Business Council of Australia

SUBMISSION

Vehicle Emissions Discussion Paper

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Working to achieve economic, social and environmental goals that will benefit Australians now and into the future

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Contents

The Business Council of Australia (Business Council) is a forum for the chief executives of Australia's largest companies to promote economic and social progress in the national interest.

About this submission

This is the Business Council's submission to the Australian Government's Vehicle Emissions Discussion Paper (discussion paper).

Our submission focuses on measures that could reduce greenhouse gas emissions from the road transport sector. The Business Council is mid-conversation on what might constitute a preferred suite of policies capable of delivering Australia's 2030 emissions reduction target at lowest possible cost to the Australian economy. We are therefore still considering how best to address emissions from the road transport sector and so this submission should be interpreted as directional rather than categorical.

Key recommendations

As part of a broader suite of integrated energy and climate change policy measures, the Business Council supports, in-principle, further consideration of a mandatory vehicle fuel efficiency standard for new passenger vehicles.

Any standard adopted in Australia might more suitably align with that in the USA, rather than the European Union (EU), given the similarity in vehicle fleets (greater penetration of SUVs and a preference for automatic transmission systems) and the longer distances travelled. This review of vehicle emissions could consider the costs and benefits of Australia matching the US standard for all light vehicles of 107g CO_2/km by 2025 with an appropriate interim target at 2020.

However, given the lack of available data on the incremental vehicle costs from the implementation of various standards, the Business Council strongly recommends that a comprehensive Regulatory Impact Statement (RIS) be undertaken to ascertain the best possible estimates of the cost imposts or savings as a consequence of any given standard.

Mandatory vehicle emissions standards for new passenger vehicles should only be implemented if they are demonstrated to deliver a net benefit to the Australian economy.

To further support emissions reductions from the road transport sector, consideration should also be given to allowing the importation of used passenger vehicles where they meet defined fuel efficiency standards.

While there may be increased demand for lower sulphur fuels as a result of introducing mandatory vehicle fuel efficiency standards, the incremental CO_2 emissions benefits from mandating lower sulphur levels does not seem to outweigh the significant cost this would place on Australia's refining industry.

The Business Council does not support any changes to sulphur levels in Australia's fuel quality standards at this time.

Given climate change policy instability, it would be very difficult for purchasers of passenger vehicles to cost future carbon prices into their vehicle purchasing decisions. However, these decisions will have a long-term impact on Australia's emission outcomes.

Three-quarters of the passenger vehicles that will be on Australia's roads in 2030 are yet to be purchased and the opportunity exists to incentivise these investments and assist in delivering a lower emission future.

Government fleets should move towards electric and/or alternative fuel vehicles to:

- address some of the barriers to the uptake of these technologies
- capture the lifetime benefits from lower fuel costs.

The government should also conduct a comprehensive review to find the most cost-effective measures to encourage take-up of electric vehicles in Australia.

Policies to reduce road congestion, such as intelligent transport systems and road pricing, can also have the effect of reducing vehicle emissions by improving the efficiency of vehicle use.

Background

The 21st Conference of the Parties meeting in Paris in December 2015 reached a historic agreement (Paris Agreement) to limit global temperature rises to 'well below two degrees Celsius'. To achieve this will require deep global emissions reductions with most countries, including Australia, eventually reducing net greenhouse gas emissions to zero.

Australia's stated target of reducing greenhouse gas emissions by 26–28% on 2005 levels by 2030 is a credible step on this path that, as noted by the Climate Change Authority (CCA 2015, p. 1) in its draft report, will require 'substantial and sustained effort'. The scale of transformation required in the Australian economy to achieve this target should not be underestimated.

The opportunity now exists to build on, or adapt, the current legislative framework to create a suite of durable, integrated energy and climate change policies. These policies should be capable of delivering Australia's 2030 emissions reduction target, at lowest possible cost, while maintaining competitiveness and growing Australia's future economy.

Any suite of policies will need to be scalable and capable of evolving through time to ensure Australia can also meet any future emissions reduction targets.

The Business Council supports consideration of a suite of policy measures (rather than relying on a single instrument) provided they are durable, integrated with broader energy and economic policy, and cognisant of any second order effects across the full range of sectors within the Australian economy. Understanding how policy options interact and their cumulative effect is critical, but has rarely been understood.

Bain & Company undertook analysis for the Business Council on options for emissions abatement (attached). They found that Australia can make the most headway towards lowering its emissions by focusing on three key areas:

- Shifting its mix of power sources away from fossil fuels and towards renewables while encouraging greater energy efficiency

- Better managing land use
- Encouraging the adoption of more fuel-efficient vehicles.

While Australia could also make cost effective changes in other emitting sectors, such as agriculture, direct combustion, fugitive emissions, industrial processes and waste, the opportunities are highly fragmented.

In relation to transport, Bain & Company found that although small opportunities exist across the road transport sector, the greatest opportunity is in the passenger vehicle segment. Australia's passenger vehicle emissions per capita and per GDP are very high relative to other developed nations. This is partly due to Australia's large land mass. It is also the result of large, fuel inefficient vehicles popular among Australians, and the country's relatively weak emissions standards. Passenger vehicle emissions per kilometre in 2012 were 40% higher than in the EU and 7% higher than in the US, both of which have mandatory vehicle fuel efficiency standards.

Since 2005, the efficiency of Australia's passenger vehicles has improved at a rate of 2.8% per year, but from a high starting point. Countries with more efficient fleets have demonstrated that further improvement is possible. For example, fuel efficiency has improved in Japan by 3.3%, in the USA by 2.7% and in the EU by 2.3%.

Encouraging the adoption of more fuel efficient passenger vehicles

The transport sector currently accounts for approximately 17% of Australia's total emissions and is projected to grow based on population and income growth. This includes emissions from direct combustion of fuels in transportation by road (light vehicles – passenger and light commercial – and heavy vehicles), rail, domestic aviation and domestic shipping.

The Business Council is currently focused on reducing emissions from passenger vehicles because:

- light vehicle emissions account for more than 60 per cent of emissions in the transport sector (and approximately **ten per cent** of Australia's total emissions)
- heavy vehicle fuel efficiency standards and testing are relatively more complex and the benefits from their application are still being understood
- three-quarters of the passenger vehicles that will be on Australia's roads in 2030 are yet to be sold
- CSIRO (cited in CCA 2014) has previously estimated that the largest emissions reductions available in the transport sector are from more efficient use in light vehicles. Total transport emissions are projected to increase by 14 per cent to 105 million tonnes of CO_2 to 2019–20, with most of these emanating from light passenger vehicles.

Options to reduce emissions from passenger vehicles include:

- introducing a price on emissions
- developing mandatory or voluntary $CO_{2\text{-}e}$ emissions standards
- changing the fuel mix to reduce emissions intensity
- providing incentives or removing barriers to the uptake of low-emissions vehicles including electric vehicles
- promoting the use of Intelligent Transport Systems
- encouraging passenger shifts from light vehicles to public transport
- managing congestion through road pricing.

Cost of introducing a fleet average standard for fuel efficiency

While a price on emissions is usually the most efficient and cost effective way to reduce emissions, the relatively modest carbon prices expected on a global basis in the short to medium term would be unlikely to significantly affect driving behaviour or vehicle purchasing decisions.

