Business Council of Australia

submission

Senate Inquiry on Unconventional Gas Mining

APRIL 2016

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

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 Senate Select Committee on Unconventional Gas Mining. Unconventional gas will be critically important in securing Australia's future gas supply as a source of export revenue, a feedstock to business and to assist in transitioning Australia's economy to a lower-carbon future. To develop these resources requires a robust regulatory framework that manages risk and addresses community concerns. To not responsibly develop these resources would be a missed opportunity for Australian economic growth.

This inquiry is a chance to identify and agree on the features of a national approach to the regulation of unconventional gas resources.

The Business Council respectfully requests that this submission, and its attachment (a report prepared by Bain & Company for the Business Council), be kept confidential until such time as the Bain report is released by that company. We will advise when this submission is able to be made public.

Key recommendations

The Business Council recommends the Committee support:

- the responsible, safe and sustainable development of Australia's natural gas resources
- a stable, efficient and evidence-based regulatory environment for gas development
- addressing the regulatory barriers to gas development, including:
  - removing duplication of regulation between Commonwealth and state governments, including the water trigger under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
  - streamlining and improving existing state approval processes, regulation and administration
  - removing the moratoria on exploration and fracking following community consultation and based on scientific evidence.

The Business Council also recommends that:

- Australian governments seek to further engage independent authorities such as gas and land use commissioners, the independent scientific committee and CSIRO in community consultation on the science and safeguards supporting unconventional gas development to expedite priority gas projects.

Priority gas projects could also be further expedited by:

- providing additional resources and expertise to the government administration of project approvals processes and/or National Productivity Payments.

Background

Affordable and reliable gas supply is essential to Australia's energy security and economic growth. A stable gas policy is critical for ensuring a continued supply of gas, which is a

vital energy source for many homes along with agricultural, mining and manufacturing businesses, and will play an important role in our transition to a lower-emissions future.

Australia has the 11th largest gas reserves in the world but our conventional gas reserves are declining.[1] However, the role of gas from unconventional reserves could easily replace this, with eastern Australia's coal seam gas (CSG) resources four to seven times larger than established 'conventional' resources.[2] Today unconventional gas accounts for more than 90 per cent of proven and probable reserves on the east coast and already 40 per cent of the gas produced on the east coast.[3]

The Australian Energy Market Operator (AEMO) notes that, as current proved and probable reserves start to decline from 2019, currently undeveloped gas reserves and contingent and prospective resources will be required to meet forecast demand.[4]

The case for developing unconventional gas

Economic benefits for Australia

The expansion of the Liquefied Natural Gas (LNG) sector brings economic benefits such as increased employment, infrastructure investment and will deliver significant additional revenue to Australian governments and shareholders. LNG exports will be a strong driver of future economic growth and is forecast to earn export revenue of almost $45 billion by 2019-20 (against $17 billion in 2014-15) as a result of expected increased exports of approximately 80 million tonnes (up from 23 million tonnes in 2013-14).[5]

Gas is crucial for Australia's energy security

A stable supply of gas is crucial to meet Australia's energy demand. AEMO has forecast that conventional gas reserves will start to deplete from 2019. However, from 2020 to 2025 gas-powered generation is projected to increase, to support electricity consumption and the withdrawal of some coal-fired generation assets across the National Electricity Market.[6]

AEMO has also noted that the majority of current proven and probable conventional and unconventional gas reserves will be taken up by LNG exports, so the domestic market will require new development of contingent and prospective reserves to meet forecast demand from 2019 to 2035.[7] AEMO expects unconventional gas to supply three times more than conventional sources over the period 2016–2035.[8]

[1] Department of Industry 2014, *Eastern Australia Domestic Gas Market Study,* p. 22.

[2] Council of Australian Governments 2015, *Gas Supply Strategy,* 4 December 2015, p. 1.

[3] Dr Malcolm Roberts, Chief Executive APPEA, Speech to EUAA National Conference, Sydney, 6 October 2015.

[4] AEMO 2016, *Gas Statement of Opportunities,* p. 2.

[5] Office of the Chief Economist 2015, *Gas Markets 2015,* p. 19.

