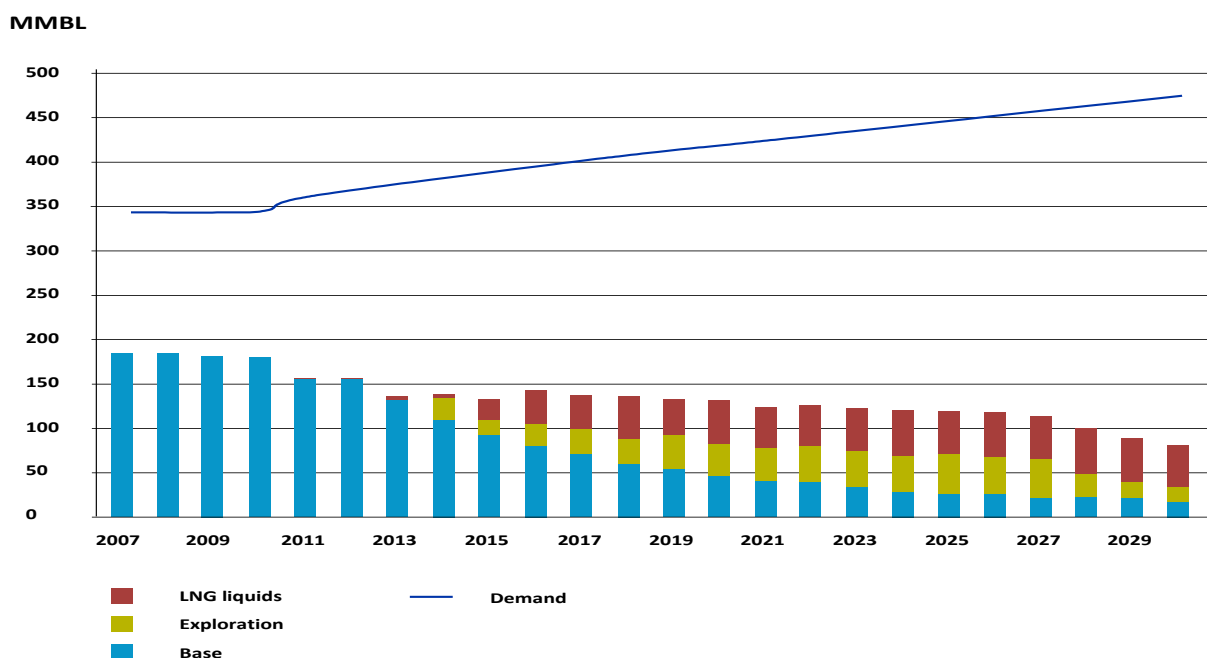


Figure 1 Projected deficit between transport energy demand and supply to 2030 (EnergyQuest 2009)

If the global oil outlook is one that is characterised by abundant and affordable oil-based fuels, this decline in oil self-sufficiency is in itself not necessarily a cause for alarm.

Unfortunately, the outlook for the affordable supply of conventional fuels is characterised by a high level of uncertainty and strong suggestions that global oil-based fuels are likely to be increasingly scarce over the next 20 years, with significant risk of dramatic cost increases. The magnitude of this decline in oil self-sufficiency

begs the question ‘how will Australia manage its economy in the face of a looming transport energy deficit?’.

The net effect of this significant decline in Australia’s national oil self-sufficiency suggests reduced transport fuel independence; increased vulnerability to fuel supply interruption; decreased competitiveness of Australian business and industry; and price flow-on effects in terms of the cost of goods and services for Australian consumers.

2.2 The greenhouse imperative

Under a business as usual (BAU) scenario, Australia’s GHG emissions are predicted to double by 2050 (Treasury 2008). After stationary energy and agriculture, transport is the third largest contributor to Australia’s GHG emissions, accounting for around 14% of all GHG emissions in 2008 (DCC 2010).

In the Australian domestic transport sector, emissions grew by 16.8% in the ten years from 1997–98 to 2007–08 (CTEE 2010).

Road transport is currently (and is expected to remain) the most significant source of GHG emissions in the Australian transport sector. In 2007–2008 it accounted for 84% of GHG emissions, with annual emissions projected to grow by 12.5% by 2017–2018 (CTEE 2010) (Table 1).

In light of the above, the role of alternative fuels in fulfilling Australia’s international obligations to reduce GHG emissions, and improving the outlook for energy security, should also be considered (Figure 2).

Table 1 Transport sector GHG emissions (Apelbaum 2008)

Transport mode (domestic)	Emissions 2005–06 ('000 tonnes CO ₂ -e)	Projected emissions 2015–16 ('000 tonnes CO ₂ -e)	Projected GHG emissions 2025–26
Road	83,313	97,476.2	114,047.2
Rail	4,536.3	5,533.9	6,751.4
Sea	1,834.6	1,911.0	1,991.3
Air	8,245.9	11,996.5	17,454.9
All modes	97,929.9	116,917.6	140,244.7

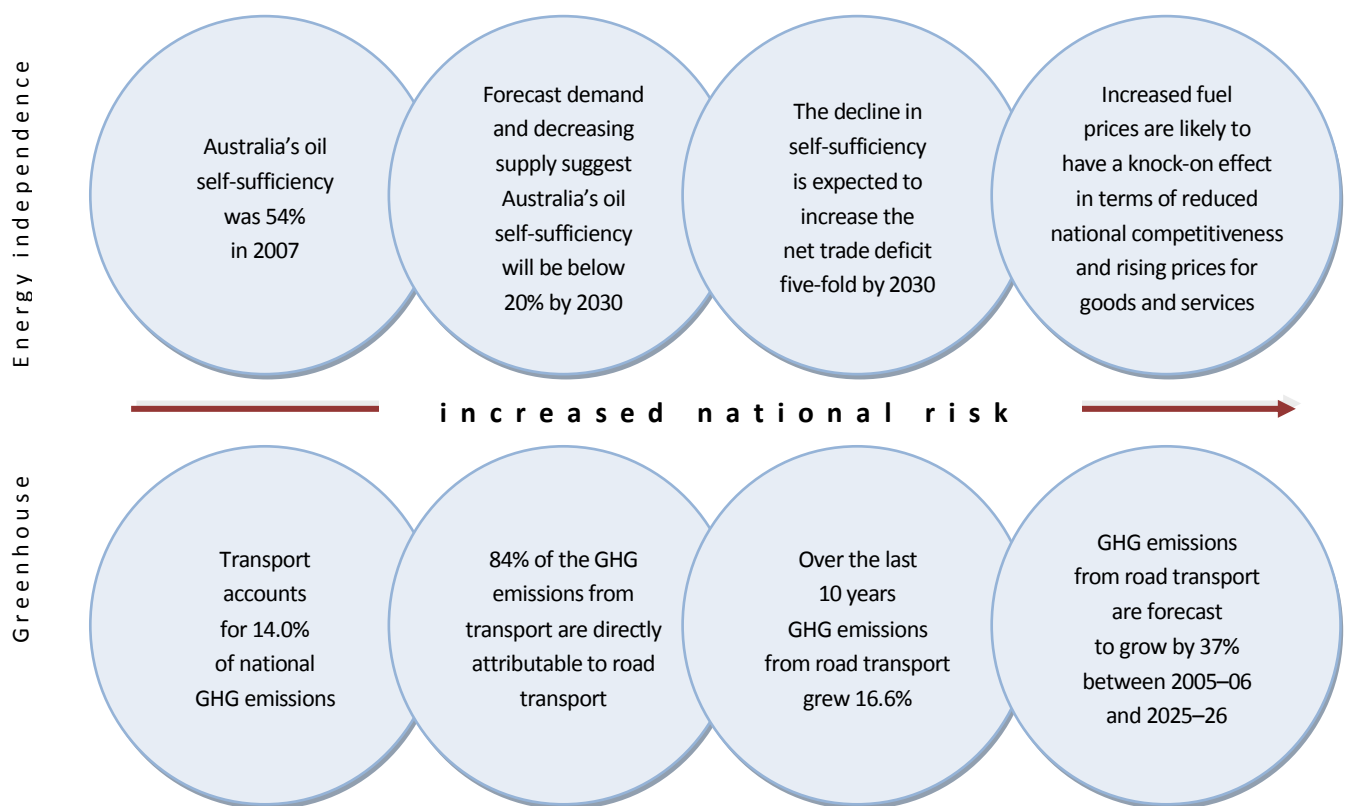


Figure 2 **Dual imperatives for action at a national level**

2.3 The role for alternative fuels (including LPG)

In the past, Australia's transport fleet has been almost entirely dependent on GHG-intensive conventional oil-based fuels, which are increasingly sourced from imports. When considered on an energy basis, these fuels produce the most GHG emissions when combusted.

As shown in Figure 3, analysis of the projected fuel mix to 2030 forecasts significant growth in annual diesel demand, and hence diesel imports. It can also be seen that there is a significant increase in LPG production with the expansion of LNG projects from 2013. Although there is some uncertainty surrounding the projected consumption of both traditional and Autogas LPG, there remains a significant projected surplus of

LPG. Given Australia's forecast reliance on imported fuels and the projected increase in GHG emissions from the transport sector, alternative fuels represent an attractive opportunity to reduce the degree to which these occur.