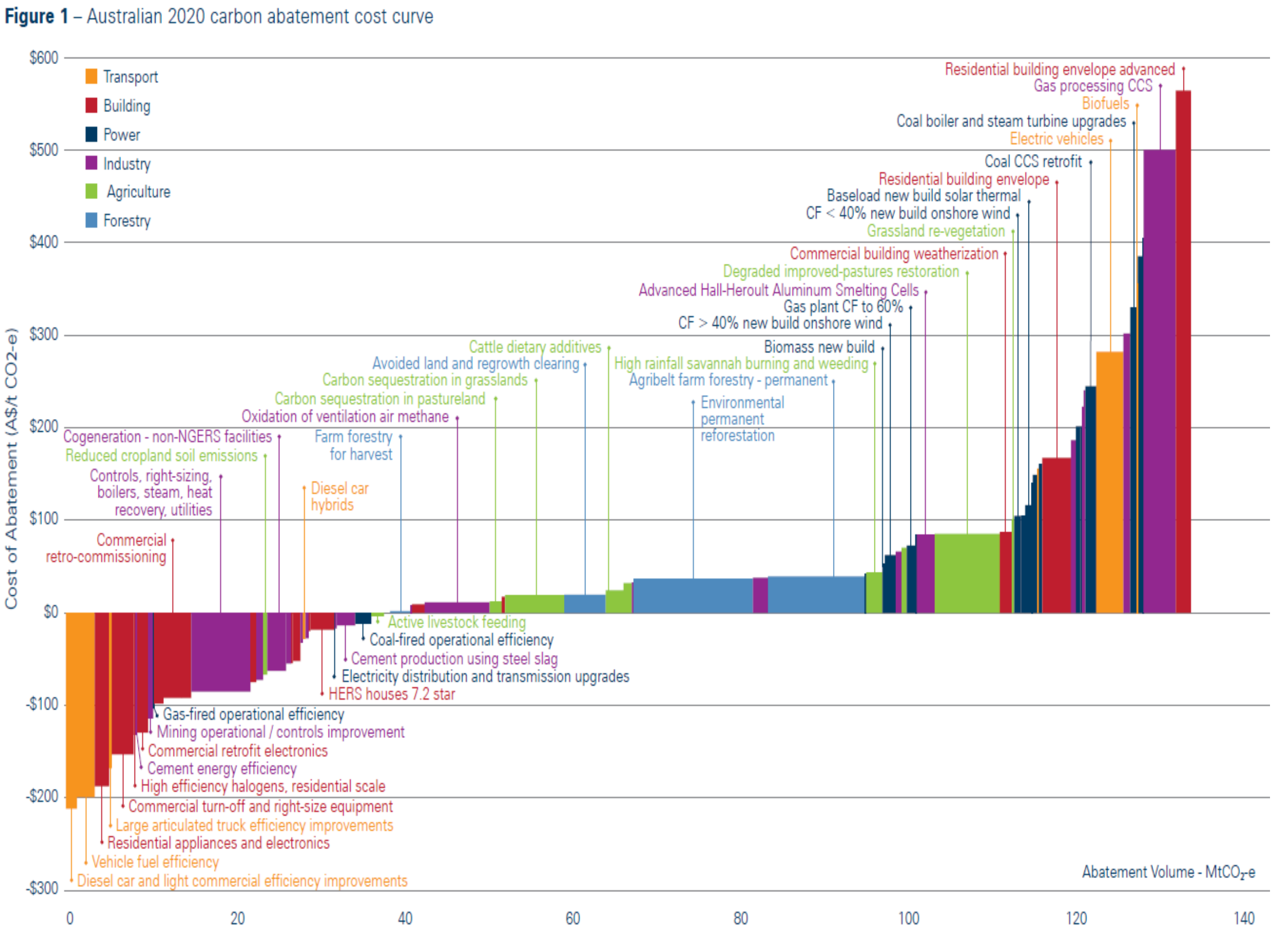
Analysis by ACIL Allen for the Business Council suggests one litre of unleaded petrol produces around 2.4kg of CO_2. For a carbon price of $30/tonne of CO_2, this would add around seven cents per litre, which is well inside the variation in prices experienced in the normal price cycle. In the long term, a modest effect on emissions could be expected as customers at the margin shift to smaller, more fuel efficient and hybrid-electric vehicles; and later electric vehicles.

As noted in the discussion paper, Australia will gain moderate advantages over time from overseas fuel economy standards, as more imported vehicles incorporate technologies aimed at meeting the fuel efficiency standards adopted in other markets. This is likely to have a much greater effect on any improvements in transport fuel efficiency than the introduction of a carbon price.

In fact, research suggests that a CO_2 standard is the most efficient method of reducing emissions from light vehicles: the International Energy Agency (IEA 2012, p. 10) notes that light vehicle emission standards are proven to reduce large amounts of emissions at low cost, and McKinsey & Company (2009, p. 92) has found that using existing technologies to increase fuel efficiency is where the greatest greenhouse gas abatement potential lies (60 per cent of abatement in the light vehicle sector can be achieved with technical improvements to conventional engines for fuel efficiency).

The Reputex (2015) chart below depicts an Australian abatement cost curve for 2020, which highlights that vehicle fuel efficiency represents some of the lowest cost abatement in Australia.

Figure 1: Reputex Marginal Abatement Cost Curve to 2020[1]



Source: RepuTex Carbon, January 2015

The principal cost of a fleet average standard is the higher production cost, and therefore retail price, of vehicles incorporating fuel saving technologies adopted in response to standards. There is also a potential non-financial cost from the loss of consumer choice through vehicle manufacturers changing their fleet mix or offering different variants of the same model to meet the fleet standard. A third, and significantly smaller cost, would be the administrative and compliance costs of the scheme. These costs could be mitigated by designing a standard based on a comprehensive RIS and using existing testing and data collection arrangements.

There are no published estimates for Australia (CCA 2014, p. 49) on the impact of standards on incremental vehicle costs. However, the CCA used modelling to estimate that standards could add between $1000 and $1500 per vehicle by 2025, but estimated this would be outweighed by fuel savings of up to $7000 (depending on the standard adopted) over the life of the vehicle.

As Bain & Company demonstrated, a simple calculation illustrates this. Assume that Australia can reduce the average fuel consumption of its passenger vehicles by 30%, from 10 to 7 litres per 100 kilometres travelled, which would be broadly in line with average fuel

[1] http://www.reputex.com/forecasts-data/marginal-abatement-cost-curves/mac-curve-2020/

consumption in the EU today. Across a fleet of 16 million vehicles and an average of 15,000 kilometres travelled per vehicle, that translates into 7,200 million litres of fuel saved every year, or roughly $4.7 billion per annum. These benefits will be offset by higher upfront costs of some of the technologies that drive fuel efficiencies (such as direct injection and lean burn engines), as well as the intangible cost of limitations on consumer choice. Overall, however, Bain & Company believes transportation is one of the few abatement levers that could come at a substantial net financial benefit.

Given the lack of available data on the incremental vehicle costs from the implementation of various standards, the Business Council strongly recommends that a comprehensive RIS be undertaken to ascertain the best possible estimates of the cost imposts or savings as a consequence of any given standard.

A possible fleet average fuel efficiency standard for Australia

Australia is one of only six OECD countries without vehicle fuel efficiency standards. Even without a mandatory standard, vehicle emissions have been reducing and are now at a fleet level of approximately 190g CO_2/km (down from 247g CO_2/km in 2004). The Department of Infrastructure and Regional Development (2014, p. 10) suggested that it is reasonable to expect reductions to continue, although at a slower pace than the rest of the world, given Australia's lack of a mandatory target.

ClimateWorks Australia has noted Australia's lag relative to other developed economies: for example, in respect of all light vehicles, Australia's BAU projection is 169g CO_2/km in 2020 and 156g CO_2/km in 2025. In contrast, the USA (and the EU) have committed to achieving 144g CO_2/km by 2020 (95g CO_2/km) and 107g CO_2/km by 2025 (73g CO_2/km).

Depending on how aggressively fuel efficiency standards were pushed and smaller vehicles encouraged, Bain & Company estimates that Australia could achieve up to 600 Mt of cumulative abatement by 2050 from passenger vehicle improvements. However, achieving this level of abatement assumes that Australia could quickly implement strict standards for new cars to meet the EU's current target by 2020 and match their target by 2025.