[6] AEMO 2016, op. cit., p. 10.

[7] AEMO 2016, op. cit., p. 1.

[8] AEMO 2016, *Gas Statement of Opportunities,* p. 16, notes that 30,616 PJ of CSG reserves and 9, 162 PJ of conventional gas will be required to meet forecast demand.

The challenge is to ensure that gas producers can access new gas resources to meet domestic and international demand at the lowest possible cost. Increasing Australia's gas supply is the best way to ensure that Australia can access a reliable and competitively priced supply of natural gas.

Gas will be required to decarbonise Australia's economy

A range of electricity generation technologies will be required to meet Australia's future emissions reduction targets. Bain & Company has prepared a report (attached) on Australia's options for emissions abatement.

Highly efficient, combined-cycle gas turbines produce one-third of the emissions of brown coal-fired electricity generators and half the emissions of black coal-fired generators. Gas-fired power stations could also have a vital role to play in providing lower emission electricity at times when wind and solar resources are unavailable. Bain estimate that it could be 2030 before a grid-scale lithium-iron battery is commercially available in Australia.

The Bain report found that changing the fuel mix of Australia's electricity generation sector could play a significant role in reducing Australia's greenhouse gas emissions at relatively low cost (compared to other sectors).

However, these estimates lean heavily on two assumptions: the cost of solar energy will continue to decline rapidly; and that the opening of Australia's east coast energy market to LNG exports leads to only relatively modest increases in domestic gas prices due to increases in gas supply ($8.90 per gigajoule in 2020, $9.80 in 2030 and $10.70 in 2050).

With current restrictions on new gas supplies, such as moratoria on the development of new unconventional gas, this could lead to higher than anticipated domestic gas prices to the point where nuclear technology may be a more cost-effective alternative for Australia's future baseload, lower emission electricity supply.

Bain & Company found that nuclear should be considered as an insurance policy against future gas price rises in Australia. However, increasing Australia's gas supply and enabling economies of scale to deliver lower-cost projects is the best way to ensure that Australia can access a reliable and competitively priced supply of natural gas to support the transition to a lower emissions economy.

Australia has safely produced unconventional gas for 20 years

A well-designed and efficient environmental assessment framework is important for giving investors and the community the confidence that the formal assessment and approval of projects by governments will be managed well. Such a regime for the development of natural resources is required because these resources should be developed for the benefit of the Australian community.

A stable and effective regulatory regime should also provide the community (and indeed business) with confidence that activities have the appropriate safeguards to manage multi-land use and minimise the risk to the environment.

The Business Council notes the number of concerns raised in submissions to this inquiry around the impact unconventional gas may have on water resources and issues surrounding access by gas companies to privately held agricultural land.

Like other activities in our economy, gas development comes with some risks. These risks are generally well known and can be managed through engineering, technologies, and best practice. Many of these solutions have been successfully employed in the natural gas industry for several decades.

The Australian Academy of Technology and Engineering noted in December 2015 that where best practice is followed, unconventional gas can be produced in a manner that is environmentally responsible and that provides significant societal benefits.[9]

Australia has been producing coal seam gas safely for the past 20 years. Gas companies invest in these practices for the safety of their workers, the integrity of their operations, and for the protection of the environment. It is in their interest to do so.

These practices, combined with effective and scientifically based regulatory arrangements, need to be better explained to build community confidence in the safe and environmentally responsible development of our gas resources.

Gas producers too have a responsibility to work with landholders and communities to understand their concerns, and explain how risks are managed early in the process.

Industry and government need to work with the community in an open and transparent manner to realise the mutual benefits of Australia's natural gas resources. Good communication and transparent information-sharing with communities in the early stages of gas development are key to providing the community with the information they need to make their own assessments.

State and federal governments collectively are encouraged to facilitate gas projects that meet approved environmental standards, as these standards are designed by experts in the field to appropriately manage the risk of natural gas development.

Current regulatory approaches are impeding investment

The safe, environmentally responsible and timely development of Australia's gas resources requires a stable and efficient regulatory regime. Any regime should be risk-based and informed by science.

Stability provides investors with the confidence they need to make long-term capital-intensive investment decisions in new gas developments. Without a stable investment environment, decisions to invest will not occur and new gas supplies will not come into the market.