Enhancing the position of alternative fuels in the Australian market can play a role in offsetting the increasing level of diesel (and other fuel) imports and subsequent risk to Australia's energy independence. In addition, a number of alternative fuels represent an opportunity to reduce Australia's transport sector GHG emissions when considered on a life cycle basis.

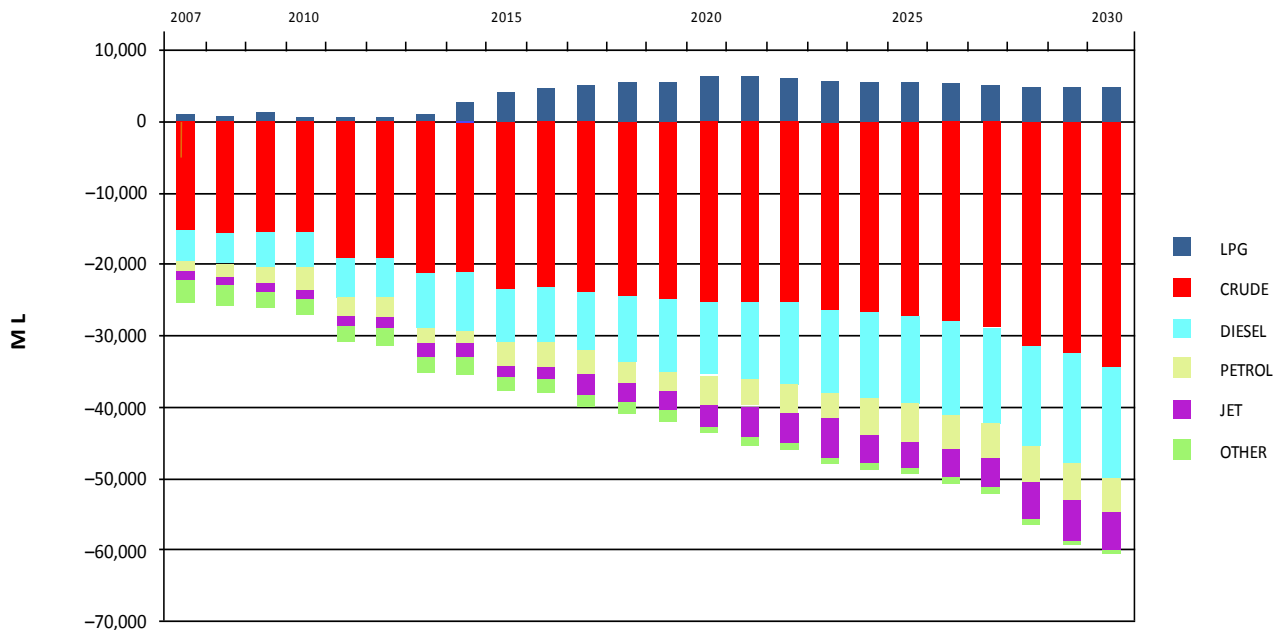


Figure 3 Forecast Australian crude oil and product imports (Energy Quest 2009)

2.4 The automotive and component industry

The automotive industry in Australia is a significant contributor to the manufacturing sector, and the Australian economy. The industry represents around 6% of Australia's total value added manufacturing and contributes around 1% of national gross domestic product. It includes the retail, service and repair sectors of the industry, and is estimated to produce more than \$50 billion in annual turnover and employment for over 400,000 people (FCAI 2008).

The industry comprises three key segments:

- **Motor vehicle manufacturing:** three Australian-based manufacturers employing over 60,000 people.
- **Component producers:** more than 200 organisations producing automotive

components, and approximately 500 firms supporting these organisations and their tooling requirements.

- **Retail, service and repair:** employing around 300,000 people, includes vehicle repair and maintenance as well as supply of aftermarket equipment (FCAI 2008).

Importantly, Australia's automotive industry is a key source of investment in R&D, accounting for more than 20% of R&D undertaken by the manufacturing sector and forming the single highest sector for R&D expenditure (ABS 2010). This has led to the industry being recognised globally for its engineering and design capacity, and its key role in Australia's ability to innovate.

In 2007, the automotive industry in Australia sought to increase its export business. At that time, Australian vehicle manufacturers exported over 40% of domestic vehicle production to global markets, and the industry constituted the single greatest export market for Australia, behind only mining products (FCAI 2008).

However, since 2007 this strong export market has experienced significant decline, with exports of passenger vehicles falling more than 20% between 2007–2008, and close to 60% from 2008–2009 (DFAT 2009). Although there is significant potential for the industry to capitalise on its strong grounding and global recognition, there is a need to reverse the decline of recent years by repositioning and improving the industry in the short term.

3 Why LPG?

Consideration of the issues in Section 2 presents three key strategic insights:

1. Australia faces a looming transport fuel deficit and increased reliance on imported fuels.
2. The road transport sector in Australia is likely to pose significant challenges to Australia's aspirations to reduce GHG emissions.
3. The automotive industry represents a significant contributor to the Australian economy that has suffered a recent decline.

This section considers the role of LPG in responding to the challenges presented above, and the opportunity presented by increasing the market uptake of LPG technologies and fuel in the transport sector.

3.1 An indigenous fuel

With abundant supplies of LPG, Australia has a significant opportunity to increase the role of LPG within the transport sector. The forecast increase in LNG production from 2013 (Figure 4), will reduce Australia's reliance on imported liquid fuels.

Domestic supply of LPG is expected to exceed 6500 kilotonnes by 2018, while domestic demand (under a BAU scenario) is not expected to exceed 2000 kilotonnes – suggesting a net surplus of around 4500 kilotonnes (LPGA 2008). In addition, naturally occurring reserves are able to continue to meet the domestic needs beyond 2030, even with increases in demand beyond BAU (Anyon 2003).

Indeed, even with no further increases in LPG production capacity from 2020, there is still the potential to meet a 200% increase in domestic LPG demand by 2030. The projected consumption of both traditional and Autogas LPG is likely to reduce the LPG surplus by up to 15% between 2020 and 2030.

While the above supply/demand outlook illustrates the potential role of LPG in reducing Australia's dependence on foreign transport fuels, it is important to consider this role in light of the ongoing debate surrounding other alternative fuels available to the market. Figure 5 illustrates the characteristics of fuels currently being promoted as alternatives to petrol in the Australian light vehicle road transport market.

A number of fuels present an opportunity to capitalise on Australia's indigenous fuel resources. However, as shown, very few also constitute a greenhouse-positive alternative to petrol. In light of the greater global focus on climate change, this is a key consideration in the alternative fuels debate and one that is well-addressed by LPG.

Why LPG?

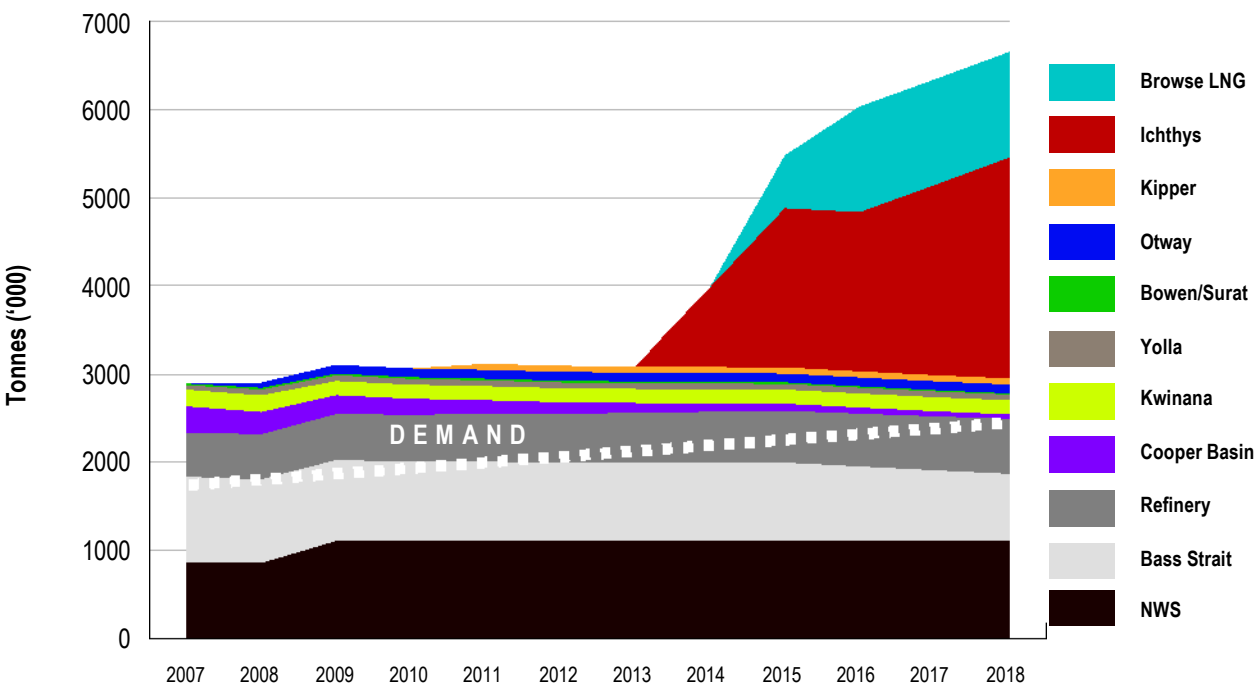


Figure 4 Australian forecast LPG production from fields and refineries to 2018 (LPGA 2010)