At least in the short to medium term, any standard for new passenger vehicles adopted in Australia might more suitably align with that in the USA rather than the EU, given the similarity in vehicle fleets (greater penetration of SUVs and a preference for automatic transmission systems) and the longer distances travelled.

This Australian Government review of vehicle emissions could consider the costs and benefits of Australia matching the US standard of 107g CO_2/km by 2025 for new passenger vehicles with an appropriate interim target at 2020.

Any standard should be consistent in its coverage, with clear guidelines on responsibility for compliance; include flexible compliance mechanisms; maintain consistency with existing Australian Design Rules; and contain provision for review.

To further support emissions reductions from the road transport sector, consideration should also be given to allowing the importation of used passenger vehicles where they meet defined fuel efficiency standards.

Fuel quality standards

Lower sulphur levels in fuel does not seem to be a critical requirement to achieving significantly lower CO_2 emissions from passenger vehicles.

The Australian Institute of Petroleum (2010, p. 3) has repeatedly stated that 'prospective conventional engine technologies can readily operate on the fuels that are already in the Australian market and therefore any proposal for mandatory vehicle CO_2 standards will not require any further tightening of Australian fuel quality specifications,' and any introduction of a 10ppm sulphur limit in unleaded petrol would threaten the ongoing viability of the Australian refining industry.

While there may be increased demand for lower sulphur fuels as a result of introducing mandatory vehicle fuel efficiency standards, the incremental CO_2 emissions benefits from mandating lower sulphur levels does not seem to outweigh the significant cost this would place on Australia's refining industry.

The Business Council does not support any changes to sulphur levels in Australia's fuel quality standards at this time.

A net-zero emission economy will require a shift towards low emission vehicles

Three-quarters of the passenger vehicles that will be on Australia's roads in 2030 are yet to be purchased (DIRD 2014, p. 10). This presents an opportunity to incentivise these investments and assist in delivering a lower emission future.

Given climate change policy instability, it would be very difficult for purchasers of vehicles to cost future carbon prices into their passenger vehicle purchasing decisions. However, these decisions will have a long-term impact on Australia's emission outcomes.

Policies to encourage a shift towards low emissions vehicles could focus on:

- electrification: the Climate Change Authority (2014, p. 20) found that the fully electric vehicles available at the time were less emissions-intensive than the average light car, and that electric light vehicles had greater abatement potential than technology changes for increasing light vehicle efficiency. McKinsey and Company (2009, p. 100) has also found that electric vehicles have substantially higher emissions-reduction potential per vehicle than hybrids or improvements in internal combustion engines.

  Estimates of the rate of penetration of electric vehicles vary widely. The Australian Energy Market Operator (2015, p. 60) recently forecast a relatively pessimistic uptake of electric vehicles penetration given the lack of policy incentives to purchase them, consumer anxiety and lack of public infrastructure. This suggests that a combination of measures (and a commitment to them) to support electric vehicle uptake may be required, not only from government, but from all sectors.
- fuel switching to less emissions intensive fuels: diesel, natural gas and sustainable biofuels.

Governments should support the transition to low emission vehicles and capture the lifetime benefits for their fleets

Government fleets should move towards electric and/or alternative fuel vehicles. This would play a vital role in addressing some of the barriers to the uptake of these technologies such as availability of recharging and refuelling stations. While this option may involve a higher upfront cost to government, the lifetime benefits from lower fuel costs should more than offset this.

Incentives may be required to drive transformational change

The IEA's statistics show that global sales of electric vehicles increased by 50 per cent in 2014 (CSIRO and Energy Networks Association 2015a, p. 13), a trend that the CSIRO attributes, at least partially, to the availability of subsidies. Modelling by the Electricity Network Transformation Roadmap (CSIRO and Energy Networks Association 2015, p.55) suggests that with some government policy incentives and manufacturing scale efficiencies, electric vehicles are likely to reduce in cost along a similar trajectory to that of rooftop solar and batteries.

The CSIRO and ENA (2015 p. 42) further notes that there is no upper limit on the adoption of electric vehicles except for the rate of the vehicle stock. However, the key enabler to drive the take-up of electric vehicles is some form of government subsidy.

Outside of direct financial incentives, which could be either rebates or tax concessions, the Energy Supply Association of Australia (2013, p. 6) noted that government support could also take the form of direct and indirect infrastructure provision; implementing appropriate planning arrangements; support for research and development; and consumer education. Time-of-use tariffs and full cost reflective pricing for electricity will also be critical to ensure optimal use of electric vehicle infrastructure.

The Business Council would support the government conducting a comprehensive review to find the most cost-effective measures to encourage take-up of electric vehicles in Australia.

Addressing congestion can reduce vehicle emissions

Policies to reduce road congestion can also have the effect of reducing vehicle emissions by improving the efficiency of vehicle use.

Addressing congestion is primarily aimed at reducing unproductive time spent in vehicles from sitting in traffic, but it will also have the benefit of reducing any additional associated emissions.

Road congestion can be addressed in essentially three ways: providing new transport infrastructure; better utilising the capacity of existing transport infrastructure; or managing demand.

There are significant steps that can be taken to provide new transport infrastructure or better use what we have. Investment in the public transport and road transport projects on Infrastructure Australia's priority project list will improve traffic flow and provide positive net returns to the community. Investment in intelligent transport systems hold potential for better using existing infrastructure. Existing cost-benefit analyses for infrastructure projects may undervalue the potential of intelligent transport systems for achieving reductions in congestion.

In the longer term, implementing cost-reflective road pricing reforms – as proposed by Infrastructure Australia and the Competition Policy Review – can assist in addressing congestion by ensuring a sustainable revenue base for providing infrastructure and by better aligning the provision of infrastructure with user demand.

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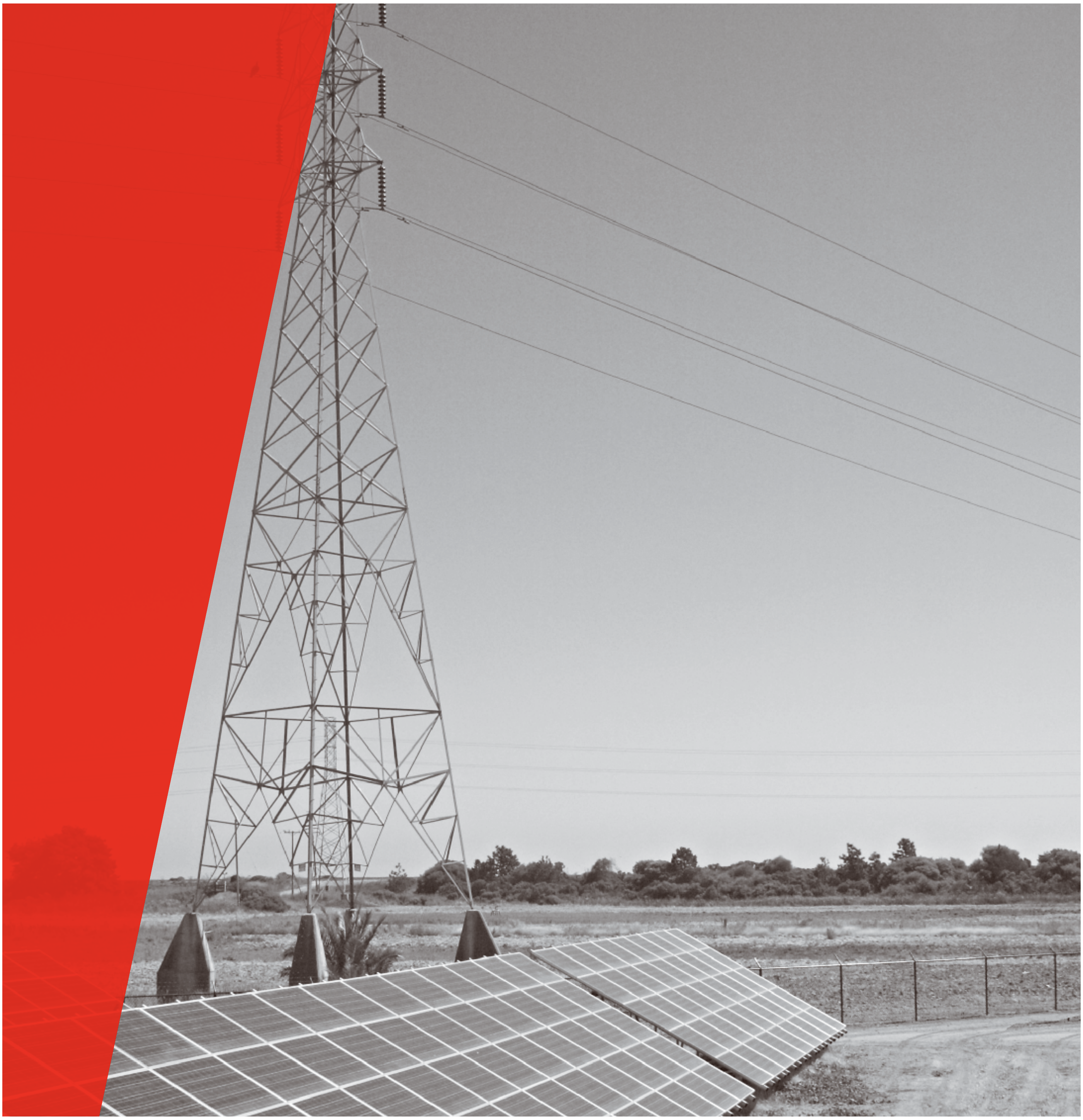