Moratoria on hydraulic fracturing still exist in Tasmania and Victoria and it is possible that a ban on fracking could be implemented in the Northern Territory, depending on the August 2016 election result (which would also impact the viability of the new Northern

[9] Craig Simmons 2015, 'Massive Challenges, but We Must Meet Them', *ATSE Focus, December 2015,* p. 5.

Territory gas pipeline). The development of unconventional gas supplies in New South Wales has also proved extremely difficult.

Governments need to urgently address the regulatory barriers to gas development, including:

- removing duplication of regulation between Commonwealth and state governments, including the water trigger under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
- streamlining and improving existing state approval processes, regulation and administration
- removing the moratoria on exploration and fracking following community consultation and based on scientific evidence.

Better and earlier community engagement is needed by industry alongside the replacement of these bans with a robust regulatory regime that ensures best-practice environmental standards and land-use practices.

The Business Council welcomes some positive moves in this area such as:

- The adoption by the COAG Energy Council of the National Harmonised Regulatory Framework for CSG, which implements a suite of leading best-practice principles focused on technical aspects around managing CSG development, and the Gas Supply Strategy.
- The establishment of the Queensland Gasfields Commission, which has been a positive step towards building community trust in the industry.
- The recent report by the Western Australian Parliamentary Standing Committee on Environment and Public Affairs that recommended establishing consultation processes; an information disclosure regime; and a statutory body, along the lines of the Queensland Gasfields Commission, to act as independent arbiter.
- processes in train to overhaul exploration licences in New South Wales.

However, uncertainty continues to be compounded by the duplicative assessment of water through the ‘water trigger’ provision in the *Environmental Protection and Biodiversity Conservation Act 1999* for CSG activity, which should be removed. The ‘water trigger’ provision was implemented in the absence of a Regulatory Impact Statement to assess the costs and benefits of the proposal (including any identified environmental benefit), without genuine stakeholder consultation, and with little regard for the unnecessary duplication of existing state responsibilities regarding water resources and the uncertainty created for affected projects.

The Business Council is preparing a report into ‘Competitive State and Territory Planning Systems’ that articulates a best-practice model for planning systems to encourage the efficient delivery of major projects. The plan includes a central role for strategic plans, restructuring planning institutions for better co-ordination and establishing community participation processes to assess the merits of a specific project. We would be happy to elaborate further on this project if the Committee would like more information.

Recommendations

Given the significant economic benefits to Australia and the important role gas will play in ensuring our energy security and the decarbonisation of our economy, the Committee should consider recommendations to support the responsible, safe and sustainable development of Australia's gas resources with a stable, efficient and evidence-based regulatory environment for gas development.

Any regime should address the regulatory barriers to gas development by removing duplication, streamlining state regulation and administration and by removing moratoria. It should include evidence from independent authorities such as gas and land use commissioners, the independent scientific community and provide mechanisms for early consultation by gas companies with the community.