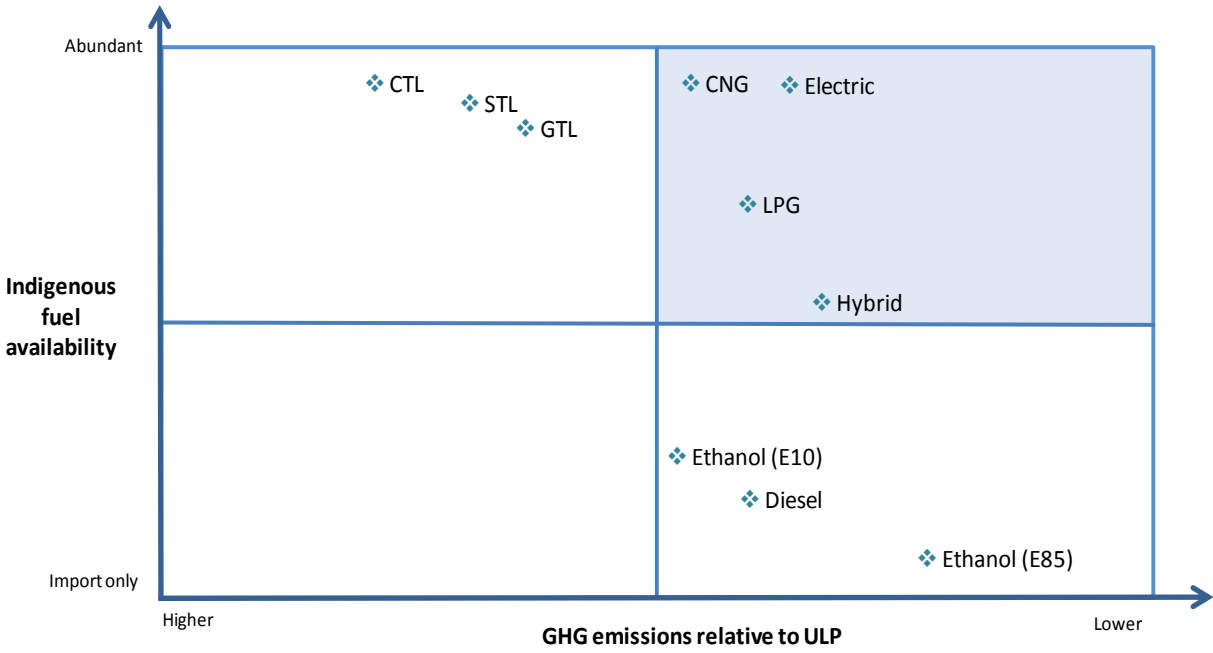


Figure 5 Indigenous availability and GHG emissions of alternative fuels relative to petrol

3.2 A greenhouse-positive solution

When considered on a life cycle basis, LPG powered vehicles deliver a GHG reduction relative to petrol, both now and into the future, with the optimisation of engine technologies (Figure 6).

The use of LPG in lieu of ULP in passenger vehicles in Australia is likely to decrease GHG emissions by approximately 13% over the full life cycle, based on current fuel supply and engine technologies. Looking forward, the carbon benefit offered by LPG as a transport fuel has the potential to grow as indigenous supplies become increasingly focused on natural gas fields (as opposed to refinery-sourced LPG) and as the emissions from production are reduced.

Forecasts suggest that LPG extracted from natural gas (GHG intensity of 0.186 kg CO₂-e per kilogram LPG produced) is likely to double over the next ten years, while LPG from refineries (0.364 kg CO₂-e per kilogram) is projected to remain static or decline slightly (LPGA 2008). The net effect of this increase in gas field sourced LPG, as well as the optimisation of LPG technologies, is shown in Table 2.

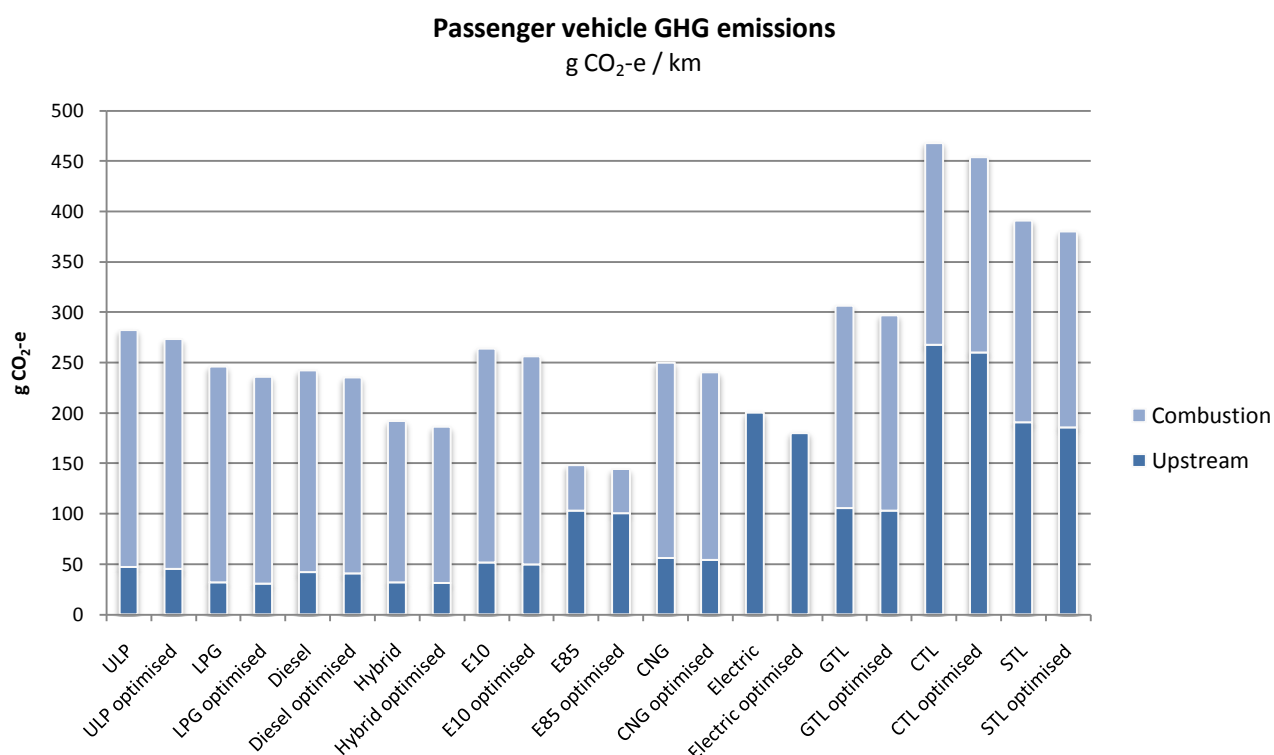


Figure 6 Carbon intensity of an Australian passenger vehicle

Table 2 Potential increase in LPG carbon benefit over petrol to 2020

Fuel	Life cycle emissions (g CO ₂ -e/km)	LPG GHG benefit over today's ULP (%)
ULP	282	–
LPG (2010)	246	13
LPG (2020)	239	15
LPG (2020) <i>optimised engine technology</i>	229	19

3.3 A market-ready alternative

LPG stands alongside a number of alternative fuels in terms of domestic availability and GHG positive outcomes (Figure 5). However, there are a number of significant barriers surrounding the availability and cost to the consumer of alternatives to petrol that have received considerable attention in recent years, namely that these alternative fuels are either awaiting significant advances in technology, or their current market offerings exclude the majority of the light duty vehicle consumer market due to price (Figure 7).

As shown in Figure 7, LPG is one of three fuels that have the technology and vehicles available to the market for ready deployment, and that also do not have prohibitively high costs associated with their use.

In addition, the necessary infrastructure and service force is in place to deliver the support to an increased uptake of LPG vehicles. The refuelling network for LPG is in place (although it is subject to some issues associated with a lack of modernisation), and vehicle servicing is widely available.

This suggests that the short-term replacement of petrol vehicles in Australia would not be heavily restricted by a lack of access to the necessary infrastructure by consumers (as is the case with a number of other alternatives to petrol).

Why LPG?