AUSTRALIA'S OPTIONS FOR EMISSIONS ABATEMENT

By Lodewijk De Graauw and Errol Levitt

BAIN & COMPANY

This report, commissioned by the Business Council of Australia, is the result of a research effort led by Bain & Company Partner Lodewijk De Graauw and Senior Advisor Errol Levitt.

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Additionally, we would like to acknowledge the cooperation of the Business Council and its members in the preparation of this report. We are grateful for their willingness to share their expertise with us.

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Executive summary

In August 2015, leading up to the United Nations Framework Convention on Climate Change in Paris, the Australian government announced a plan to reduce emissions by 26%–28% (compared with 2005 levels) by 2030. Following the agreement achieved in Paris, the world is coming together to limit emissions of greenhouse gases. Australia has joined the 'high-ambition coalition' of countries in favour of meaningful climate action.

Other countries in the coalition, such as the UK, have taken a longer view and aspire to an 80% reduction by 2050. If Australia were to adopt similar long-term aspirations to reduce emissions by over 80% (compared with 2005 levels) by 2050, it would imply cumulative reductions of nearly 10 gigatonnes (Gt) over the next 35 years, relative to our estimated reference case. Achieving such an outcome would require dramatic and simultaneous shifts in all emitting sectors.

Australia's electricity sector is in the early stages of the greatest technological disruption in its history. More energy-efficient technologies, combined with behavioural changes, will reduce electricity consumption per capita. This, in turn, will reduce emissions. At the grid level, zero-emissions renewable technologies are striving to reduce costs. The cost of grid-scale solar photovoltaic (PV) is falling rapidly, making it a particularly promising option. Meanwhile, providers of fossil fuel technologies are racing to find cost-effective ways to reduce emissions. The costs of carbon capture and storage (CCS) are currently very high and would have to decrease materially for CCS to play a meaningful role in power generation. Gas prices heavily affect the appeal of gas-fired power.

A range of uncertainties remain. The cost of grid-scale solar PV may not decline as far or as fast as expected. Gas prices could increase. Cost-effective and reliable battery storage may not become available as early as anticipated. Given these unknowns, it would also be prudent to consider a regulatory framework that could support nuclear power.

These discontinuities are occurring at the grid level, but distributed generation is challenging the grid's role. We expect penetration of zero-emissions rooftop solar to increase due to the way electricity is priced, even though this technology is not as cost-effective as centralised generation in urban or regional areas. In parallel with these developments in generation technologies, battery storage and electric vehicles will play an increasing role in emissions reduction over the longer term. In the context of this evolving technology landscape, further work will be necessary to determine the optimum policy, regulatory frameworks and market mechanisms to achieve the ideal balance between emissions reductions and incremental costs in the electricity sector.

Other high-emitting sectors have potential for emissions abatement. In land use, land-use change and forestry (LULUCF), policymakers could encourage better land management, including avoiding first-time land clearing and significant planting on private land. In transport, there is an opportunity to accelerate reductions in vehicle emissions. Although Australia has steadily reduced emissions from passenger vehicles over the past decade, absolute levels remain materially higher than in the EU and US. Both regions have also mandated further reductions. Australia has an opportunity to substantially reduce cumulative road transport emissions and can do so at a net benefit due to savings on fuel.

Although it will be extremely challenging, Australia has significant potential to reduce its greenhouse gas emissions in multiple sectors. The implied challenge for policymakers is how to achieve the targeted abatement in the most cost-effective way. Furthermore, as the abatement task that Australia sets itself increases, the marginal cost of each incremental tonne of abatement will increase. Our analysis suggests that the cost of domestic abatement will intersect with the cost of international carbon credits well before the target is achieved. This raises a second question for policymakers: What premium, if any, should be placed on a tonne of domestic abatement vs. a tonne of abatement elsewhere in the world?

Point of departure: Historical emissions in Australia

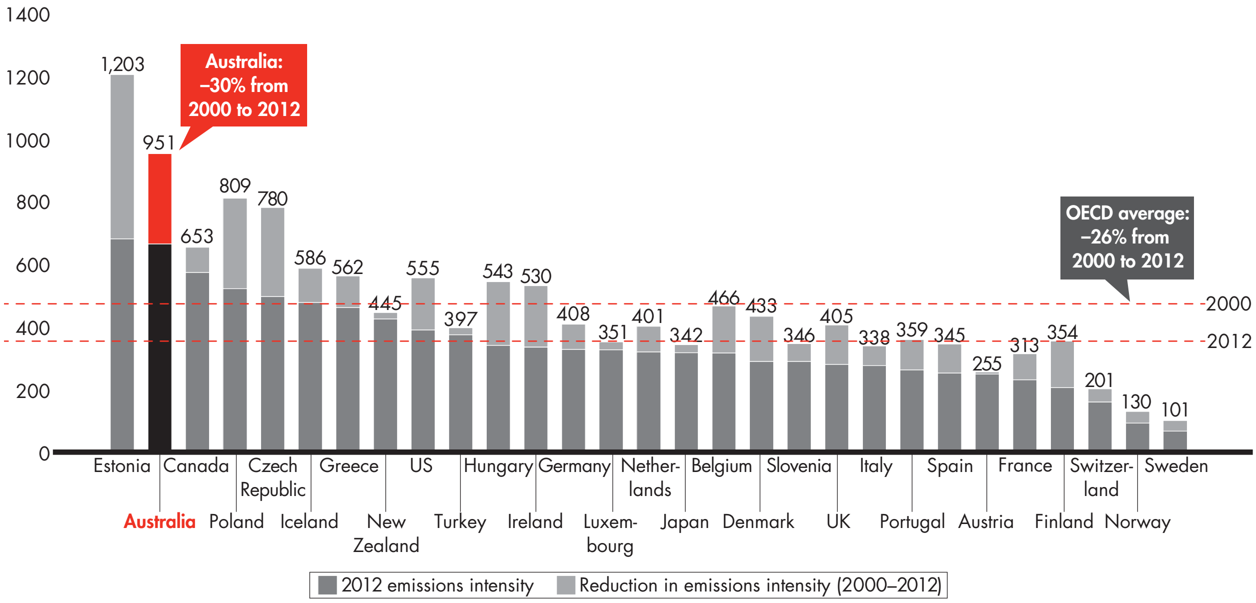
Australia is a small emitter in absolute terms, contributing approximately 1.4% of global emissions in 2012. However, it has historically had a high level of emissions per GDP and per capita. Between 2000 and 2012, Australia improved its record on both of these metrics, largely due to decreased deforestation, with relative reductions broadly in line with those achieved by other OECD countries.