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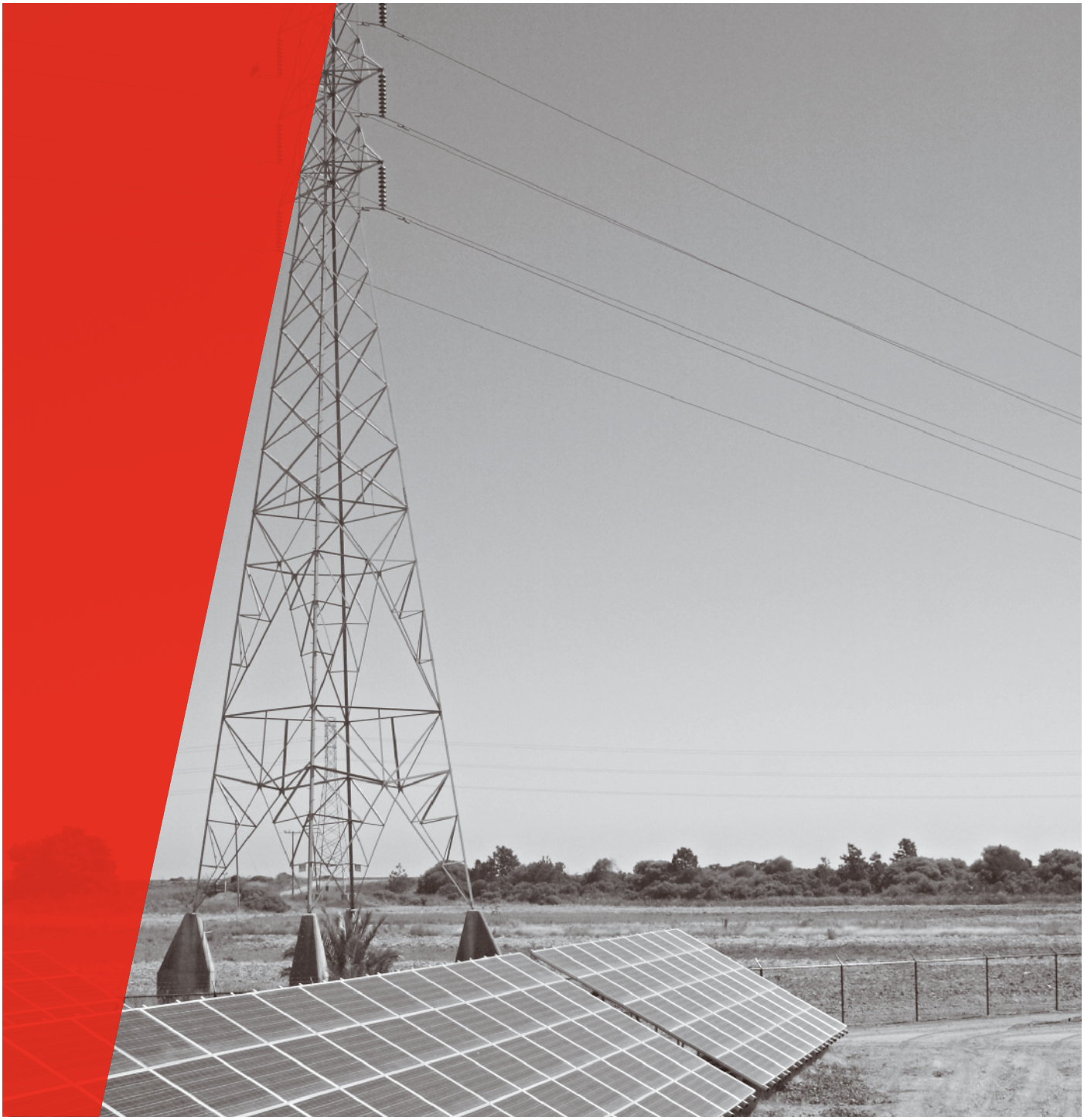