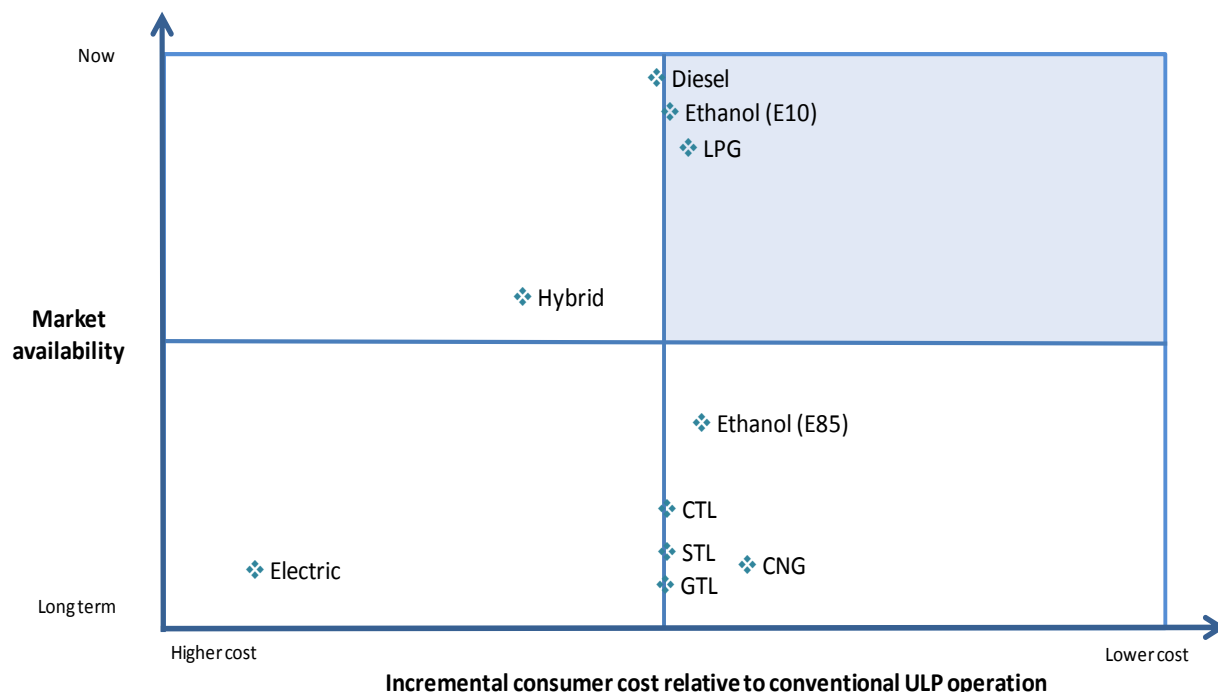


Figure 7 **Market availability and incremental cost of alternative fuels relative to petrol**

3.4 A vibrant industry

The LPG industry in Australia is a significant contributor to the domestic economy. As well as supporting a network of manufacturers, component producers and maintenance facilities, the industry forms a key component of Australia's innovation community, with globally recognised advances in vehicle technology.

When compared with other alternative fuel industries, there is relatively strong potential to work off the existing base of advanced knowledge and global market credibility held by the LPG

industry by promoting the continued development of LPG vehicle technologies in Australia. The revitalisation of the industry is likely to bring short- and long-term benefits to the Australian economy, in terms of both job growth and international recognition of the domestic automotive and components industry.

3.5 Potential community dividends

The primary strategic objective of this roadmap is to enable the realisation of the economic and community dividends of increased LPG use. The main areas where benefits will be realised are:

- balance of trade benefits (owing to avoided importation of oil);
- reduction of Australia's transport sector GHG emissions;
- benefits of an affordable fuel to Australian households;
- revitalising the Australian automotive industry.

The degree to which these benefits are realised will be dependent on the ability to increase the market share of LPG in Australia's light duty fuel mix. Based on existing forecasts (LPG reference scenario developed by Rare [2010b]) the LPG Autogas industry faces a significant challenge in maintaining existing market share in the light duty fuel mix, unless barriers to market adoption can be adequately addressed. In the short term the removal of the LPG vehicle scheme rebate and imposition of excise will dramatically reduce growth in the LPG vehicle fleet.

Without support, it is likely that LPG use in the light duty vehicle fleet will decline to around 6% by 2030. This estimate is driven by the following principal observations.

- LPG fumigation systems will continue to be the predominant technology used owing to their lower overall cost (and absence of the rebate).
- The attractiveness of LPG fumigation systems relative to emerging alternative fuels, such as electric vehicles and petrol-electric hybrids, will be reduced.

- LPG will remain price competitive relative to petrol following the imposition of excise.
- There will be limited OEM product availability.

Performance uncertainty, market relevance and legislative uncertainty are significant barriers that inhibit LPG growth in the market. Performance uncertainty has been driven by variability in conversion standards and LPG engine technologies, while market relevance has suffered due to the increased profile of competing technologies (e.g. hybrids) and poor consumer knowledge regarding performance, safety, cost and environmental benefits. Legislative uncertainty with excise has only recently featured in the decision making of fleet and private buyers.

In recognition of these barriers, there are two clear strategies that can be pursued independently to increase the market share of LPG in Australia's light duty fuel mix beyond 6% in 2030. An expected LPG uptake scenario has been developed for each strategy. The first scenario represents LPG achieving approximately 10% of market share through support of OEM LPG sales. The second scenario corresponds to an extended transition to full excise, but delivers only a short-term impact with virtually no difference in the 2030 fuel mix.

Scenario 1: Increased production of new factory-fit LPG vehicles

For the purpose of understanding what the maximum potential uptake of LPG might be to 2030, an improved technology scenario was applied to the reference case. This involved adjusting the likely adoption of new (OEM) LPG vehicles on the assumption that more efficient LPG systems would become available (for both six-cylinder and four-cylinder vehicles) providing performance certainty and greater market appeal

Why LPG?

for LPG vehicles. A level of increased support for local production of more advanced LPG systems has also been assumed in this scenario.

Scenario 2: Extended excise transition

A further scenario was modelled to investigate the likely effect of adopting a longer phase-in period for introducing excise tax on LPG. This scenario was intended to represent the increased market confidence in the legislative impact of excise. The scenario relates to smaller annual increments of 1.25 cpl rather than 2.5 cpl that would be used to stretch the timeframe to full imposition of excise to 10 years in line with the proposed tax treatment of ethanol.

Comparison of market scenarios

The associated impact of each scenario on the LPG market share by 2030 is illustrated in Figure 8, in comparison to the BAU (reference) scenario. Based on these scenarios, an expected increase in the market share of LPG from 6% to 10% has been used to understand the additional economic and community benefits realised beyond BAU.

Balance of trade benefits

(owing to avoided importation of oil)

Replacement of imported oil with domestically produced LPG delivers significant economic benefits to an economy where the cost of LPG is likely to be cheaper than oil when considered on a petrol litre equivalent basis. This saving represents a net economic benefit that is realised in terms of the reduced unit cost of the energy consumed to support the national transport task.

The expected net economic return to the economy that accrues from the energy independence benefit of using LPG Autogas can be determined using the amount of avoided oil use, expected price of imported oil and the opportunity cost of reduced LPG exports.

The expected improvement in the balance of trade was calculated based on the increased consumption of LPG needed to achieve a market share of 10% in 2030. The energy independence benefits associated with the increased use of LPG are described below.

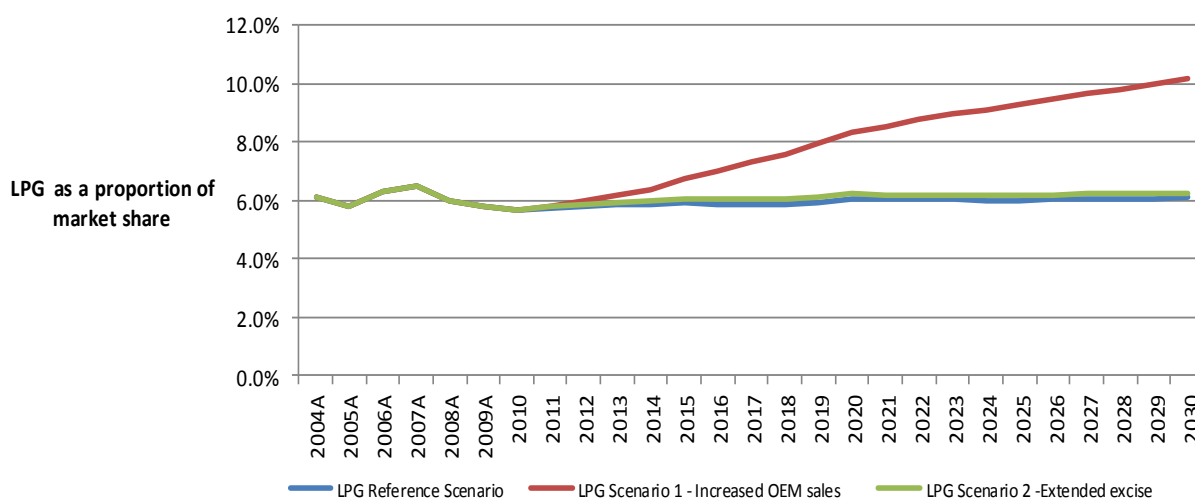


Figure 8 Expected market share of LPG in the light duty fuel mix to 2030

Why LPG?

Avoided oil use

The total avoided oil consumption can be calculated using the petrol litre equivalent of the additional LPG consumption from 2010 to 2030. An assumption of 140 litres of petrol per barrel of oil was assumed based on the energy equivalence of a barrel of oil (note that the Australian refining process produces approximately 70 litres of petrol per barrel of oil and will vary depending on type and production methods).

The value of oil imports offset over the period 2010–2030 was calculated using an expected oil price trajectory obtained from the International Energy Outlook 2010 (EIA 2010). Based on this trajectory, oil prices are expected to reach \$124 per barrel in 2030.

The opportunity cost of reduced LPG exports was based on the 12-month average Saudi Aramco contract LPG price in 2009 (34.7 cpl) adjusted with an annual price escalation of 3% to estimate an LPG price of 65 cpl in 2030.