Despite this improvement, Australia still has one of the highest emissions per GDP among OECD countries (see Figure 1). This is due mainly to Australia's high use of coal in power generation, high emissions from transportation (driven by both distance and emissions per kilometre travelled) and large primary sector (agriculture, mining and more recently natural gas extraction) relative to the rest of its economy.

Australia's total emissions are projected to increase by 22% between 2014 and 2030 and then plateau until 2050 (see Figure 2).[1] Continued growth in population and GDP per capita, as well as growth in production of liquefied natural gas (LNG), are long-term drivers that will contribute to this increase. Partially offsetting these factors will be improvements in energy efficiency, which will result in continued per capita reductions in electricity consumption.

Figure 1: Australia's emissions were second highest in OECD despite 30% decrease between 2000 and 2012

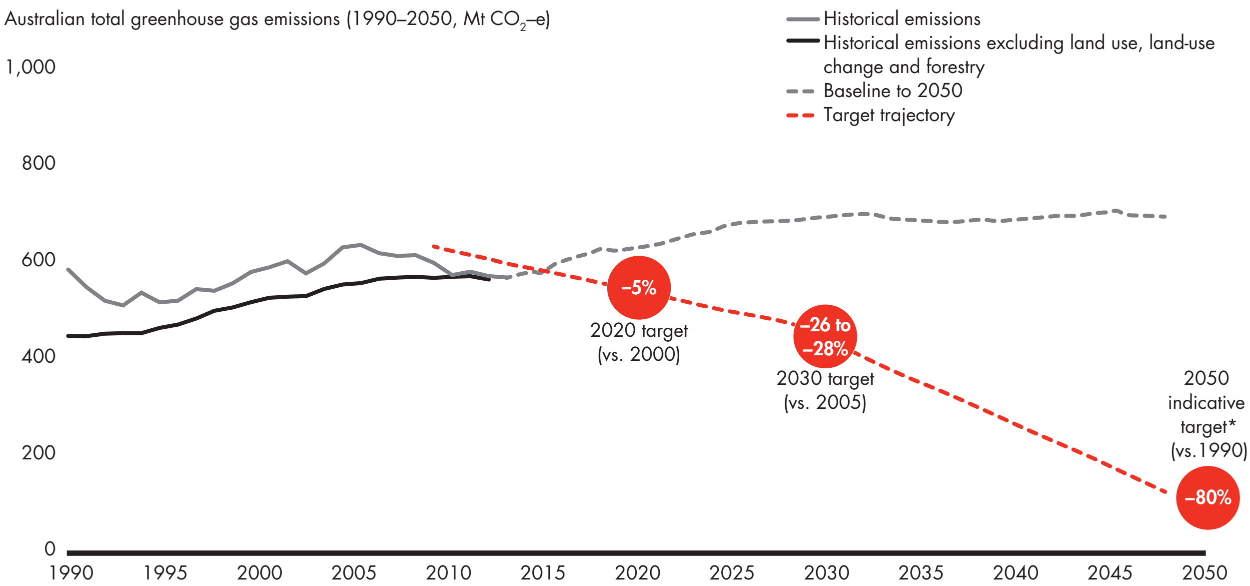
OECD countries' annual anthropogenic greenhouse gas emissions per GDP, 2000 and 2012, t CO_2–e/USD



Notes: Excludes Chile, Israel, Mexico, Slovak Republic, South Korea; GDP in real 2010 USD
Sources: National Greenhouse Gas Inventory; United Nations Framework Convention on Climate Change; OECD

1 Based on Department of Environments, 'Emissions Projections,' March 2015, for all sectors other than electricity, with adjustments made to factor in Emissions Reduction Fund (ERF); Bain forecast used to estimate electricity emissions baseline. Government forecasts have subsequently been revised downward.

Figure 2: Australia's 2030 emissions targets imply a cumulative abatement task of 1,700–1,800 million tonnes



*2050 target trajectory indicative only based on adopting similar target to UK; carryovers not considered
Notes: Abatement calculated relative to grey baseline projection; chart target line shown to 2030 is the midpoint (27%) of government range; Mt is million tonnes
Sources: DoE emissions forecast (March 2015); technical experts

Given Australia's stated emissions reduction targets, however, the nation cannot proceed with business as usual. This brief is designed to identify realistic directions that Australia could take to materially lower its greenhouse gas emissions domestically, on a sector-by-sector basis. It is designed to inform policy decisions about emissions abatement, using facts about and analysis of available sources of abatement and their associated costs. Government-enacted policies will ultimately determine who ends up carrying those costs. We leave that debate to politicians and other stakeholders.

The future: Options for lowering emissions

Bain & Company examined scenarios under which Australia could lower domestic emissions to pledged levels by 2030 and further reduce emissions by 2050. This longer time frame is particularly relevant because in some sectors—notably electricity—assets' lives can exceed 50 years. Capacity investments lock in technologies and resulting emissions outcomes for long periods of time.

Our research suggests that Australia can make the most headway towards lowering its emissions by focusing on three key areas:

- shifting its mix of power sources away from fossil fuels and towards renewables;
- better managing land use; and
- encouraging adoption of more fuel-efficient vehicles.

Changing the fuel mix in power generation and better managing land use together represent more than half of the total abatement potential in our high-case scenario *(see Figure 3)*. Both will come at a net cost to the economy. Improving vehicles' fuel efficiency, though representing a much smaller abatement potential, can bring significant net financial benefits to the Australian economy due to reduced spending on fuel.

Figure 3: Summary of 2014 emissions and abatement potential by sector

Production sector	Percentage of 2014 emissions	Abatement potential (Megatonnes carbon dioxide equivalent between 2015 and 2050 Mt CO_2–e)	
		Low case	High case
Electricity	33%	1,030	3,440
LULUCF	3%	530	2,110
Transport	17%	170	650
Other sectors	47%	830	1,610
Total domestic abatement potential	**100%**	**2,560**	**7,810**

Source: Bain analysis

The country must also make changes in other emitting sectors, such as agriculture, direct combustion, fugitive emissions, industrial processes and waste. Although there are relatively lower-cost abatement options in each of these sectors, they are highly fragmented.

For electricity, our low-case scenario reflects an electricity grid supply scenario with a transition from coal to gas by 2050. The high case represents an accelerated transition away from coal to renewables by 2035, in addition to increased rooftop solar PV, electric vehicle penetration and energy efficiency.

Energy efficiency is a significant driver of emissions abatement (most of which will also result in net savings to the economy), especially in the near term while the grid remains highly emissions-intensive. Over the past decade, Australia has achieved significant improvements in electricity use. Continuing this trend would reduce demand for electricity by 25% by 2050. In our high case, we have assumed that a further 10%–15% reduction is feasible, driven mainly by the introduction of more stringent standards on appliances and buildings (both residential and commercial).

Within transport, the low and high cases similarly reflect a range of vehicle emissions improvements, depending on the speed and strength of policy introduced, with the high end assuming that by 2020, Australia matches the European vehicle efficiency 2020 target for new cars and continues to strengthen the targets to match the EU's prospective 2025 target.

Across all other segments, the low case includes abatement options estimated to cost below $20 per tonne of carbon, whereas the high case expands those opportunities to those lower than $50 per tonne of carbon.