AUSTRALIA'S OPTIONS FOR EMISSIONS ABATEMENT

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

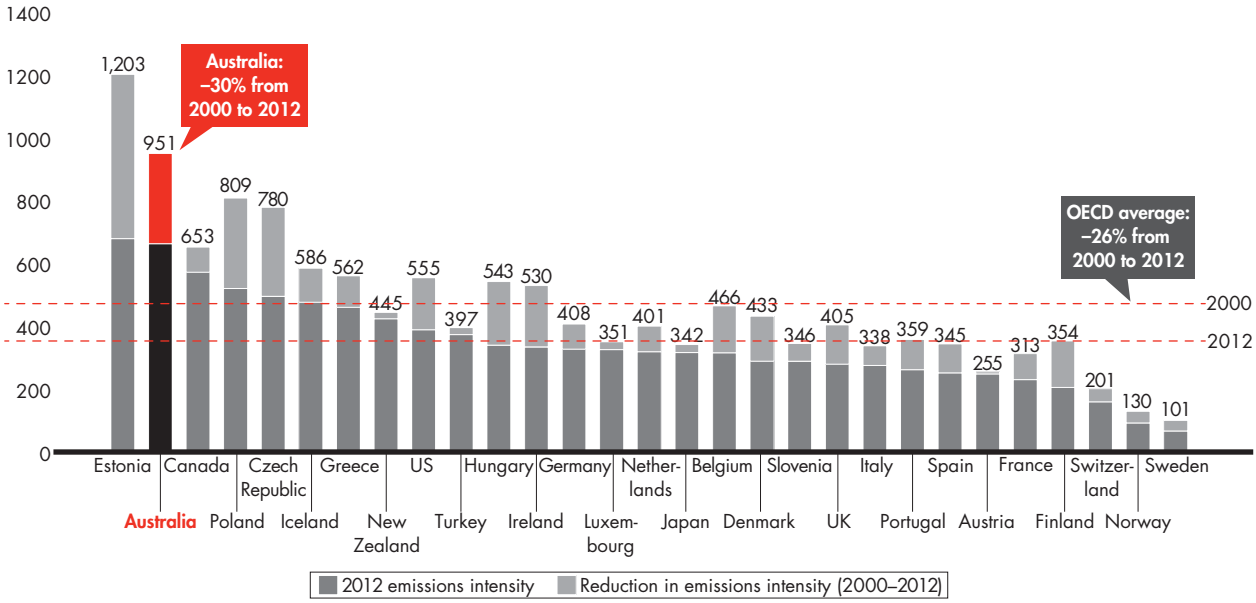
Australia is a small emitter in absolute terms, contributing approximately 1.4% of global emissions in 2012. However, it has historically had a high level of emissions per GDP and per capita. Between 2000 and 2012, Australia improved its record on both of these metrics, largely due to decreased deforestation, 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

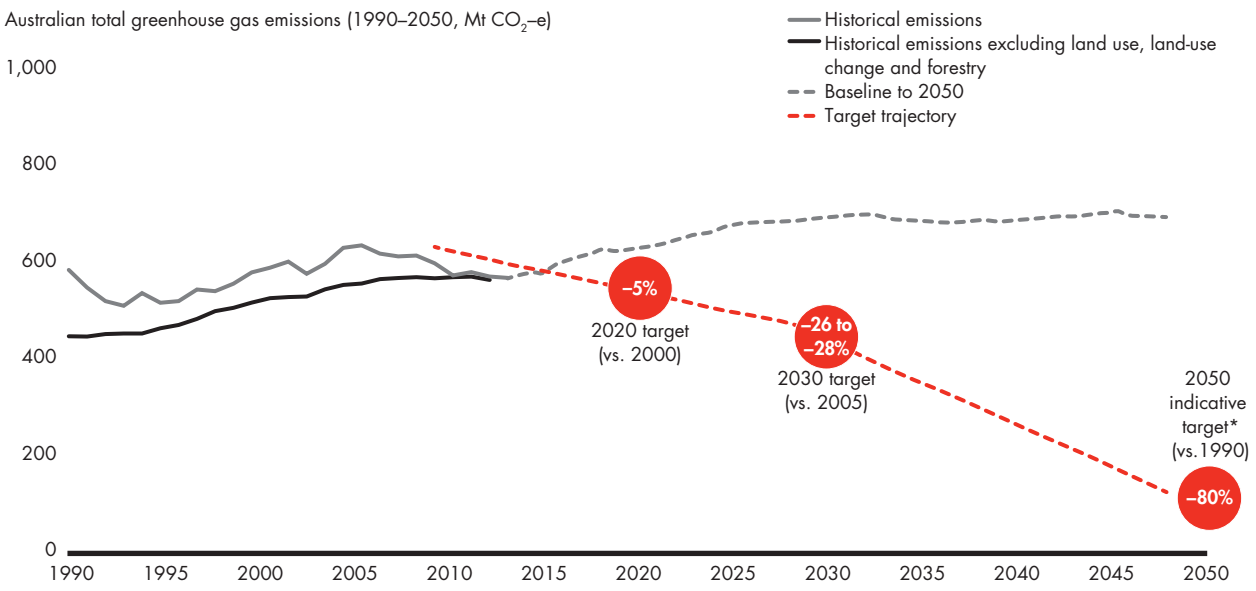
OECD countries' annual anthropogenic greenhouse gas emissions per GDP, 2000 and 2012, t CO_2–e/USD



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.