Net trade deficit improvement

An increase in the market share of LPG from 6% to 10% in 2030 is likely to reduce total cumulative petrol consumption by 14,300 ML (or approximately 100 million barrels of oil) by 2030.

Analysis of the net trade deficit improvement in this period is around \$3.8 billion based on the above increase in the market share of LPG. The reduction in the value of oil imports over this period is approximately \$11.6 billion which is offset by an expected \$7.6 billion reduction in LPG exports (2010 dollars).

Table 3 Net change in trade deficit for increased use of LPG

Fuel	Net improvement in trade deficit 2010 (\$m)	Net improvement in trade deficit 2020 (\$m)	Net improvement in trade deficit 2030 (\$m)	Cumulative improvement in trade deficit from 2010–2030 (\$m)
BAU (6% fuel mix in 2030)	355.5	566.4	496.6	9925.2
Accelerated LPG uptake (10% fuel mix in 2030)	355.5	780.1	825.2	13719.8
Additional trade deficit improvement achievable with industry support	0	213.7	328.5	3794.6

Why LPG?

Reduction of Australia's transport sector GHG emissions

In Australia, the use of LPG in lieu of ULP is likely to decrease GHG emissions by approximately 13% over the full life cycle, based on current fuel supply and engine technologies. This represents a

greenhouse saving of approximately 370 g CO₂-e per litre of petrol avoided. Based on a reduction of total petrol consumption by 14,300 ML, the full life cycle greenhouse savings associated with increased LPG use will be approximately 5.3 million tonnes CO₂-e in the period 2010–2030.

Table 4 Net change in GHG emissions for increased use of LPG to 2030

Fuel	Annual GHG savings in 2010 ('000 t CO ₂ -e)	Annual GHG savings in 2020 ('000 t CO ₂ -e)	Annual GHG savings in 2030 ('000 t CO ₂ -e)	Cumulative GHG savings from 2010–2030 ('000 t CO ₂ -e)
BAU (6% fuel mix in 2030)	527,030	720,440	765,540	14,293,650
Accelerated LPG uptake (10% fuel mix in 2030)	527,030	992,230	1,271,920	19,588,420
Additional GHG savings achievable with industry support	0	272,790	506,380	5,294,770

Assuming an LPG vehicle life of 10 years (average of both new and existing vehicle conversions), and annual LPG consumption of approximately 3000 litres, the expected greenhouse savings from using LPG compared to petrol over the life of an LPG vehicle is approximately 8.5 tonnes.

Indeed, the expansion of the LPG vehicle fleet in lieu of ULP vehicles allows for a greater increase in the total passenger vehicle fleet numbers for no net greenhouse penalty. To illustrate, for a total projected fleet growth of 500,000 ULP vehicles, substitution with LPG vehicles would allow for 570,000 total vehicles for the same GHG impact.

Looking forward, the carbon benefit offered by substituting LPG as a transport fuel has the potential to grow as indigenous supplies become increasingly focused on natural gas fields as opposed to refinery sourced LPG, reducing the upstream emissions from LPG production.

Benefits to Australian households

Assessed on an individual household basis, the lifetime savings from using an LPG vehicle are expected to be over \$6000. This is based on an average annual mileage of 20,000 km over 10 years, average fuel saving of 5 cents per kilometre and \$3000 cost for the initial LPG conversion.

Why LPG?

Based on an accelerated adoption scenario with an additional 570,000 LPG vehicles in the fleet in 2030, this allows for \$3.4 billion increased discretionary spending across Australian households to be put back into the economy.

Revitalising the Australian automotive industry

The Australian automotive industry is a significant investor in R&D, and has gained an international reputation for its design skills and componentry. Although this industry has suffered in the face of recent economic uncertainty, it is still a significant contributor to the Australian economy. Importantly, there remains the potential to expand the industry and build on the strong export potential (and historical record) that the industry holds.

Within this context, LPG has the potential to contribute significantly. There is a market appetite for alternative fuels, and LPG is currently the most established and available alternative fuel that does not come at a prohibitive cost to the consumer. There would therefore appear to be a strong potential to develop and fast track new LPG technologies to market that meet the existing public demand.

In turn, promoting the R&D of advanced LPG technologies brings with it the revitalisation of the Australian automotive industry by:

- growing the domestic motor vehicle manufacturing industry;
- building on the international recognition of Australia's automotive industry and offering cutting edge LPG componentry to a competitive global market;
- growing the automotive industry export market (currently in decline) with domestically developed advanced OEM LPG vehicles;
- seeding a strong R&D industry for the continued enhancement of LPG technologies into the future.

With the above come strong benefits to the Australian economy in terms of gross domestic product and employment growth, as well as growth of supporting industries.

4 Current market barriers

The adoption of any new automotive technology in the presence of incumbent technologies typically requires navigation of nine groups of market barriers (Figure 9). While some of these barriers are more critical than others, each barrier must be systematically addressed if the potential economic and community benefits of the technology are to be fully realised by the national community.

4.1 Price disadvantage

LPG vehicles are typically delivered to the market by way of an additional fuel system fitted to the vehicle (i.e. dual-fuel operation) which comes at an additional expense to that of a conventionally fuelled vehicle. In addition, the smaller volumes of LPG vehicles introduced into the market (either as new vehicles or conversions of existing vehicles) mean that suppliers are required to amortise their product development and engineering costs over a smaller number of annual vehicles sales – producing a higher cost premium than would otherwise be the case.

The net effect of these two characteristics is that LPG vehicles are generally more expensive to purchase than conventionally fuelled vehicles – creating a consumer barrier to the increased market penetration of LPG vehicles.

The quantum of this price disadvantage varies from \$1800 to \$4500 per vehicle depending on the system and whether the vehicle is purchased new or converted to LPG operation.

While it has historically been reasoned that the consumer recoups the additional expenditure from reduced fuel costs over the life of the vehicle, consumers are generally capital sensitive and do not usually consider vehicle purchases on the basis of whole-of-vehicle life economics.

An examination of the market position of LPG in the Australian automotive market in light of the nine strategic barriers provides an indication to the strategic directions that will need to be pursued.

The traditional approach to this barrier has been for government to provide rebates for the capital purchase of LPG vehicles. Care is needed in terms of the design of these schemes, however, as schemes that require the consumer to pay up front (with a view to a rebate being returned following purchase) tend to be less effective than those that provide the rebate at the time of purchase.

In the near term, the continued provision of up-front rebate schemes is likely to be the most effective means of redressing the price disadvantage barrier.

As the number of annual sales of LPG vehicles grow, the industry is likely to reach a point where the incremental capital cost of LPG vehicles becomes insignificant and the rebate is no longer required. The achievement of this 'tipping point' could be accelerated if R&D assistance were provided to industry to reduce the costs associated with the commercialisation of advanced LPG vehicle systems.

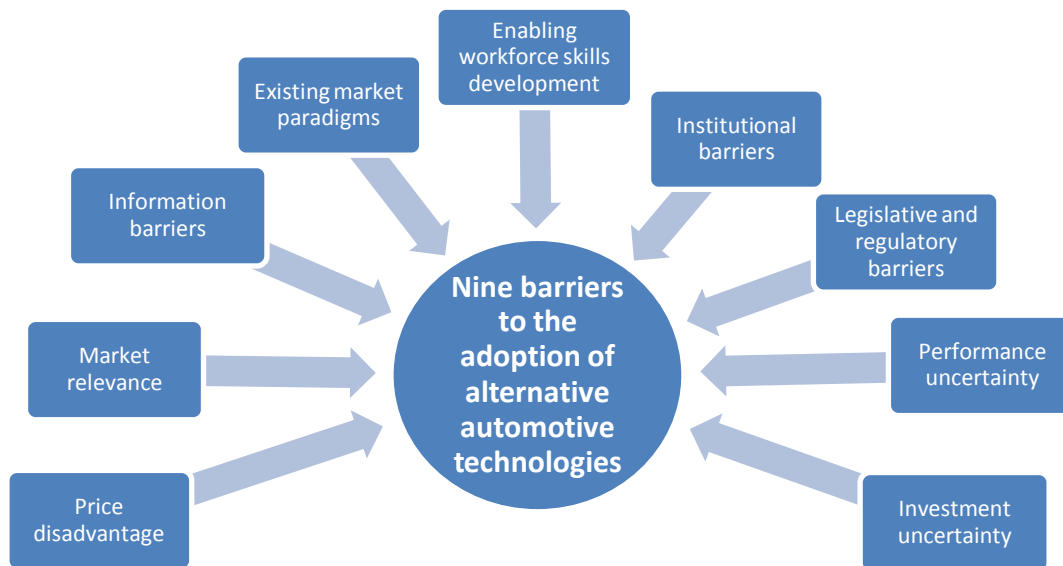


Figure 9 **Nine barriers to the market adoption of alternative automotive technologies**

4.2 Market relevance

Market relevance is typically a measure of the strategic fit of a new fuel (or technology) with the core requirements of the market – considered at both a community aspiration level and a consumer level.

As highlighted earlier, LPG provides a good level of fit with Australia's national aspirations for improved transport energy security and reduced GHG emissions. As such, this fuel is directly relevant to the contemporary economic and environmental aspirations of Australian society.