We conducted an in-depth analysis of opportunities in the power sector (which accounts for the greatest proportion of emissions) and higher-level assessments of the range of emissions reduction outcomes for LULUCF and transportation. The sections that follow discuss major drivers and cost trade-offs for these three sectors.

Power generation: Building tomorrow's energy sources

Electricity was the largest contributor (33%) to Australia's emissions in 2014. Baseline demand for electricity is expected to grow by 1% per year, reaching approximately 330,000 gigawatt hours (GWh) by 2050.[2]

However, the sector also has the greatest potential for emissions reduction. On the demand side, improved energy efficiency is putting downward pressure on consumption. Australia has made significant improvements in efficiency of electricity use over the past decade (across buildings, appliances and industrial applications). Partly as a result of this, there is now a large surplus of generation capacity. Despite the current capacity excess, new investment in renewables will occur over the next 5 to 10 years to meet the legislated renewable energy target. New system capacity to meet demand growth will likely only be needed by 2030, buying time for improvements in technology and cost.

New investments in capacity will only occur if expected unit revenues (market or contract unit prices plus subsidies) are at least equal to the levelised cost of energy (LCOE)[3] for the chosen technology. It is therefore instructive to estimate how relative LCOEs will change over time, assessing the impact of key drivers such as technology experience curve effects and forecast fuel prices, especially for gas.

Based on existing LCOE analysis, together with input from a range of technical experts, we estimate the following LCOEs for Australian energy sources (see Figure 4):

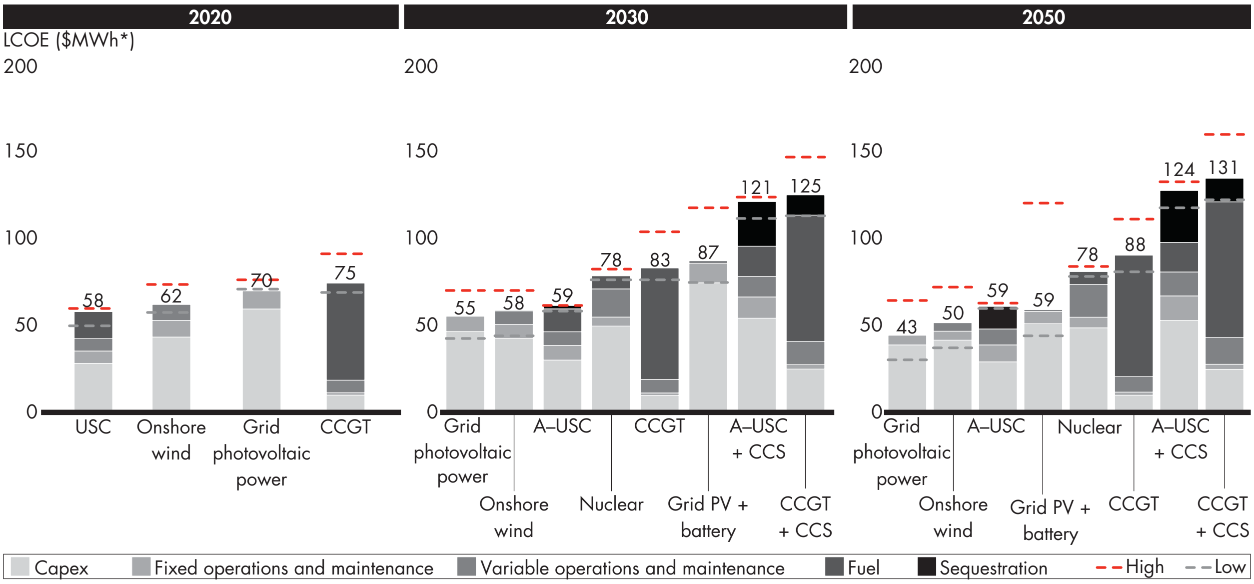
- **By 2020.** New black coal is likely to still have the lowest cost at $58. It is followed by onshore wind at $62, grid-scale PV at $70 and combined cycle gas turbines (CCGT) at $75.
- **By 2030.** The costs of grid PV and onshore wind are expected to be similar to new coal at about $58, but without battery storage, so the use of these intermittent sources would be capped at roughly 10% for solar and 40% for wind to retain system reliability. Grid-scale battery storage technology is expected to be commercially available by this time, but its application to solar energy will likely push the combined cost beyond that of coal, nuclear and CCGT. CCS will also be available, but applied to either coal or gas, the combined cost of over $125 is projected to be significantly higher than that of all other energy sources.
- **By 2050.** Grid solar PV is expected to be the most cost-effective option at about $43. Onshore wind is estimated at $50, and new coal and grid solar with battery storage are both at $59 (but with a much broader range of uncertainty around solar). Nuclear and CCGT will still cost more, in the $78–$88 range. Fossil fuels with CCS will remain prohibitively expensive at over $120.

These estimates lean heavily on the assumption that the cost of solar energy will continue to decline rapidly (see the sidebar 'Australia's solar opportunity'). We also assume that the opening of Australia's east coast energy market to LNG exports may lead to increases in domestic gas prices (Australian dollars per gigajoule) of $8.30 in 2020, $9.90 in 2030 and $10.90 in 2050. These increases could be ameliorated if oil prices remain at current low levels over the long term.

2 'Behind the metre' demand as met by distributed and grid electricity, including 2% transmission losses.

3 LCOE is a standard way to compare distinct electricity generation methods. It takes into account the average total cost to build and operate a power source, divided by its total output over its lifetime. In this report, LCOEs are expressed in Australian dollars per megawatt hour (MWh). These values represent the minimum cost at which electricity must be sold for a project to break even over its lifetime.

Figure 4: We estimate grid photovoltaic power will be the same range as new coal by 2030



*Real 2014 $AUD have been used throughout this report
Notes: We assume a 50-year amortisation period for fossil technologies and a 30-year period for renewables; nuclear waste costs not included
Sources: ACIL Allen (2014); 'Australian Energy Technology Assessment,' (BREE 2012 and 2013); EPRI; IEA; interviews with technical experts

We used a scenario approach supplemented by sensitivity analysis to make sense of demand and supply uncertainties. The bulk of Australia's emissions come from grid-level power generation in the east coast National Electricity Market (NEM) and west coast South West Interconnected System (SWIS). We modelled outcomes for these two grids under 12 distinct plausible fuel mix scenarios. We then tested sensitivities to changes in energy efficiency, electric vehicle penetration and distributed energy penetration. The twelve fuel mix scenarios were chosen to cover likely bounds on two dimensions:

- continued growth in coal, with and without CCS;
- declining use of coal and replacement by:
  - gas on an ongoing basis,
  - gas then nuclear,
  - gas then renewables, and
  - renewables on an ongoing basis.

Timing choices for the coal decline scenarios assume retirement of all plants by 2050 (which broadly matches the technical retirement profiles of the fleets) and accelerated retirement by 2035. We did not include additional costs in our analysis for the early closure of coal plants in advance of their technical retirement.