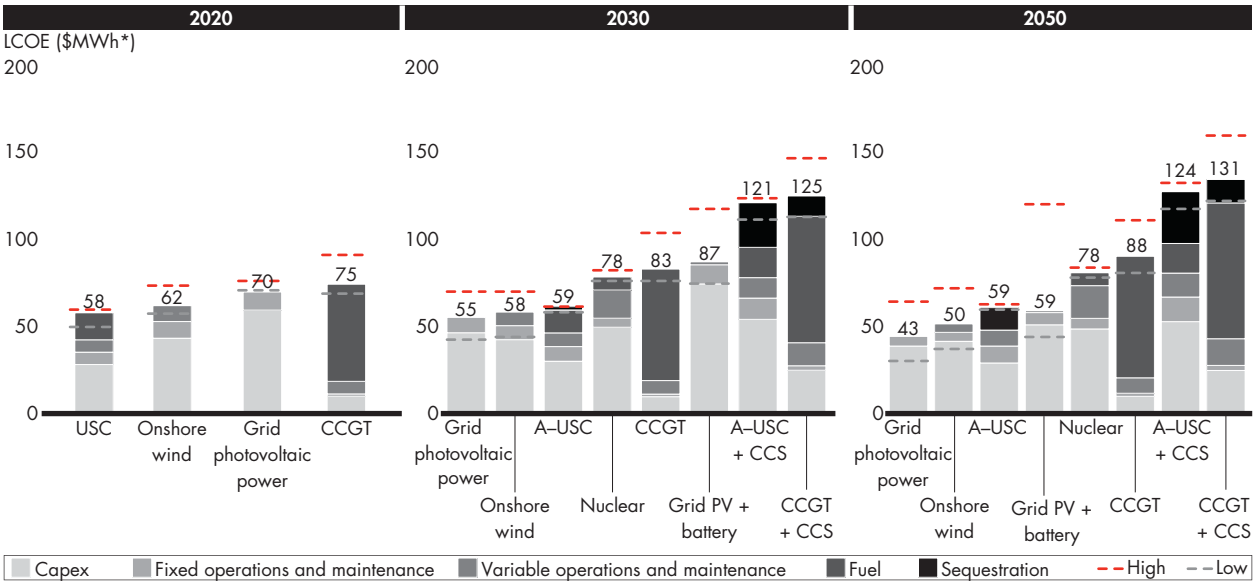
- **By 2050.** Grid solar PV is expected to be the most cost-effective option at about $43. Onshore wind is estimated at $50, and new coal and grid solar with battery storage are both at $59 (but with a much broader range of uncertainty around solar). Nuclear and CCGT will still cost more, in the $78–$88 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.

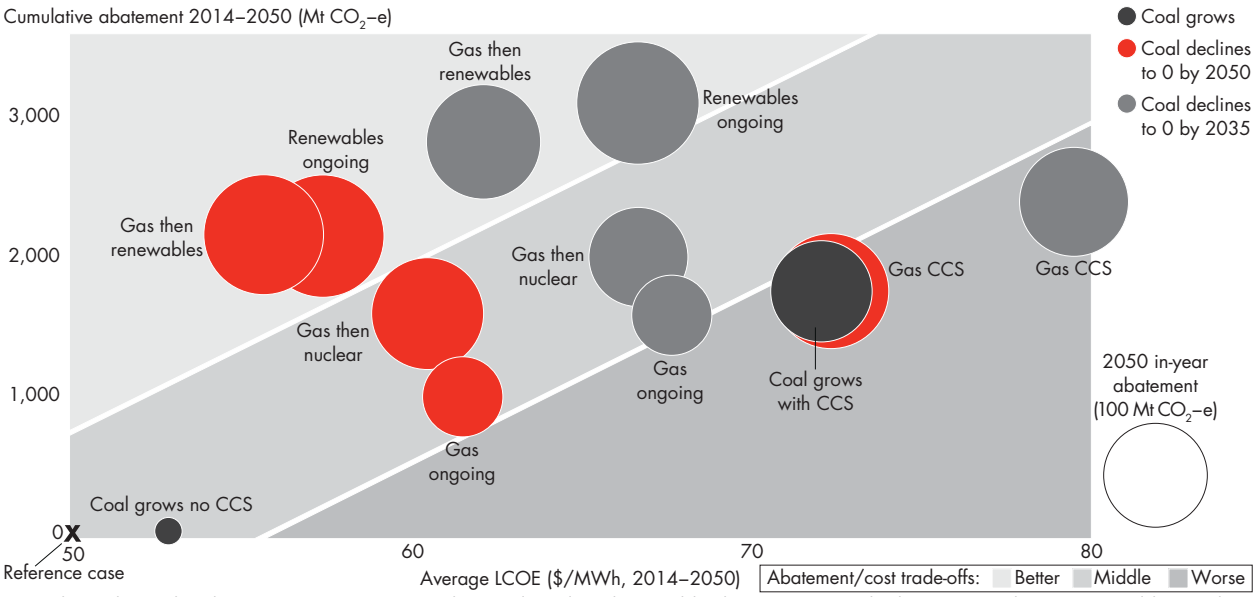
In our scenario analysis, we mapped each scenario's cumulative abatement between 2014 and 2050 and its average LCOE over the same period (*see Figure 5*). The analysis shows that there is typically a trade-off between cost and abatement. However, for any given LCOE, we assert that the scenario with the 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.