The level of fit of LPG at the consumer level tends to be sporadic. Essentially, the consumer relevance of LPG appears to wax and wane in proportion to the rise and fall in the cost of conventional transport fuels (and consumer perceptions of price volatility). This phenomenon

creates significant challenges for ensuring continuous investment in the development and refinement of LPG technologies for automotive application in Australia. To some extent, this barrier is expected to be resolved by expected increases in the cost of conventional transport fuels in the near term, relative to LPG.

At the consumer level, there appear to be opportunities for the industry to better market LPG vehicles. As evidenced in this paper, increased use of LPG vehicles will deliver environmental benefits such as reduced GHG emissions. The emergence of the carbon constrained economy therefore creates a new product attribute that could be marketed to fleet buyers and private buyers alike.

4.3 Information barriers

The development of the LPG vehicles agenda in Australia requires coordination of the total supply chain. The relatively immature nature of the market means that information processes are poor and that industry development activities are predominantly being advanced by largely disconnected industry stakeholders.

Analysis of the current state of the industry suggests that there are currently a number of information failures in the LPG vehicle industry. Key information failures include:

- incomplete information on the current capacity and nature of the national LPG refuelling asset;
- incomplete information on the actual number of LPG vehicles in operation, given the varied registration requirements for LPG vehicles in Australia's states and territories;

- conflicting information on the indigenous LPG supply outlook in Australia.

In order for the industry to continue to grow and attract investment, there is a need to assemble a comprehensive and credible fact base surrounding all aspects of the current and likely future market. In some cases, the resolution of this issue will require cooperation between industry and government to improve data collection processes such as registration requirements for LPG vehicles.

Once assembled, this data then needs to be made available to industry and government to assist with the development of market and public policy responses that will help Australia to realise the significant potential benefit of continued investment in LPG vehicle technologies.

4.4 Existing market paradigms

Previous work conducted by industry and government has revealed that the market adoption of LPG vehicles is also being constrained by adverse market perceptions.

Market research and anecdotal evidence suggest that LPG vehicles are a victim of their long tenure in the alternative fuels market, with alternatives such as hybrid vehicles and electric vehicles being considered as more contemporary (or 'sexier') alternatives. In addition, the historical delivery of LPG vehicles via 'local garage' conversions has resulted in consumer perceptions that LPG technology is not a mainstream technology being pursued by the serious elements (i.e. manufacturers) of the Australian automotive industry.

In short, LPG vehicles are often perceived as the cheap alternative that often comes at the cost of vehicle performance. Consumers currently appear to fail to appreciate the significant developments that have been made in producing advanced LPG systems that deliver substantial environmental and energy security benefits when used in lieu of conventional fuels.

The reality of LPG vehicles is markedly different, and there appears to be a need for the LPG vehicle industry to reinvent itself by focusing on the performance and near-term market availability of advanced LPG systems.

Clearly, there is a need to correct these adverse consumer perceptions by articulating the broader benefits and performance of advanced LPG vehicles (Figure 10). Such an approach needs

to be measured and credible, and be designed to cut ties with the past legacy of being a cheap alternative to conventional fuels.

4.5 Enabling workforce skills development

In some ways, the significant past tenure of the Australian LPG vehicle industry means that it has already developed the workforce skills required to support the continued growth of the market. The development of these workforce skills, however, has largely occurred on an ad hoc basis, resulting in varied levels of technical expertise and workforce skill levels.

The continued growth of the industry and market introduction of advanced LPG systems signals a

need for a more structured approach to the future development of the enabling skills of the workforce in areas such as gas kit installation, gas vehicle maintenance, and safe working practices for gas vehicles.

One approach would be for the industry to develop training and certification programs designed to lift workforce skill levels and prepare the workforce for the near-term introduction of advanced LPG powered vehicles.

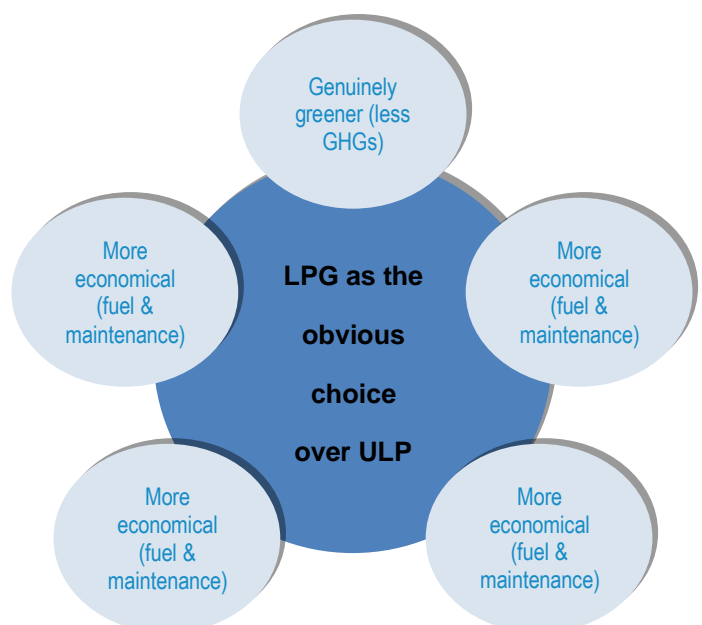
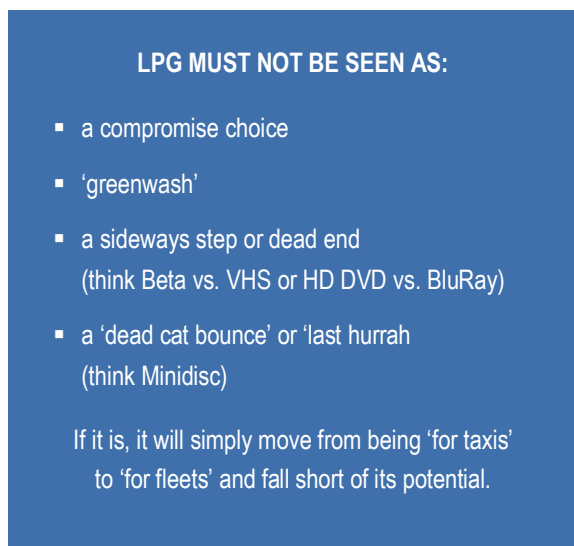


Figure 10 There is a need to reposition LPG in the market by improving consumer awareness of the characteristics of modern LPG vehicle systems

4.6 Institutional barriers

Institutional barriers typically relate to the structure of the industry and the coordination issues that can often arise between different elements (or 'silos') of industry. In the case of the LPG industry, given the long tenure of market presence in the Australian automotive industry, there are very few institutional barriers.

One area that needs to be addressed in respect of this barrier relates to the apparent disconnect

between the management of the national LPG refuelling asset and the emergence of advanced LPG vehicle technologies. Analysis of the needs of LPG vehicle consumers (in respect of refuelling convenience) and the requirements of advanced LPG systems highlights an urgent need for improvement in existing LPG refuelling infrastructure.

4.7 Legislative and regulatory barriers

One of the key barriers in this area relates to differences in Australian state/territory vehicle registration authorities in respect of vehicle registration requirements. Some states and territories require that vehicles fitted with LPG systems are nominated and fitted with a plate delineating use of LPG while others do not.

Review of related practices in relation to workplace design (and safety) and installation oversight also reveals significant variance between different Australian states and territories.

The development of the LPG vehicle industry in Australia beyond its current infant state suggests that there is a need to identify and then rectify inconsistencies in current regulations to ensure that LPG vehicle consumers across Australia are treated similarly, irrespective of the state or territory in which they live.

A further area for investigation relates to the current Australian fuel quality standard for LPG sold in Australia. Industry and consumer feedback suggests that variation in the composition of LPG can significantly affect fuel consumption and vehicle performance, despite the fuel being compliant with the requirements of the LPG Fuel Determination (2004) of the *Australian Fuel Quality Standards Act 2000*.

At the time of writing this paper, the Australian Government was working on the revision of the 2004 Fuel Quality Standard Determination for LPG, and the LPG vehicle industry was providing strong support to this process.

4.8 Performance uncertainty

Performance uncertainty relates to the unpredictability of economic and environmental outcomes associated with the operation of a given fuel or vehicle technology. This uncertainty can be a factor of different drive cycles, component quality and durability, or a combination of both. In the case of LPG, there are currently a range of different LPG technologies available in the Australian marketplace. The cost, fuel consumption and emissions performance of these products varies markedly.

While gaseous vehicles are widely acknowledged as delivering a 'well to wheel' GHG benefit in the order of 10% relative to conventional petrol powered vehicles (see Figure 6), different LPG system technologies deliver mixed results. As a consequence, there is a need to ensure that only the systems that deliver GHG positive results and satisfy applicable emission design standards are funded under any future program.

The quality of gas kit installation can also have a significant bearing on the real-world environmental and economic performance of a

gas powered vehicle. Incorrect installations can also present a safety risk to the vehicle user and the general public.

The result of these two observations is that consumers tend to experience mixed outcomes from fitting LPG systems to their vehicles (or purchasing a new LPG vehicle). Left unaddressed, these issues will likely generate market uncertainty about the real-world performance of LPG vehicles thereby creating a barrier to the wider market adoption of advanced LPG vehicle systems.