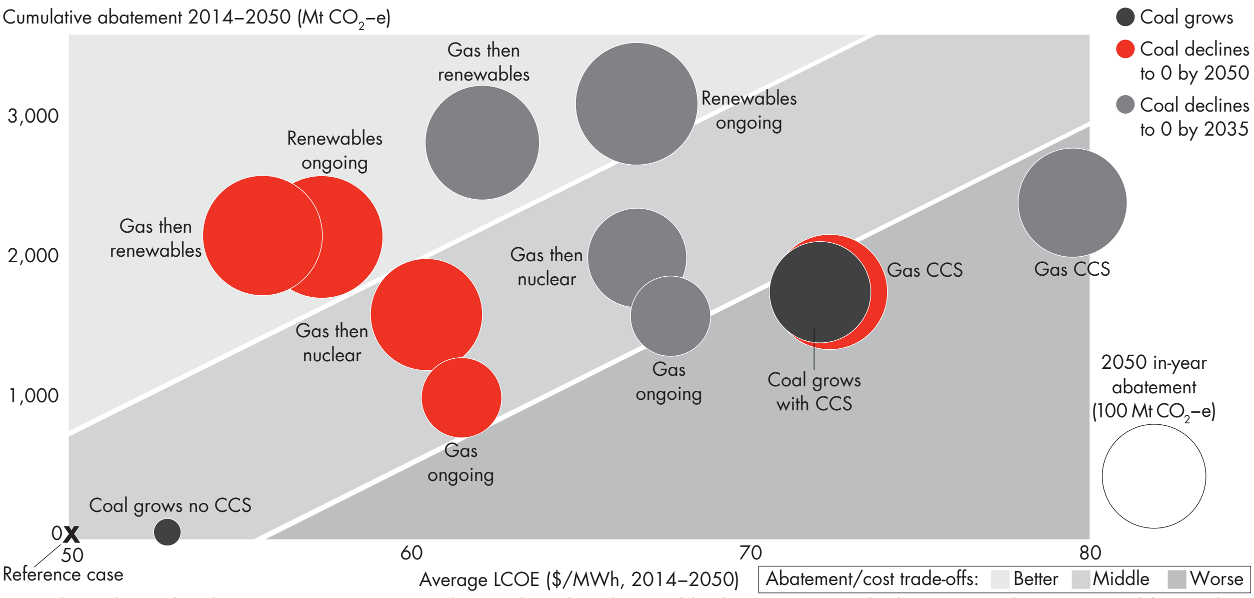
In our scenario analysis, we mapped each scenario's cumulative abatement between 2014 and 2050 and its average LCOE over the same period (see Figure 5). The analysis shows that there is typically a trade-off between cost and abatement. However, for any given LCOE, we assert that the scenario with the higher abatement would be preferable. On this basis, four scenarios emerge as providing more abatement at similar or lower costs compared with the other scenarios.

- Coal declines to zero by 2050 and is replaced first by gas, then renewables.
- Coal declines to zero by 2050 and is replaced on an ongoing basis.
- Coal declines to zero by 2035 and is replaced first by gas, then renewables.
- Coal declines to zero by 2035 and is replaced by renewables on an ongoing basis.

Among the four scenarios, there are still complex choices to be made regarding the speed of the phaseout of coal and the extent to which new gas capacity is added during the transition to renewables. These choices will be made gradually over time and will continue to be influenced by a wide range of uncertain factors.

Phasing out coal by 2050 would reduce cumulative emissions by 2,140 Mt and result in an average estimated LCOE of about $56. A faster transition, in which coal phases out by 2035, would reduce cumulative emissions by 2,780 Mt over the period up to 2050. However, this transition would be risky and costly, unless the performance and costs of grid-scale solar energy and battery storage drop even faster than expected.

Figure 5: Based on expected costs, renewables options have the best mix of abatement and cost



Notes: This simulation is based on optimising system capacity with system demand; we determined the plant in year capacity by short run marginal cost; we assumed the natural gas price (Australian dollars per gigajoule) of $8.30 (2020), $9.90 (2030), $10.90 (2050); all costs are represented in real 2014 AUD; the cost for reference case is indicative only; CCS=Carbon Capture and Storage
Sources: ACIL Allen (2014); BREE (2012 and 2013); EPRI (2014), ESAA (2014), IEA (2015); technical expert interviews

Battery storage is a critical enabler for the penetration of solar and wind energy, given their intermittent nature. Batteries are expected to improve rapidly both in cost and capacity, with learning rate improvements of 7% to 14%. Reliable grid-scale lithium-ion batteries are expected to be commercially available by 2030. If this development fails to materialise, penetration of solar and wind energy would be limited.

Furthermore, if gas prices increase less than expected, CCGT's cost-competitiveness would improve. This could lead to a larger degree of gas substitution in the medium term, though emissions outcomes would be less favourable than grid-scale solar PV (or nuclear). In addition, if the cost of capital increases beyond the 7% assumed in this analysis, the attractiveness of CCGT would increase relative to other, more capital-intensive technologies.

CCS has significant potential to reduce emissions, but present indications suggest it will not be cost-competitive for electricity generation.

Meanwhile, nuclear technology providers are innovating to improve safety and reduce scale through ongoing improvements of Generation III to incorporate passive safety features and the development of small modular reactors (SMRs).

Australia's solar opportunity

By 2030, grid-scale solar PV is expected to reach parity with coal as Australia's cheapest newly installed source of energy. Because of the great opportunity solar energy presents for both reducing emissions and lowering costs, we believe this power source is worth exploring in more depth.

With a direct normal irradiance (DNI) of roughly 6 kilowatts per square metre per day, Australia is one of the sunniest places on Earth. The country is also endowed with large open areas where solar farms could be built, though the economic viability of these areas may be constrained by the availability of nearby transmission and distribution infrastructure.

In this favourable environment, solar PV energy is becoming more cost-effective. The two main determinants of LCOEs for solar PV are decreasing costs and increasing module capacity. In the past, solar PV has had high upfront capital costs and small ongoing fixed costs. However, thanks to technological advancements such as reduced wafer thickness, increased uptime and throughput of production equipment, and decreases in polysilicon prices (panels' main raw material), these capital costs are on the decline.

In fact, module costs have decreased by roughly 90% since the early 1990s. And, capital costs of utility solar are expected to continue falling 1.7% per year until 2050.[4] Future cost improvements could come from increased module efficiency (which could reach 24%–35% by 2050), economies of scale in module manufacturing, and lessons in panel orientation and processes from large-scale installations.

Note that these estimates apply to grid-scale solar energy. The LCOE of grid-scale solar is lower than rooftop solar due to the grid's economies of scale. In addition, utility-scale installations tend to capture more sun due to better location and orientation, unobstructed by trees and buildings.

Whereas grid-scale solar will reach cost parity with coal by 2030, rooftop solar generation has already reached 'socket parity' at the household level, meaning that the cost of solar energy is equal to or lower than the retail price of electricity. This parity results from current tariff mechanisms that bundle utilities' fixed and variable costs into single, largely variable rates. As a result, owners of rooftop solar panels who reduce their energy consumption from the grid pay less than their fair share of the fixed cost of the grid, which is effectively subsidised by other consumers (or squeezed from the utilities' margins).

It is likely that tariff mechanisms, especially for the networks, will need to be reviewed to better reflect the fixed cost structure of providing services. If this does not happen, penetration of rooftop solar and other distributed energy sources will continue to decrease grid usage, putting pressure on asset values and increasing total system cost. On the other hand, new tariff mechanisms may reduce returns on investment in rooftop solar. By making necessary fee adjustments and supporting innovation, Australia can lead the world in embracing grid-scale solar.

4 Agora, Current and Future Costs of Photovoltaics, 2015

Land use: Rebuilding Australia's forests

Between 1990 and 2014, emissions from the LULUCF sector decreased by 120 Mt predominantly due to decreased deforestation. Keeping trees in the ground made LULUCF the biggest contributor to Australia's overall emissions decreases over that period.

Beginning in the 1990s, there was also a significant increase in the level of annual planting, following the introduction of managed investment schemes, with a total of 1.2 million hectares of land planted between 1990 and 2013.

This trend may soon reverse. The Department of the Environment forecasts deforestation to increase approximately 50% beyond current levels in the near term and then subside. Regulatory reforms enabling land clearing, together with rising agricultural prices creating incentives to repurpose land for farming, have led to the increase in deforestation.