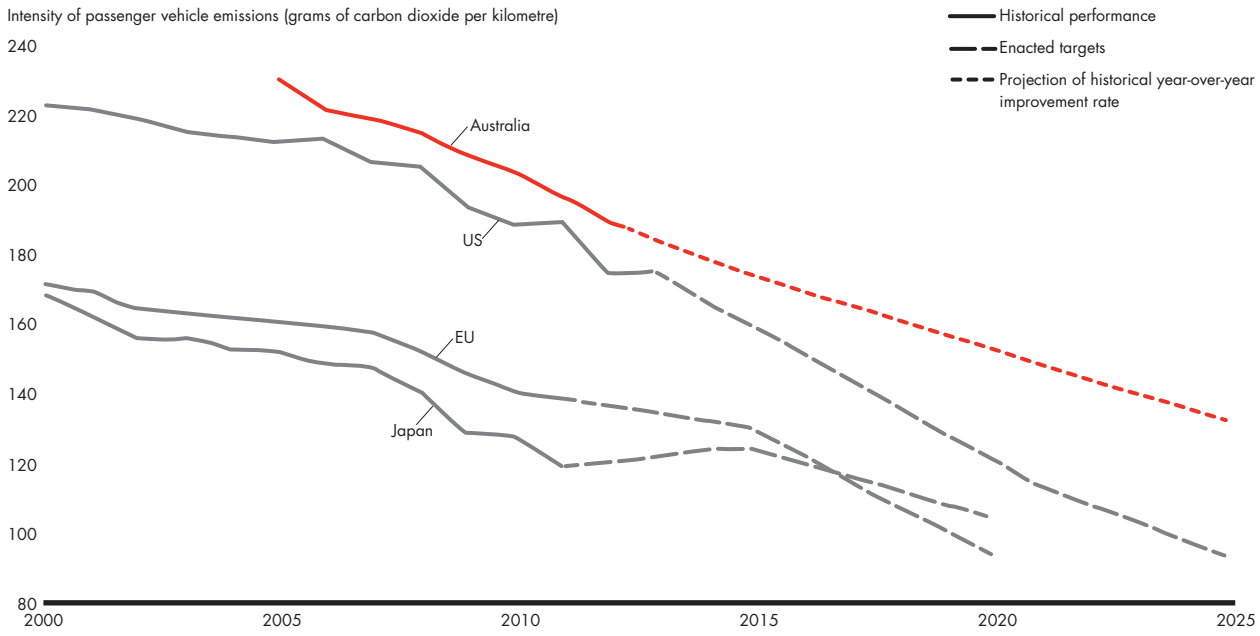
Since 2005, the efficiency of Australia's passenger vehicles has improved at a rate of 2.8% per year, but from a high starting point. Countries with more efficient fleets have demonstrated that further improvement is possible *(see Figure 6)*. For example, fuel efficiency has improved annually in Japan 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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