There is need for the industry to provide improved consumer guidance on the selection of LPG vehicle systems and to work with component suppliers and equipment installers to improve the quality of LPG installations. This action might extend to the development of a rating system for LPG systems (that is developed along similar lines to the energy efficiency and water efficiency ratings used for household appliances) and the introduction of a training and certification scheme for LPG kit installers.

4.9 Investment uncertainty

The final barrier relates to the investment made by consumers towards the purchase of an LPG vehicle. Most vehicle consumers are prepared to countenance a small increase in the capital cost if they believe that such an investment will deliver fuel savings that offset this cost over the life of the vehicle.

The variable performance of different LPG systems (and varying costs of these systems) means that consumers are often confused as to the total quantum of economic benefit derived from an investment in an LPG vehicle. This

confusion is often compounded by the fact that the use of dual-fuel technologies means that the fuel savings are not locked in (i.e. the driver can elect not to use LPG) and the price of both LPG and conventional fuels is volatile.

There appears to be an opportunity for the industry to address this issue by improving the quality of economic information available to the consumer (i.e. price calculators, information on the historical movements in the price differential). While some of this information exists on industry websites, there is a need to make credible

information available to prospective consumers at the point of LPG vehicle sale or LPG vehicle conversion.

Care would need to be taken to ensure that all information provided is appropriately vetted and does not risk misleading customers, suggesting that this information would need to be centrally controlled (and periodically updated) by an industry organisation such as LPG Australia.

5 The road ahead

5.1 Strategic objectives

The discussion in this paper suggests that the increased use of LPG as a transport fuel in the Australian vehicle fleet constitutes significant potential for Australia to realise energy security, GHG emissions, and industry development benefits (Figure 11).

As such, the LPG industry has an obligation to work with key government and industry stakeholders to assist with the realisation of this potential.

Unlike other alternative fuel industries in Australia, the LPG vehicle industry has been in operation for more than 30 years. This means that the industry has developed an industry capability and infrastructure that provides the foundation for any future change. Accordingly, there is a need to ensure that all future strategic directions take due account of the need to manage the transition of the industry over a time period that takes due account of key commercial and market considerations.

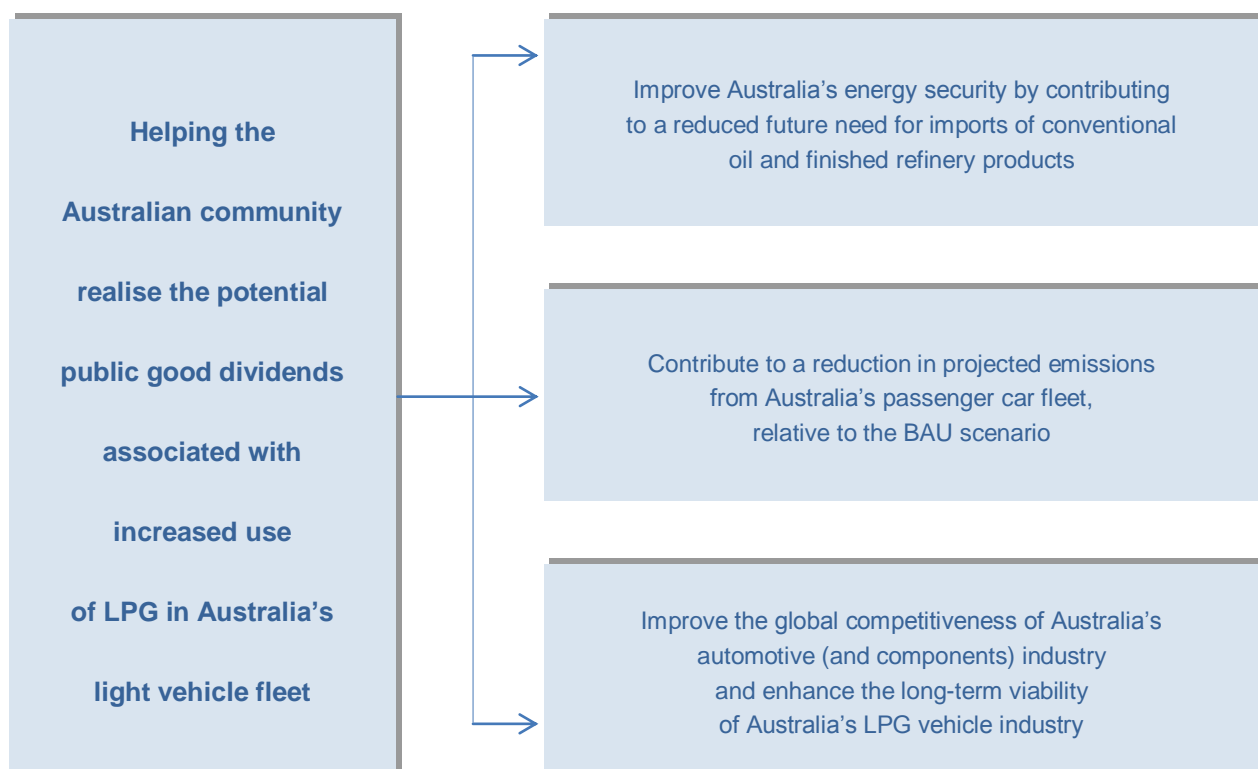


Figure 11 **The strategic objectives for development of the LPG vehicle market in Australia to 2030 and beyond**

5.2 Key strategic directions and supporting actions

Analysis of the strategic discussion in the preceding sections, together with the market barriers discussion in Section 4, suggest that the future development of the LPG vehicle industry in Australia could be premised on the pursuit of four strategic directions.

Strategy 1: Better LPG vehicles

The LPG vehicle industry in Australia has reached a critical juncture in its evolution. Historically, the industry has grown on the back of fringe interests in alternative fuels. Over the past decade, the emergence of concerns about the outlook for oil supplies (and pricing) and concern over the GHG emissions from road transport has seen the mainstreaming of the alternative fuels debate.

Within this context, the LPG vehicle industry must respond to the changed market dynamics by providing advanced LPG vehicle technologies that take full account of the national strategic energy and environmental benefits afforded by use of an indigenously available, carbon-positive fuel

While conversions of older vehicles to LPG operation will continue in the near term, the industry must develop and deliver new LPG vehicles that meet the sophisticated needs of contemporary new vehicle purchasers as soon as practicable.

Ultimately, the long-term viability of the industry will be dependent on the speed with which the industry can transition from a predominant focus on aftermarket conversions of older vehicles to a dominant focus on provision of new LPG vehicles from the floor of Australian car showrooms.

Practical achievement of this strategy will require the pursuit of a suite of actions across multiple fronts.

Key actions include:

- Accelerating the market introduction of advanced LPG combustion technologies such as liquid phase injection and high-pressure combustion systems.
- Collaborative research to support advanced technology breakthroughs in areas such as (a) the performance of LPG in high-pressure conditions, (b) the operation and durability of high-pressure LPG pumps, and (c) the impact of the variation in LPG composition on LPG physics.
- Improving LPG tank storage technologies to reduce the loss of cargo space associated with on-board storage of LPG.
- Revision of existing LPG vehicle standards to accommodate new technologies such as (a) gaseous phase manifold injection, (b) liquid phase manifold injection, and (c) direct injection.

Strategy 2: Better LPG refuelling infrastructure

Analysis of the interface between the LPG vehicle fleet and LPG refuelling infrastructure suggests that there is a need to improve the existing LPG infrastructure in Australia.

While the existing LPG infrastructure is extensive (over 3000 outlets across Australia) this asset is ageing, creating two principal challenges. The first challenge is consumer related and concerns the limited user friendliness of current refuelling nozzles and the significant delays that can be experienced when refuelling in warm weather.

The second challenge relates to the current limitations in the capacity of the existing LPG infrastructure to support the market entry of

advanced LPG vehicle technologies. As a consequence, there will likely be a requirement for retrofit of refuelling nozzles to support the introduction of these vehicles into the Australian passenger car market.

The achievement of this strategy will require pursuit of the following major actions.

- Investigation of the current issues associated with the operation of the existing LPG refuelling asset including (a) performance of existing infrastructure under variable environmental conditions, (b) typical fill rates, and (c) average queuing times.
- Conduct of a national audit of LPG refuelling infrastructure in terms of asset age, equipment type, and capacity to support advanced LPG vehicle technologies.
- Investigation of the issues surrounding the replacement of existing LPG nozzles with 'quick connect' nozzles, including consideration of the degree to which these nozzles can be used to refill existing LPG vehicles.
- Development and implementation of a national program to upgrade the LPG refuelling infrastructure asset (long term), possibly including government funding assistance.
- Revision of existing Australian Standards for LPG refuelling equipment and vehicle mounted hardware.

Strategy 3: A more informed marketplace

The long tenure of LPG in the Australian marketplace has resulted in the development of longstanding customer perceptions that are either outdated or quite simply incorrect. These perceptions are perhaps best characterised as a perception that LPG is just a cheap fuel that is

used in taxis or installed on older family cars in local garages. In truth, the Australian LPG vehicle industry is fast emerging as one of the serious contenders for the provision of an alternative transport fuel that is economic, clean and consistent with high-performance modern vehicles.