However, preservation of forests is a key priority of the agreement achieved in Paris. The agreement recognises the importance of forests for offsetting the impact of human activity and encourages nations to reduce deforestation and commit to sustainable forest management. By tightening policies to avoid a large portion of the anticipated first-time land clearing, Australia could achieve 530 Mt of abatement by 2050, at a cost of approximately $15 per tonne, reflecting our "low case."[5]

Afforestation and reforestation (planting trees on land without forest and on land that recently contained forest, respectively) can provide up to 1,580 Mt of further abatement. This could be accomplished through environmental planting and significant permanent planting on private land within Australia's agricultural belt.

This level of abatement would require unprecedented levels of planting, requiring coverage of more than five times the area planted between 1990 and 2013. This would carry an average cost of $39 per tonne. Some projects may be able to be completed less expensively, however, such as those that have already benefitted from the Emissions Reduction Fund (ERF).[6]

5 RepuTex, 'The Lost Years—An updated Marginal Abatement Cost Curve for Australia to 2030'; Bain analysis

6 The volume of these abatement options for LULUCF and across sectors has been used to adjust baseline.

Transportation: An unexpected equaliser

Transport made up 17% of Australia's emissions in 2014, with the majority coming from road transport. Emissions from this sector are expected to grow over time as the country's population and economic activity increases.

Although several opportunities exist across the road transport sector, the greatest opportunity is in the passenger vehicle segment. Australia's passenger vehicle emissions per capita and per GDP are very high relative to other developed nations. This is partly due to Australia's large land mass. It is also the result of large, inefficient vehicles popular among Australians and the country's relatively weak emissions standards. Passenger vehicle emissions per kilometre in 2012 were higher than in the EU and the US, which both have mandatory vehicle fuel efficiency standards.[7]

Electric vehicles are an often-cited example of greater fuel efficiency. Interestingly, though they do result in a net emissions reduction, their impact in the short term tends to be overestimated. Electric vehicles use less energy than conventional ones but they are still powered by electricity—which today is largely generated by burning coal. In any case, more Australians will purchase electric vehicles as technology matures and cost decreases. Electric vehicles' abatement impact will increase in the longer term as the grid fuel mix shifts to lower-emissions sources.

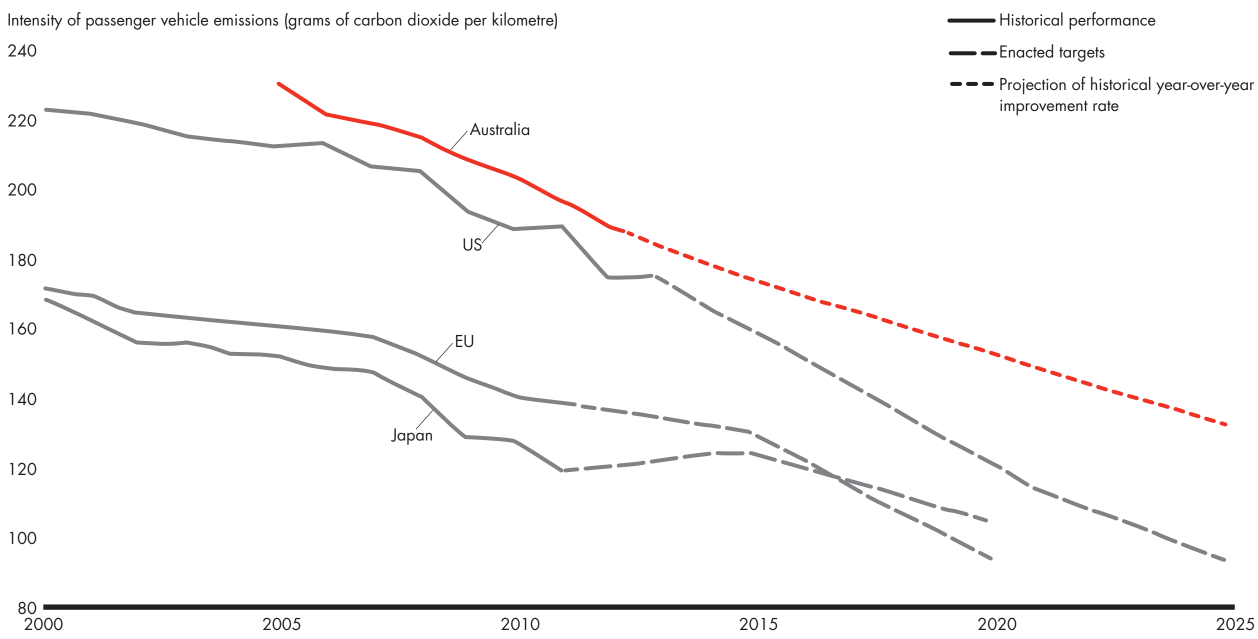
Since 2005, the efficiency of Australia's passenger vehicles has improved at a rate of 2.8% per year, but from a high starting point. Countries with more efficient fleets have demonstrated that further improvement is possible (see Figure 6). For example, fuel efficiency has improved annually in Japan by 3.3%, in the US by 2.7% and in the EU by 2.3%. Depending on how aggressively fuel efficiency standards are pushed and smaller vehicles are encouraged, Australia could achieve up to 600 Mt of cumulative abatement by 2050 from passenger vehicle improvements alone, and a further 50 Mt from the remainder of the transportation sector. That assumes that by 2020, Australia matches the European vehicle efficiency 2020 target for new cars and continues to strengthen the targets to match the EU's prospective 2025 target.

This abatement could come at a significant benefit to the economy, simply because smaller and more efficient cars burn less fuel. A simple calculation illustrates this. Assume that Australia can reduce the average fuel consumption of its passenger vehicles over time from 11.3 to 5.6 litres per 100 kilometres travelled, which is the enacted target for new vehicles in the EU today. Across a fleet of 13.5 million passenger vehicles and an average of 15,500 kilometres travelled per vehicle, that translates into roughly 12 billion litres of fuel saved, or $7.7 billion per annum (assuming a cost of petrol of 65 cents per litre, excluding taxes and retail margins).

These benefits will be offset by higher upfront costs of some of the technologies that drive fuel efficiencies (such as direct injection and lean burn engines), as well as the intangible cost of limitations on consumer choice. Overall, however, we believe transportation is one of the few abatement levers that could come at a substantial net financial benefit and should therefore receive due attention.

7 Climate Change Authority, 'Light Vehicle Emissions Standards for Australia,' 2014

Figure 6: Improvements to the fuel efficiency in cars will lead to potential transport abatement



Source: Climate Change Authority, 2014

Uniting our efforts: Australia's abatement potential

If Australia takes advantage of all abatement opportunities assumed under the high-case scenario, it could achieve 95% of its current 2030 target before carryovers domestically. This scenario would result in 1,650 Mt in cumulative abatement between 2015 and 2030 relative to our reference case, implying that Australia would have to purchase 50–150 Mt worth of international carbon credits to meet its target. However, this scenario would require dramatic and simultaneous shifts in all emitting sectors and assumes that domestic policy triggers opportunities up to $50 per tonne, which is likely to substantially exceed the international price of carbon.

Looking ahead to 2050, we believe Australia can achieve the large majority of an ambitious target of 10 Gt in cumulative reductions domestically. But the economic implications of emissions abatement will vary widely across stakeholders. For example, energy companies may be burdened with substantial costs, while others, such as car owners, may see net financial benefits.

Meeting abatement targets while fairly distributing costs and benefits will not be easy. But Australia's policymakers must act. The coming years will determine what the country's energy future—and its contribution to global emissions reductions—will be.

We see three key questions for policymakers to consider going forward:

- How can policies be enhanced to target the most cost-effective abatement opportunities and minimise total system cost?
- How can costs be distributed fairly if certain sectors or constituents of the economy are impacted disproportionately?
- To what extent should Australia rely on international carbon permits if the marginal cost of abatement domestically exceeds the cost of abatement elsewhere?

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