The current contrast between industry reality and market perceptions signals a need for the industry to undertake a program to better inform the market about recent developments in LPG vehicles in Australia. To this end, the following principal actions will be pursued by the LPG vehicle industry to improve market awareness of the LPG vehicle opportunity.

- Development of a public awareness campaign to inform the market of the benefits and likely near-term market availability of advanced LPG vehicle technologies in Australia.
- Development of point-of-sale materials for LPG vehicles (including cost calculators) in partnership with new car manufacturers and the LPG conversion industry.
- Conduct of authoritative research into the environmental and economic performance of different aftermarket LPG vehicle technologies with a view to developing and implementing a program for the assessment and rating of aftermarket conversion systems.

Strategy 4: A better industry

The sustained community realisation of the benefits of LPG vehicles (and the long-term survival of the LPG industry) requires that the industry get its own house in order. The sporadic development of the LPG industry in Australia over the past 30 years has meant that there are a number of issues that need to be addressed to (a) change community perceptions of the industry and (b) create a solid platform for sustained growth.

A number of these issues relate to the development of industry standards and norms governing the operation of the industry, the quality of workmanship and the safety of employees.

The following specific actions will be pursued under this strategy.

- Development and implementation of an accreditation for aftermarket installers of LPG vehicle systems.
- Revision of Australian Standards relating to LPG gas components sold in the Australian automotive market.
- Revision of Australian Standards relating to safe working practices for installation of LPG systems and repair of LPG vehicles.
- Provision of national stewardship of key research projects to support the continued enhancement of LPG vehicle technologies for the Australian community, possibly extending to the development and administration of a joint government/industry fund for research.
- Development and delivery of training programs for the Australian vehicle repair industry.

6 Key implementation considerations

6.1 Key transition considerations

The strategic directions highlighted in Section 5 constitute a significant departure from the historical thrust of the LPG vehicle industry in Australia – from a focus on aftermarket conversions to a primary focus on delivery of new LPG vehicles.

It should be noted that the future strategic directions in this document have been made possible only by the progressive development of a national refuelling infrastructure, and enabling workforce skills over the past 30 years.

Accordingly there is a need to ensure that the transition from the current industry focus on conversion of aftermarket vehicles, to a predominant focus on advanced LPG technologies, does not come at the expense of the already developed industry capacity.

It is worth noting that the industry capacity that has been developed has largely occurred as a result of government incentives in the area of excise exemption for LPG and rebates for LPG conversions.

The Australian government has already signalled changes in both of these program areas, but the degree to which the industry capacity will be adversely affected by these changes remains uncertain.

The combination of new industry directions and changes to government assistance programs suggests that there is a need to carefully assess the degree to which these influences might combine to destroy industry capacity in the near term.

Successful management of this risk will require close cooperation between the LPG industry and government to progressively unpick current assistance programs and replace them with complementary programs that support the early market adoption of advanced technology LPG vehicles and the enhancement of already developed industry capacity.

6.2 A collaborative responsibility

Increased use of LPG for automotive use in the Australian light vehicle fleet will deliver commercial dividends for industry stakeholders and public good dividends for the community at large. Accordingly, the burden associated with the pursuit of the strategic direction contained in this document will likely require collaboration within the industry, across industry sectors (i.e. fuel and vehicles) and between government and industry.

This collaboration will be vital in the early stages of the changed market direction when it is often

difficult to justify investment in expanded infrastructure and commercialisation of advanced technologies purely on a commercial basis.

In these circumstances, the commercial risk associated with significant industry investment in the early commercialisation of advanced technologies can be offset by the provision of targeted government assistance in the enhancement of infrastructure and commercialisation of technologies.

7 Summary and next steps

The discussion in this paper reveals that the increased use of LPG in Australia's passenger car fleet over the next 20 years will deliver significant benefits to the Australian community in terms of improved energy security, reduced GHG emissions, and automotive industry development.

An increase in the market share of LPG from the current 6% to 10% in 2030 is estimated to result in the following principal benefits to the Australian community.

- Balance of trade benefits – a reduction in petrol consumption of up to 100 million barrels of oil by 2030, equating to a cumulative net trade deficit benefit of around \$3.8 billion by 2030.
- Reduced GHG emissions – a GHG reduction of up to 5.3 million tonnes by 2030, relative to the BAU scenario. This estimate is based on a calculated saving of up to 13% (CO₂-e) per vehicle compared with petrol, when considered on a full life cycle basis.
- Economic benefits for Australian households – a cumulative increase in discretionary household expenditure in the order of \$3.4 billion to 2030 relative to the BAU scenario, based on an estimated average saving of \$6000 per household and an additional 570,000 LPG vehicles.
- A stronger automotive industry – LPG and the Australian automotive industry have a long synergy. Continued investment in LPG vehicles is therefore likely to have positive industry development benefits for Australia's wider car industry.

Achievement of the above benefits will require implementation of an industry strategy comprising actions in four key directions, namely:

- Better LPG vehicles – a major focus on the early market entry of advanced LPG systems provided by vehicle manufacturers, with continued focus on the fitment of sophisticated aftermarket LPG conversion systems.
- Better LPG refuelling infrastructure – LPG infrastructure is improved to take account of the requirements of advanced LPG vehicles and increased volumes of users.
- A more informed marketplace – provision of better information to the community in respect of both market developments and point-of-sale materials.
- A better industry – revision of standards and adoption of certification standards to improve the operation of the industry, skills of the workforce, and safety of all employees.

Achievement of the actions outlined in this strategy will require collaboration with government and other industries to successfully manage the key industry transition issues and build the foundations for a vibrant industry that will continue to contribute positively to the Australian community in the future.

8 Recommendations

It is recommended that the LPG vehicle industry work cooperatively with other industries and government (state and federal) to advance the following strategic actions to support the development of the Australian LPG industry to 2030 and beyond.

Better vehicles (Strategy 1)

- 1 Accelerate the market introduction of advanced LPG combustion technologies such as vapour and liquid phase injection and high-pressure combustion systems.
- 2 Conduct collaborative research to support advanced technology breakthroughs in areas such as (a) the performance of LPG in high-pressure conditions, (b) the operation and durability of high-pressure LPG pumps, and (c) the impact of the variation in LPG composition on LPG physics.
- 3 Improve LPG tank storage technologies to reduce the loss of cargo space associated with on-board storage of LPG.
- 4 Revise existing LPG vehicle standards to accommodate new technologies such as (a) gaseous phase manifold injection, (b) liquid phase manifold injection, and (c) direct injection.

Better refuelling infrastructure (Strategy 2)

- 5 Investigate the current issues associated with the operation of the existing LPG refuelling asset including (a) performance of existing infrastructure under variable environmental conditions, (b) typical fill rates, and (c) average queuing times.
- 6 Conduct a national audit of LPG refuelling infrastructure in terms of (a) asset age, (b) equipment type, and (c) capacity to support advanced LPG vehicle technologies.

- 7 Investigate of the issues surrounding the replacement of existing LPG nozzles with 'quick connect' nozzles, including consideration of the degree to which these nozzles can be used to refill existing LPG vehicles.
- 8 Develop and implement a national program to upgrade the LPG refuelling infrastructure asset (long term), possibly including government funding assistance.
- 9 Revise existing Australian Standards for LPG refuelling equipment and vehicle mounted hardware.

A more informed marketplace (Strategy 3)

- 10 Develop a public awareness campaign to inform the market of the benefits and likely near-term market availability of advanced LPG vehicle technologies in Australia.
- 11 Develop point-of-sale materials for LPG vehicles (including cost calculators) in partnership with new car manufacturers and the LPG conversion industry.
- 12 Conduct authoritative research into the environmental and economic performance of different aftermarket LPG vehicle technologies with a view to developing and implementing a program for the assessment and rating of aftermarket conversion systems.

A better industry (Strategy 4)

- 13 Develop and implement an accreditation program for aftermarket installers of LPG vehicle systems.
- 14 Revise Australian Standards relating to LPG gas components sold in the Australian automotive market.

Recommendations

- 15 Revise Australian Standards relating to safe working practices for installation of LPG systems and repair of LPG vehicles.
- 16 Provide national stewardship of key research projects to support the continued enhancement of LPG vehicle technologies for the Australian community, possibly extending to the development and administration of a joint government/industry fund for research.
- 17 Develop and deliver training programs for the Australian vehicle repair industry.

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Glossary

ABS	Australian Bureau of Statistics
BAU	business as usual
CNG	compressed natural gas
CO ₂ -e	carbon dioxide equivalent
cpl	cents per litre
CTEE	Centre for Transport, Energy and the Environment
CTL	coal to liquids
DCC	Department of Climate Change
DFAT	Department of Foreign Affairs and Trade
DRET	Department of Resources, Energy and Tourism
E10, E85	ethanol blended with diesel at 10%, 85%
EIA	Energy Information Administration
FCAI	Federal Chamber of Automotive Industries
g	gram
GHG	greenhouse gas
GTL	gas to liquids
kg	kilogram
km	kilometre
LPG	liquefied petroleum gas
ML	megalitre
MMBL	million barrels
NWS	North West Shelf
OEM	original equipment manufacturer
R&D	research and development
STL	shale to liquids
ULP	unleaded petrol